INTERNATIONAL COURT OF JUSTICE

CASE CONCERNING
AERIAL HERBICIDE SPRAYING

ECUADOR
V.
COLOMBIA

MEMORIAL OF ECUADOR

VOLUME III

ANNEXES

28 APRIL 2009

VOLUME III

ANNEXES

VOLUME III

ANNEXES

TABLE OF CONTENTS

CHEMICAL LABELS AND SAFETY INFORMATION

Annex 103 *Argentina, Roundup TRANSORB Material Safety Data Sheet*

Annex 104 *Argentina Roundup Ultramax Label Recommendations*

Annex 105 *Australia Roundup Label*

Annex 106 *Australia Roundup Biactive Label*

Annex 107 *Australia Roundup CT Label*

Annex 108 *Australia Roundup PowerMAX Label*

Annex 109 *Brazil Roundup Label*

Annex 110 *Canada Roundup Original Label*

Annex 111 *Canada Vision Silviculture Herbicide Label*

Annex 112 Cosmoagro, S.A., *Cosmo-Flux 411F*

Annex 113 *Colombia Cosmo-Flux 411F Label*

Annex 114 *Cosmo-Flux 411F Safety Data Sheet*

Annex 115 *Colombia Roundup SL Label*

Annex 116 *Ecuador Ranger 480 Label*

Annex 117 *Germany Roundup TURBO Label*

Annex 118 *Germany Roundup UltraMax Label*

Annex 119 *Italy Roundup 450 Plus*

Annex 120 *Japan Roundup Agrochemical Registration*

Annex 121 *Japan Roundup Product Safety Data Sheet*

Annex 122 *South Africa Roundup Label*

Annex 123 *United Kingdom Glyphosate 360 Label*

Annex 124 *United Kingdom Roundup Ultra ST Label*

Annex 125 *United States Roundup Export Label*, United States Pesticide Product Label System, Registration No. 524-308 (9 July 1997)

Annex 126 *United States Fuete SL Label*, United States Pesticide Product Label System, Registration No. 524-308 (19 Feb. 2002)

Annex 127 *United States Roundup Original Label*

Annex 128 *United States Roundup Pro Label*

Annex 129 *United States Roundup SL Label*, United States Pesticide Product Label System, Registration No. 524-308 (15 Nov. 2001)

Annex 130 Intentionally Omitted

SCIENTIFIC AND TECHNICAL REPORTS

Annex 131 C. André Lévesque & James E. Rahe, *Herbicide Interactions with Fungal Root Pathogens, with Special Reference to Glyphosate*, Annu. Rev. Phytopathol., Vol. 30 (1992)

Annex 132 United States Environmental Protection Agency, *Glyphosate Reregistration Eligibility Decision Fact Sheet* (Sep. 1993)

Annex 133 D.C. Sands et al., *Characterization of a Vascular Wilt of Erythroxylum coca Caused by Fusarium oxyspurum f. sp. Erythrowyli Forma Specialis Nova*, Plant Disease, Vol. 81, No. 5 (May 1997)

Annex 134 United States Environmental Protection Agency, *GLYPHOSATE – Report of the Hazard Identification Review Committee* (20 Apr. 1998)

Annex 135 Intentionally Omitted

Annex 136 United States Department of Agriculture, Agricultural Research Service, *Discovery and Development and Mechanism of Action of Biocontrol Agents for Perennial and Annual Weeds* (1 Oct. 1993 – 30 Sep. 1998)

Annex 137 United States Department of Agriculture, Agricultural Research Service, *Mechanisms of Microbial-Plant Interactions Related to Biocontrol of Weeds and Narcotic Plants* (1 Oct. 1993 – 30 Sep. 1998)

Annex 138 Ron Collins, Agronomist, Weed Science Laboratory, Agricultural Research Service, United States Department of Agriculture, *Glyphosate Aerial Application to Control Erythroxylum sp. In Colombia: Spray Droplet Evaluation, Draft* (23 Dec. 1998)

Annex 139 United States Department of Agriculture, Agricultural Research Service, *Strategies for Controlling Narcotic Plant Production* (30 Sep. 1995 – 29 Sep. 2000)

Annex 140 United States Department of Agriculture, *April 2001 Colombia Coca Eradication Verification Mission Trip Report* (13 June 2001)

Annex 141 Ronald T. Collins & Charles S. Helling, *Surfactant-Enhanced Control of Two Erythroxylum Species by Glyphosate*, Weed Technology, Vol. 16 (2002)

Annex 142 United States Environmental Protection Agency, *GLYPHOSATE – 2nd Report of the Hazard Identification Assessment Review Committee* (22 Jan. 2002)

Annex 143 United States Environmental Protection Agency, Office of Prevention, Pesticides and Toxic Substances, *Report on Issues Related to the Aerial Eradication of Illicit Coca in Colombia, Response from EPA Assistant Administrator Johnson to Secretary of State* (19 Aug. 2002)

Annex 144 United States Department of State, Bureau for International Narcotics and Law Enforcement Affairs, *Report on Issues Related to the Aerial Eradication of Illicit Coca in Colombia: Chemicals Used in the Aerial Eradication of Illicit Coca in Colombia and Conditions of Application* (Sep. 2002)

Annex 145 Intentionally Omitted

Annex 146 United States Environmental Protection Agency, Office of Pesticide Programs, *Details of the 2003 Consultation for the Department of State: Use of Pesticide for Coca and Poppy Eradication Program in Colombia* (June 2003)

Annex 147 United States Department of Agriculture, Agricultural Research Service, *Pathogens of Narcotic Crops and Their Use in Biological Control Strategies to Reduce Narcotics* (1 Oct. 1998 – 30 Sep. 2003)

Annex 148 United States Department of State, Bureau for International Narcotics and Law Enforcement Affairs, *Report on Issues Related to the Aerial Eradication of Illicit Coca in Colombia: Updated Report on Chemicals Used in the Aerial Eradication Program* (Dec. 2003)

Annex 149 United States Environmental Protection Agency, Office of Pesticide Programs, *Letter and Consultation Report from Administrator Leavitt* (17 Nov. 2004)

Annex 150 Rick A. Relyea, *The Impact of Insecticides and Herbicides on the Biodiversity and Productivity of Aquatic Communities*, Ecological Applications, Vol. 15, No. 2 (2005)

Annex 151 Keith R. Solomon et al., *Environmental and Human Health Assessment of the Aerial Spray Program for Coca and Poppy Control in Colombia*, prepared for the Inter-American Drug Abuse Control Commission (CICAD) section of the Organization of American States (OAS), 31 Mar. 2005

Annex 152 National University of Colombia, Institute of Environmental Studies, *Observations on the "Study of the effects of the Program for the Eradication of Unlawful Crops by aerial spraying with glyphosate herbicide (PECIG) and of unlawful crops on human health and the environment* (10 May 2005)

Annex 153 Ecuadorian Scientific-Technical Commission, *Technical Report from the CCTE on the CICAD Document on the Study of the Effects Produced by Spraying Glyphosate (within the coca crop eradication program) on the Border Between Ecuador and Colombia* (2 June 2005)

Annex 154 United States Environmental Protection Agency, Office of Pesticide Programs, *CICAD Environmental and Human Health Assessment of the Aerial Spray Program for Coca and Poppy Control in Colombia (Ecological Effects Assessment)* (26 Oct. 2005)

Annex 155 Inter-American Drug Abuse Control Commission (CICAD), *Interim Report on Follow-Up Studies: Environmental and Human Health Assessment of the Aerial Spray Program for Coca and Poppy Control in Colombia*, (July 2006)

Annex 156 United States Department of State, *Report to Congress: A Preliminary Evaluation of the Risk Posed to Colombia's Amphibians and Threatened Species by the Government of Colombia's U.S.-Supported Program of Aerial Eradication of Illicit Crops* (Aug. 2006)

Annex 157 Ecuadorian Scientific Commission, *The Plan Colombia Aerial Spraying System and its Impacts on the Ecosystem and Health on the Ecuadorian Border* (April 2007)

Annex 158 Charles A. Menzie, PhD, Pieter N. Booth, MS & Susan B. Kane Driscoll, PhD, *with contributions/advice from* Angelina J. Duggan, PhD, Charlotte H. Edinboro, DVM, PhD, Anne Fairbrother, DVM, PhD, Marion Joseph Fedoruk, MD, CIH, DABT, FACMT, Janci Chunn Lindsay, PhD, Katherine Palmquist, PhD & Brian J. Prince, MRQA, *Evaluation of Chemicals Used in Colombia's Aerial Spraying Program and Hazards Presented to People, Plants, Animals, and the Environment in Ecuador* (Apr. 2009)

Annex 159 Inter-American Drug Abuse Control Commission (CICAD), *Second Phase Environmental and Human Health Assessment of the Aerial Spray Program for Coca and Poppy Control in Colombia* (date unknown)

Annex 160 Charles S. Helling & Mary J. Camp, United States Department of Agriculture, *Verifying Coca Eradication Effectiveness in Colombia* (date unknown)

ANNEX 103

Argentina, Roundup TRANSORB Material Safety Data Sheet

MONSANTO imagine™ | Roundup TRANSORB	**Monsanto Argentina S.A.I.C.** **Maipú 1210, 10th Floor – Cap.Fed.** **Customer Service Center** **0810-MONSANTO (6667268)** **callcenter@la2.monsanto.com**

MATERIAL SAFETY DATA SHEET

01 **Product Identification**

Product Name:	Roundup TRANSORB
Chemical Name:	Not applicable
Synonyms:	Not applicable

[…]

[PAGE 3]

[…]

09 **Spills and Losses**

Contain or place a barrier around the spilled liquid on the soil or other impervious surfaces using earth, sand, bentonite, attapulgite clay, or other absorbent materials. Take the material contaminated with the spilled liquid, place it in a plastic bag and then into a metal drum and, finally, proceed to dispose of according to the instructions found in section 13.
Be sure to keep the spill away from drains, sewers, canals and waterways.

MONSTANTO imagine™

1 10 10

0 10

01

Nombre del Producto:

Nombre Químico:

Sinónimos:

Revisión: 03 Fecha: 19|10|05

02 Composición Química del Producto

Ingrediente activo : Sal isopropilamina de glifosato ..... 64,8% (peso/ volumen)

Ingredientes Inertes: ..... 59.4% (peso/ volumen)

CAS Reg. No. para ingrediente activo: 1 0 1

La identidad química exacta no se especifica ya que es información comercial secreta de la empresa Monsanto.

03 Identificación de los Peligros

Contacto con la piel, contacto con los ojos, inhalación e ingestión.

Puede causar irritación ocular temporaria.

No se estima que produzca efectos nocivos importantes si se siguen las instrucciones de uso recomendadas.

No se estima que produzca efectos nocivos importantes si se siguen las instrucciones de uso recomendadas.

No se estima que produzca efectos nocivos importantes si se siguen las instrucciones de uso recomendadas.

¡CUIDADO! Puede provocar irritación ocular

04 Primeros Auxilios

Lave de inmediato con abundante agua. Continúe por lo menos 15 minutos. Si la víctima tiene lentes de contacto, retírelos en caso de que sea posible y seguro hacerlo. Busque a un médico oftalmólogo.

Lave la zona afectada con abundante agua. Lave la ropa antes de volver a utilizarla.

Tome aire fresco.

Ofrezca de inmediato agua para beber. Nunca administre algo por vía oral a una persona inconsciente. No induzca al vómito salvo que así lo indique personal médico. Se puede acudir a un médico o Centro de Control de Envenenamiento para consultas.

Este producto no es un inhibidor de colinesterasa.

En caso de necesitar más información para una guía sobre primeros auxilios o tratamiento en caso de emergencia con seres humanos, realice una llamada al Centro de Atención al Cliente 0810-MONSANTO (6667268)

ANNEX 103

09 Derrames y Pérdidas

Contenga o endique el derrame de líquidos sobre suelo u otras superficies impermeables, utilizando tierra, arena, bentonita, atapulguita u otros materiales absorbentes. Recoja el material contaminado con el líquido derramado, colóquelo en una bolsa plástica y luego en un tambor de metal, y finalmente proceda a la disposición de acuerdo con las instrucciones que se encuentran en la sección 13.
Asegúrese de mantener el derrame alejado de drenajes, cloacas, canales y cursos de agua.

10 Datos Toxicológicos

Rata, LD50: 5.108 mg/kg peso corporal. Prácticamente no tóxico.
Categoría FIFRA IV.

Conejo, 6 animales, ensayo OECD 404:
Días necesarios para la recuperación: 3
Índice de Irritación Primaria (PII): 0,5/8,0
Esencialmente no irritante. Categoría FIFRA IV.

Conejo, 6 animales, ensayo OECD 405:
Días necesarios para la recuperación: 3
Irritación leve. Categoría FIFRA III.

NOTA: Para la realización del test de inhalación este producto fue artificialmente aerolizado. Esta condición no es alcanzada naturalmente durante el proceso de transporte y, por lo tanto, este material es clasificado como NO PELIGROSO para transporte en conformidad con los ítems 2.6.2.2.4.7 (b) y (c) del UN Recommendations on the Transport of Dangerous Goods.

0 1 10,4 mg/l (extrapolación de CL50 4h: 2,6 mg/l).

Incidencia positiva: 0 %

Ensayo(s) de mutagenicidad in vitro e in vivo:

1 Toxicidad NOAEL: **000**
Órganos/sistemas afectados :
Otros efectos:

Toxicidad NOAEL: **0 000**
Órganos/sistemas afectados:
Otros efectos:

: Tumor NOEL: **0 000**
Toxicidad NOAEL: **000**
Tumores:
Órganos/sistemas afectados:
Otros efectos:

Tumor NOEL **0 000**
Toxicidad NOAEL: ~ **000**

ANNEX 104

Argentina Roundup Ultramax Label Recommendations

[…]

- Application to perennial crops

Applications to vineyards, yerba mate, tea, citrus trees or fruit trees should be made using the doses required to control the weeds present. In all cases, avoid spraying leaves, fruits or green stems of cultivated plants, by directing application to the base of the trunk of plants older than three years, carefully protecting those less than three years old.

> For sugar cane, use a chemical glove soaked in the Roundup UltraMax Solution at 10%, controlling the weeds without affecting the crop, regardless of its development state.

< VOLVER

Recomendaciones del Marbete

Roundup UltraMax es un herbicida selectivo para el control postemergente de las malezas anuales y perennes en Soja RR, Maíz RR y algodón RR, cultivos genéticamente modificados, tolerantes al principio glifosato. De acción sistémica, es absorbido por hojas y tallos verdes y traslocado hacia las raíces y órganos vegetativos subterráneos, ocasionando la muerte total de las malezas emergidas. También se puede usar como no selectivo para el control de malezas en áreas agrícolas, industriales, caminos, vías férreas, etc como se indica en este marbete.
Los efectos son graduales, sobre todo en las especies perennes, donde después de transcurridos 4-5 días desde la aplicación comienza el amarillamiento y marchitamiento de hojas y tallos que culminan con la muerte total de las malezas.

Aplicaciones en cobertura total

- Para aplicaciones con equipos de mochila debe prepararse una solución de 0,500 a 1 Kg. de Roundup UltraMax cada 100 litros de agua limpia, mojando uniformemente el follaje, sin que el producto llegue a gotear.
- Con equipos pulverizadores terrestres debe utilizarse la dosis recomendada, diluida en agua limpia, a razón de 80-120 l/ha. Las pastillas recomendadas son las de abanico plano trabajando a una presión cuadrada. Para preparar la solución de aspersión debe llenarse el depósito con agua hasta la mitad, agregarse la dosis recomendada por Roundup UltraMax y completarse el llenado. Debido a la alta solubilidad de Roundup UltraMax es suficiente la agitación provista por el retorno de la pulverizadora.

Importante

- Después de una aplicación con Roundup UltraMax y antes de dañar mecánicamente las malezas tratadas, es necesario esperar 3 días en el caso de especies anuales y 4 a 5 en el de perennes para asegurar la completa translocación del Roundup UltraMax a todos los órganos vegetativos de las plantas
- Los mejores resultados se obtienen cuando la aplicación se realiza sobre malezas en activo crecimiento que no sufren efectos de sequía, enfermedades o cualquier otro factor adverso a su normal desarrollo.
- Evitar las aplicaciones sobre malezas cubiertas por tierra.
- No pulverizar si se prevén lluvias durante las seis horas posteriores a la aplicación o cuando el follaje de las malezas esté mojado.
- No pre – diluir el producto, agregarlo directamente al tanque del pulverizador.
-

En Post – emergencia de variedades de soja Roundup Ready (RR)
Sojas geneticamente modificadas: Partiendo de una soja RR libre de la competencia de malezas vivas en el momento de la siembra (ya sea convencional o directa), la primera aplicación de Roundup UltraMax en pos – emergencia (de cultivo y malezas) se recomienda cuando las malezas alcanzan un máximo de 15 cm. de altura o diámetro. En ese momento, y para la generalidad de los casos donde también hubiera malezas perennes emergidas, se recomienda la aplicación de una dosis de 1,1 a 1,3 k / ha. En caso de especies de malezas más exigentes (ej. Gramón, cebollin) la dosis requerida puede ser de 1,6 a 1,8 k / ha. El referido desarrollo de las malezas anuales suele alcanzarse entre los 30 y 40 días después de la siembra de cultivo, cuando la soja RR presenta 3-4 hojas verdaderas.

Debido a que Roundup UltraMax no es un herbicida residual, puede ser necesaria una segunda aplicación para controlar las malezas que emergieran con posterioridad al primer tratamiento. En este caso se recomienda aplicar entre 0,8 y 1,0k/ha de Roundup UltraMax adicional para completar el control.
Con estas dosis se controlan las malezas anuales, tanto latífoliadas como gramíneas y también malezas perennes.

En Post- emergencia de híbridos de maíz Roundup Ready (RR): Partiendo de un maíz RR libre de la competencia de malezas vivas en el momento de siembra (ya sea convencional o directa) la primera aplicaron de Roundup UltraMax en post- emergencia (de cultivo y malezas) se recomienda cuando las malezas anuales (gramíneas o latífoliadas) alcanzan un máximo de 15 cm. de altura o diámetro, antes de que comience la competencia que puede afectar el rendimiento y estado del maíz 4 hojas (V4). En ese momento, se recomienda la aplicación de una dosis de 1,3 Kg. /ha. Si las malezas son de mayor tamaño pueden aplicarse hasta 2,6 Kg. /ha.

En caso de ser necesaria una segunda aplicación para controlar las malezas que emergieran con posterioridad al primer tratamiento, se recomienda aplicar entre 0,8 y 1 Kg. /ha de Roundup UltraMax adicional, para completar el control. Las

aplicaciones no deben realizarse después de que el cultivo alcanzó el estado de 8 hojas, ya que podrían producirse daños e el cultivo.

En Post – emergencia de variedades de algodón de Roundup Ready (RR)
Partiendo de un algodón RR libre de la competencia de malezas vivas en el momento de siembra (ya sea convencional o directa), se recomienda la aplicación de Roundup UltraMax en post- emergencia (de cultivos y malezas) cuando las malezas alcancen un máximo de 7 cm. de altura o diámetro y el algodón tenga hasta 4 hojas totalmente expandidas.

Entre el período de emergencia y 4 hojas expandidas del algodón podrán realizarse hasta dos aplicaciones de un máximo de 1,4 Kg. /ha de Roundup UltraMax cada una, con un intervalo entre ambas aplicaciones. Suficiente para que las plantas de algodón crezcan, como mínimo dos nudos adicionales.

Las aplicaciones no deben realizarse entre el estado de 5 hojas y el estado de 20 % de apertura de frutos ya que podrán producirse mermas en el rendimiento.

Podrán realizarse aplicaciones en cobertura total en pre- cosecha en el estado de 20% de apertura de frutas (bochas). En ese momento podrán aplicarse hasta 2,5 kg/ha de Roundup UltraMax.

Aplicaciones en cultivos perennes

Las aplicaciones en viñedos, yerba mate, té, cítricos o frutales deben realizarse a las dosis requeridas para controlar las malezas presente. En todos los casos debe evitarse que la pulverización alcance hojas, frutos o tallos verdes de las plantas cultivadas, dirigiendo la aplicación a la base del tronco de las plantas de más de tres añoso bien protegiendo a las de menos de tres años.

- En caña de azúcar se puede usar guante químico embebido en una solución de Roundup UltraMax al 10 %, controlando las malezas sin afectar el cultivo, sea cal fuera su estado de desarrollo.

Aplicaciones de presiembra en soja, maíz y girasol

- Siembra convencional: Este tipo de aplicación es recomendable para lotes con altas infestaciones de Sorgo de Alepo, antes de destinarlos a soja de primera, girasol, maíz y otros cultivos; logrando que crezcan libres de malezas. Es conveniente arar durante el invierno y trabajar con rastra de doble acción al comienzo de la primavera con el objeto de trozar rizomas y uniformar su brotación. Deberá dejarse crecer el sorgo de alepo hasta 30 – 50 cm. de altura y luego aplicar 1,400kg/ha de Roundup UltraMax.
- Siembra directa: El uso de Roundup UltraMax es especialmente indicado para el control de las malezas presentes en el rastrojo del cultivo anterior, antes o inmediatamente después de la implantación usando esta técnica. Se recomienda esperar 2 a 3 días después de la cosecha para que las malezas recuperen la capacidad de absorber el herbicida y luego aplicar 1,4 – 2,0 kg./ha de Roundup UltraMax.

Malezas que controla (aplicaciones no selectivas)

Roundup UltraMax controla un gran número de especies, se citan algunas.
Anuales: las malezas anuales son más susceptibles a Roundup UltraMax cuando tienen menos de 15 cm. de altura, usando una dosis entre 1,0 y 1,60 Kg. por hectárea para gramíneas y de 1,4 a 2,1 Kg. por hectárea para latifoliadas.

Bajo ciertas condiciones naturales, existe la posibilidad de biotipos de una maleza que fueran tolerantes al glifosato y otros grupos de herbicidas. Dichos biotipos tolerantes podrían tornarse dominantes después del uso repetido de dichos grupos de herbicidas. Atento que la ocurrencia de poblaciones resistentes resulta difícil de detectar antes de la aplicación del herbicida, Monsanto no se responsabiliza por ninguna perdida que pudiera resultar de la falla de este producto cuando se lo aplique para controlar biotipos de maleza que hubieran desarrollado una tolerancia natural.

© 2008 Monsanto Argentina SAIC. | Términos y condiciones de uso del sitio | Avisos Legales

El titular de los datos personales tiene la facultad de ejercer el derecho de acceso a los mismos en forma gratuita a intervalos no inferiores a seis meses, salvo que se acredite un interés legítimo al efecto conforme lo establecido en el artículo 14, inciso 3 de la Ley Nº 25.326

La DIRECCION NACIONAL DE PROTECCION DE DATOS PERSONALES, Órgano de Control de la Ley Nº 25.326, tiene la atribución de atender las denuncias y reclamos que se interpongan con relación al incumplimiento de las normas sobre protección de datos personales.

*Según bases, condiciones y recomendaciones de marbete en www.elijoroundup.com.ar

ANNEX 105

Australia Roundup Label

Roundup® - Front Label

CAUTION

KEEP OUT OF REACH OF CHILDREN
READ SAFETY INSTRUCTIONS BEFORE OPENING OR USING

Roundup® *Herbicide by Monsanto*

ACTIVE CONSTITUENT : 360 g/L GLYPHOSATE
(present as the isopropylamine salt)

GROUP **M** HERBICIDE

Water soluble herbicide for non-selective control of many annual and perennial weeds in certain situations.

IMPORTANT: READ THE ATTACHED BOOKLET BEFORE USING THIS PRODUCT

N (Nufarm logo)

Distributed by
Nufarm Australia Limited ACN 004 377 780
103-105 Pipe Road, Laverton North, VIC 3026
Tel: (03) 9282 1000 Fax: (03) 9282 1001
NRA Approval No 31393/

CONTENTS

5, 20, 55, 110, 115, 200, 400, 1000 LITRES

Batch no. :
Date of manufacture :

Barcode

ANNEX 105

Roundup® - 250mL, 500mL, 1L

(front page)

CAUTION

KEEP OUT OF REACH OF CHILDREN
READ SAFETY DIRECTIONS BEFORE OPENING OR USING

Roundup® Herbicide by Monsanto

Active Constituent: 360g/L GLYPHOSATE (present as the isopropylamine salt)

Water soluble herbicide for non-selective control of many annual and perennial weeds in certain situations.

Distributed by
Nufarm Australia Limited ACN 004 377 780
103-105 Pipe Road, Laverton North, VIC 3026
Tel: (03) 9282 1000 Fax: (03) 9282 1001
NRA Approval No. 31393/0703
Batch No. / Date of Manufacture

CONTENTS 250ml, 500ml & 1Litre

(back view of pack)

Roundup® herbicide by Monsanto kills weeds, unwanted grasses and vegetation in Domestic, Public Services, Commercial and Industrial Areas.

HOW TO USE
DO NOT treat if rain is likely within 6 hours. DO NOT DISTURB treated weeds for 7 days after treatment.

WEEDS CONTROLLED	RATE	HOW TO APPLY
General Mixed Weeds Annual and Perennial Weeds	10mL per 1L water	**TIMING**: Apply when weeds are actively growing. For best results on perennial weeds treat after flowering. Treat woody leaves from flowering to leaf fall (Jan-May). DO NOT spray plants bearing edible berries.
Woody Weeds	15mL per 1L water	**APPLICATION**: Uniform and complete spray to wet all leaves. Run off should not occur. 1 litre of spray will cover 10 square metres. The addition of a non-ionic surfactant is recommended at a rate of 1ml of a 600g/L product (or equivalent) per 1L spray solution. Seeding or planting into treated areas may proceed after 7 days.

NOT TO BE USED FOR ANY PURPOSE, OR IN ANY MANNER, CONTRARY TO THIS LABEL UNLESS AUTHORISED

HOW TO PREPARE:
Mix this product with clean water. Use only plastic lined brass, copper, fibreglass, aluminium, plastic or stainless steel containers for mixing and application. DO NOT mix more than can be used within 5 days. Wash out spray equipment thoroughly after use.

CAUTION:
DO NOT allow spray to contact or drift onto plants you do not want killed. Accidental contact must be hosed with water immediately to reduce injury to plant. DO NOT allow chemical containers or spray to get into drains, sewers, streams or pond. DO NOT spray directly on humans, pets, exposed food, food preparation areas or food utensils.
STORAGE AND DISPOSAL: Store in the closed original container in a cool, dry place out of reach of children. Do not store in direct sunlight. Dispose of empty container by wrapping in paper, placing in a plastic bag and putting in the garbage.
SAFETY DIRECTIONS: Avoid contact with eyes and skin. Wash hands after use.
FIRST AID: If poisoning occurs, contact a doctor or **Poisons Information Centre Ph: 13 11 26.**

Only in Emergency call **1800 033 498 ALL HOURS**
Refer to MSDS

Barcode

ANNEX 106

Australia Roundup Biactive Label

CAUTION

KEEP OUT OF REACH OF CHILDREN
READ SAFETY INSTRUCTIONS BEFORE OPENING OR USING

Roundup BIACTIVE

Herbicide by Monsanto

ACTIVE CONSTITUENT: 360 g/L GLYPHOSATE (present as the isopropylamine salt)

GROUP M HERBICIDE

Water soluble herbicide for non-selective control of many annual and perennial weeds in certain situations.

ALWAYS READ THE LABEL AND USE ONLY AS DIRECTED

Distributed by
Nufarm Australia Limited ACN 004 377 780
103-105 Pipe Road, Laverton North, VIC 3026
Tel: (03) 9282 1000 Fax: (03) 9282 1001

Nufarm

ONLY IN EMERGENCY
CALL 1 800 033 498 ALL HOURS
Refer to Material Safety Data Sheet

DIRECTIONS FOR USE

For specific rates of application and complete directions for use read this removable booklet.

SAFETY DIRECTIONS

Product will irritate the eyes and skin. Avoid contact with eyes and skin.
When preparing product for use wear elbow-length PVC gloves and face shield or goggles.
After use and before eating, drinking or smoking, wash hands, arms and face thoroughly with soap and water.
After each day's use wash contaminated clothing, gloves and face shield or goggles.
When using controlled droplet applicator, wear protective waterproof clothing and impervious footwear.

STORAGE AND DISPOSAL

Store in the closed, original container in a dry, cool, well-ventilated area out of direct sunlight.
Do not contaminate seed, feed or foodstuff.
Do not re-use container for any purpose.
Triple or preferably pressure rinse containers before disposal. Add rinsings to spray tank. Do not dispose of undiluted chemicals on site. If recycling, replace cap and return clean containers to recycler or designated collection point.
If not recycling, break, crush or puncture and bury empty containers in a local authority landfill. If no landfill is available bury the containers below 500 mm in a disposal pit specifically marked and set up for this purpose clear of waterways, desirable vegetation and tree roots. Empty containers and product should not be burnt.

FIRST AID

If poisoning occurs, contact a doctor or Poisons Information Centre. Phone **13 1126.**

CONDITION OF SALE

Nufarm Australia Limited ("Nufarm ") shall not be liable for any loss, injury, damage or death whether consequential or otherwise whatsoever, or howsoever arising through negligence or otherwise in connection with the sale, supply, use or application of this product. The supply of this product is on the express conditions that the purchaser does not rely on Nufarm's skill or judgement in purchasing or using the same and every person dealing with this product does so at his own risk absolutely. No representative of Nufarm has any authority to alter these conditions.

ONLY IN EMERGENCY
CALL 1 800 033 498 ALL HOURS
Refer to Material Safety Data Sheet

NRA Approval No. 48518/1102

PROTECTION OF CROP, NATIVE AND OTHER NON-TARGET PLANTS

Avoid contact with foliage, green stems, exposed non-woody roots or fruit of crops, desirable plants and trees, since severe injury or destruction may result.

DO NOT apply under weather conditions, or from spraying equipment, that may cause spray to drift onto nearby susceptible plants/crops, cropping lands or pastures.

PROTECTION OF WILDLIFE, FISH CRUSTACEA AND ENVIRONMENT

Do NOT contaminate dams, rivers or streams with the product or used container. When controlling weeds in aquatic situations, refer to label directions to minimise the entry of spray into the water.

RESISTANT WEEDS WARNING

Roundup Biactive is a member of the Glycines group of herbicides. Roundup Biactive has the inhibition of EPSP synthase mode of action. For weed resistance management Roundup Biactive is a Group M herbicide.

Some naturally occurring weed biotypes resistant to Roundup Biactive and other inhibitors of EPSP synthase mode of action herbicides may exist through normal genetic variability in any weed population. The resistant individuals can eventually dominate the weed population if these herbicides are used repeatedly. These resistant weeds will not be controlled by Roundup Biactive or other inhibitors of EPSP synthase herbicides. Since the occurrence of resistant weeds is difficult to detect prior to use, Monsanto accepts no liability for any losses that may result from the failure of Roundup Biactive to control resistant weeds.

PRODUCT INFORMATION

Roundup Biactive is a non-volatile, water soluble liquid product with non-selective herbicidal activity against many annual and perennial broadleaf weeds and grasses.

Roundup Biactive may be used for weed control in agricultural land prior to sowing any edible or non-edible crop, but not prior to transplanting tomato seedlings.

Roundup Biactive is absorbed by plant foliage and green stems. It is inactivated immediately in the soil and does not provide residual weed control. Roundup Biactive moves through the plant from the point of contact to and into the root system. Visible effects on annual weeds take 3-7 days but on perennial weeds may be not be obvious for 2-3 weeks or longer in some cases. Visible effects of control may be delayed by cool or cloudy weather at and following treatment.

When applying this product prior to transplanting crops into plastic mulch, care must be taken to remove residues of this product from the plastic prior to transplanting. Residues can be removed by 2 cm of natural rainfall or by applying water via a sprinkler irrigation system.

GENERAL WEED CONTROL ALL STATES

SITUATION	CRITICAL COMMENTS Read Application Checklist before using
For general weed control in Domestic areas (Home gardens), Commercial, Industrial and Public Service areas, Agricultural buildings and other farm situations.	For the control of many grasses and broadleaf weeds. **RATE: 10 mL per litre of water.** Apply when weeds are actively growing.
For specific weeds, brush and woody weeds or unwanted trees, refer to the appropriate **Weeds Controlled** table.	Apply to ensure complete and uniform wetting of foliage. Visible symptoms may take from 3 to 7 days to develop.

ANNEX 106

USE SITUATIONS	ALL STATES *(except where noted)* For rates of application and weeds controlled, see **Weeds Controlled** tables
SITUATION	**CRITICAL COMMENTS Read Application Checklist before using**
NON-AGRICULTURAL AREAS Around buildings, Commercial and Industrial areas, Domestic and Public Service areas, Right-of-ways.	Roundup Biactive does not provide residual weed control. For residual control of annual weeds, Roundup Biactive may be tank mixed with certain residual herbicides. **See Tank Mixtures/Compatibility**.
AGRICULTURAL AREAS	Roundup Biactive may be used for control of annual and perennial weeds as directed, in agricultural land prior to sowing of any edible or non-edible crop, but not prior to transplanting tomato seedlings.
AQUATIC AREAS For the control of emerged weeds in all bodies of fresh and brackish water which may be flowing, non-flowing or transient. Also for weeds on margins of streams, lakes and dams and in channels and drains.	Reduction in effectiveness may result if more than 1/4 of the above ground portion of the weed is submerged at treatment. Submerging the treated plants following treatment may result in the spray being washed from the plant surface, thus reducing effectiveness. Do not use additional surfactant/wetting agent unless it is approved for use in aquatic situations. Do not apply this product within 0.5 km up-stream of potable water intake in flowing water (i.e. river or stream, etc.) or within 0.5 km of a potable water intake in a standing body of water such as a lake, pond or reservoir. Applications to moving bodies of water should be made while travelling upstream wherever possible to prevent concentration of this herbicide in water. When making any bankside applications, do not overspray more than 0.5 m into open water. Avoid spraying across moving bodies of water, or where weeds do not exist. When spraying floating weeds, use a low volume, low pressure boom sprayer, CDA, or sprinkler sprayer. Do not submerge the weeds when spraying as this may wash the herbicide off the leaves. When emerged infestations require treatment of the total surface area of impounded water, treating the area in strips may avoid sudden impact on habitat.
FORESTS	Roundup Biactive may be used prior to establishment of nurseries, for site preparation prior to planting and amongst established trees using a directed or shielded spray, or using selective wiper equipment. Do NOT allow wiper surface to contact any part of the tree. Do NOT allow spray or spray drift to contact foliage or green bark of desirable trees, since severe injury may result.
PEANUTS, COTTON, SOYBEANS, SUGARCANE, NAVY BEANS and CHICKPEAS Application using selective equipment QLD, NSW only	**Wiper Equipment** Apply Roundup Biactive to weeds growing between crop rows or to weeds growing at least 15 cm above the crop. Do NOT allow wiper to contact crop and ensure operating conditions do not allow solution to drip from applicator since severe injury may result. Refer to **Wiper Equipment** in the **Application** section of the label. **Shielded Sprayers (Cotton only)** Apply Roundup Biactive to weeds growing between crop rows using a shielded sprayer. Refer to the **Weeds Controlled** tables for rates of application. Do NOT apply in crops less than 20 cm high. Do NOT allow spray or spray drift to contact any part of the cotton plant as severe injury or destruction may result.
TREE AND VINE CROPS Avocado, Banana, Blueberries, Citrus fruit, Custard apples, Duboisia, Figs - dessert, Guava, Kiwifruit, Litchi, Mango, Monstera - fruit, Nuts (including Almond, Pecan, Macadamia, Pistachio and Walnut), Olives, Pawpaw, Persimmons, Pome fruit, Raspberries, Stone fruit, Tea, Vineyards.	Apply as a directed or shielded spray or using wiper equipment. Do NOT apply as a spray near trees or vines less than 3 years old unless they are effectively shielded from spray and spray drift. Do NOT allow wiper surface to contact any part of the tree, vine or palm. Avoid painting out stumps with this product as injury resulting from root grafting may occur in adjacent trees. **Citrus fruit, Nuts, Olives, Pome fruit & Vineyards** Do NOT allow spray or spray drift to contact green bark or stems, canes, laterals, suckers, fresh wounds, foliage or fruit. **Tea** Apply a maximum of 3L/ha by shielded boom or directed off-centre nozzle or 0.5L/100L by directed handgun or knapsack to avoid application to the crop. **All other crops** Do NOT allow spray or spray drift to contact any part of the plant including the trunk. **CAUTION** Where split bark on Kiwifruit and green stems on Pawpaw occur, extreme care is required. For residual control of annual weeds, Roundup Biactive may be tank mixed with compatible herbicides which are labelled for use in the above crops. See **Tank Mixtures/Compatibility** for directions.
SUGARCANE RATOON SPRAYOUT For control of sugar cane, ratoon regrowth NSW and QLD only	Apply under good growing conditions only to actively growing ratoons 60-120 cm tall. Do NOT apply if plants are under stress from low moisture or waterlogging. **RATE** 4-9 L/ha Use the lower rate for suppression or where cultivation is to follow. Use the higher rate for control.

Sifton Bush / Chinese Scrub [ab]	10 or 13 mL	1:9	Apply when actively growing. Ensure complete coverage of the bush. Pasture improvement and/or re-treatment is recommended to control seedlings and/or regrowth. **High Volume** Use the higher rate on bushes over 1 m. **Low Volume** Apply 40 mL per 0.5 m height. **Wiper Application** Double pass application is required. Application is best made to small (less than 1 m) green bushes.
Sweet Briar [bcdef]	15-20 mL	1:9	Apply to actively growing plants from late flowering to leaf fall. Spray to wet all foliage. Use the higher rate on bushes over 1.5 m high. Burning (after complete brownout), pasture improvement and/or further treatment are recommended to control seedlings and/or regrowth. low Volume Application (eg. Splatter Gun and Gas Gun): Apply 2 x 5 mL dose per 0.5 m bush height. Ensure spray contacts all foliage.

NOT TO BE USED FOR ANY PURPOSE, OR IN ANY MANNER, CONTRARY TO THIS LABEL UNLESS AUTHORISED UNDER APPROPRIATE LEGISLATION.

MIXING
Roundup Biactive mixes readily with water. Note: Reduced results may occur if water containing soil is used, eg. water from ponds and unlined ditches, or if hard water containing calcium salts is used.

Do not mix, store or apply this product or spray solutions of this product in galvanised steel or unlined steel containers or spray tanks, since a highly flammable gas mixture may be formed.

Use stainless steel, brass, copper, fibreglass, plastic or plastic-lined containers or spray tanks. Aluminium is susceptible to corrosion by Roundup Biactive and should not be used. Ensure the spray tank is free of any residue or previous spray materials.

Use spray solutions promptly and certainly within 5 days, since a gradual loss of activity will occur. Fill the spray tank with one half the required amount of clean water and add the proper amount of Roundup Biactive. Mix well before adding the remaining portion of water. Placing the filling hose below the surface of the spray solution will prevent excessive foaming. Removing hose from tank immediately after filling will prevent back siphoning into water source. Do not use mechanical agitators as these may cause excessive foaming, Spray tanks, pumps, lines and nozzles should be thoroughly rinsed with clean water following application to prevent corrosion.

TANK MIXTURES/COMPATIBILITY
Roundup Biactive may be tank-mixed with the following herbicides, insecticides and additives.

Read and follow all label directions, restraints, plant-back periods, withholding periods, regional use restrictions and safety directions for the tank mix products.

Mixing Instructions for All Tank Mixtures
1. Fill the spray tank 1/3 to 1/2 full will clean water and start agitation.
2. Where crystalline ammonium sulphate is recommended, wash 2% w/v (2 kg/100 L spray solution) through a top mesh-screen into the tank and mix thoroughly.
3. Add recommended herbicide/insecticide/additive to the spray tank and mix thoroughly.
4. Add Roundup Biactive and the remaining water Mix thoroughly.
5. Add surfactant, if required, near the end of the filling process to minimise foaming.
6. Always maintain adequate agitation during application and use the tank mix promptly.

Tank Mixtures - Herbicides
Atrazine flowable* (Agricultural uses only DO NOT apply the tank mix for Barnyard grass control.), 2, 4-D ester, dicamba, Glean, Simazine flowable*, Oust , Yield, Stomp 330E, Ally, Logran 750G, Flandor 500, LVE MCPA, and Striker.
The addition of Striker at 75 mL/ha to recommended rates of Roundup Biactive prior to planting wheat or barley will improve knockdown and increase the speed at which treated weeds develop visible signs of phytotoxicity.
*Add crystalline ammonium sulphate as per directions below.

Tank Mixtures - Additives
Crystalline Ammonium Sulphate
RATE: 2% w/v (2kg/100L spray solution). (DO NOT apply the tank mix for Barnyard grass control). The addition of crystalline ammonium sulphate to Roundup Biactive, when used to control ANNUAL weeds, MAY improve the performance of Roundup Biactive under adverse environmental conditions such as cool, cloudy weather, and assist in minimising the antagonism in tank mixes of Roundup Biactive and flowable triazine herbicides. Use only crystalline ammonium sulphate, NOT prilled or granulated forms. Ammonium sulphate may be corrosive to metal parts of the sprayer. Thoroughly flush tanks, pumps and nozzles with water after use.

Pulse® Penetrant
RATE: 200 mL/100 L spray solution
Add when treating bracken (boom application), Gorse, Eucalypt suckers and Lantana.

Wetter TX Surfactant
RATE: 200 mL/100 L spray solution
Add when treating Annual ryegrass in Spring (from beginning August to end October). Wetter TX is not a general purpose surfactant and should be used only where recommended.

Tank Mixtures - Insecticides
This product is compatible with the following insecticides: Imidan, Le-Mat, Lorsban 500, Perfekthion EC400, Sumithion ULV, and emulsifiable concentrates of dimethoate and fenitrothion. Other insecticides have not been tested.

APPLICATION
Roundup Biactive is a non-selective translocated herbicide. Direct spray contact, or even slight drift, may cause severe injury or destruction of any growing crop or other desirable plants including trees. Clean all equipment after use by thoroughly washing with water.

Boom Equipment
Use recommended rates of Roundup Biactive in 75 to 200 litres of clean water per hectare. When using Roundup Biactive at 50O mL-1.5 L/ha spray volumes in the range 25-100 L/ha are preferred. Fan nozzle equipment is recommended, using pressures in the range 240-280 kPa. Boom height must be set to ensure double over lap of nozzle patterns at the top of the weed canopy.

High Volume Application
(eg. Knapsack/Handgun Equipment)
The dilution rate is given as vol/1 litre eg: 10 mL Roundup Biactive per litre of water. This is equal to 150 mL Roundup Biactive per 15 litres of water or 1 litre per 100 litres of water. Adjust equipment to achieve an even spray pattern. Apply to ensure complete and uniform wetting of all foliage. For handgun equipment, a D6 spray tip (Spraying Systems Australia P/L) or equivalent, and an operating pressure of 400-700 kPa are recommended.

Low Volume Application
(eg. Gas Gun or Splatter Gun) Apply as an even spray to cover all foliage.
Refer to **Weeds Controlled** for the dilution and volume of mixture to be applied. The dilution is specified as "Low volume mixture, Roundup Biactive : Water". For example, a 1:9 mixture equals one part Roundup Biactive plus 9 parts water.

Wiper Equipment
Wiper Equipment (eg. ropewick, canvas, felt or carpet applicators) may be used to apply Roundup Biactive onto weeds growing in oilseed crops, sugarcane, cotton, seed and pod vegetables, tree and vine crops specified in this label, pasture and non-crop areas. Avoid contact with desirable vegetation.

Operate wiper equipment a minimum of 10 cm above the crop or pasture. Weeds should be at least 15 cm above the crop or pasture at time of application. Speed of travel should be no greater than 8 km/h, Best results are achieved at lower speeds and where two applications are made in opposite directions (double pass).

Where weeds are of variable height, or occur in dense infestations or clumps, some plants may not be contacted by the herbicide solution. In these cases repeat treatment may be necessary.

Mix only enough herbicide solution for immediate requirements. Do not store mixed solution for more than a few days. Flush out equipment with water after use.

RATE: Mix 1 litre Roundup Biactive with 2 litres clean water to prepare 33% solution.
Roundup Biactive may be used according to the above directions for suppression or control of many annual and perennial weeds.
See Weeds Controlled tables for specific use recommendations.

Controlled Droplet Application Equipment (CDA)
Use the following table as a guide for achieving the correct application rates using the Micron Herbi or similar equipment. See WEEDS CONTROLLED tables for specific rates and use recommendations. For hand held equipment a walking speed of approximately 1 m/sec (4 km/h) is recommended.

Rate of Roundup delivered at 1 m/sec	3 L/ha	6 L/ha	9 L/ha
Mixture (by volume) Roundup: water	1:3	1:1	2:1
Micron Herbi, nozzle	Blue	Blue	Yellow

DO NOT add oils to Roundup Biactive/water mixture, otherwise difficulty in application and reduced weed control may occur.

CAUTION: CDA equipment produces a fine spray pattern which is not easily visible. Ensure spray pattern or drift does not contact foliage or any other green tissue of desirable plants, since severe injury or destruction may result.

Aerial Equipment
Aerial equipment may be used to apply Roundup Biactive only in pasture or fallow situations prior to establishment of field crops, fodder crops, or new pasture, and for pre-harvest application to cotton and sorghum crops. DO NOT use in intensive horticultural cropping areas. Use recommended rates of Roundup Biactive specified in this label up to a maximum limit of 4 L/ha. For Micronair and boom equipment, apply in a minimum spray volume of at least 20 L/ha. Droplets with an average size (or VMD) of 250-350 micron dia. are recommended. Swath width should be 15-17 m. Thoroughly wash aircraft, especially landing gear, after each day of spraying to remove herbicide residues.

Application On Hilly Terrain
As spraying height may vary, to maximise target contact, increase water volume to 30-80 L/ha and increase droplet size to at least 300 micron VMD.

Application Under Summer Conditions
High temperatures and/or low relative humidity cause excessive evaporation of spray droplets which may reduce results. \When temperature reaches 25°C, increase water volume to at least 30 L/ha, and increase droplet size to at least 300 micron VMD. DO NOT apply Roundup Biactive by aircraft when temperature is above 30°C.

AVOID DRIFT
DO NOT use with spraying equipment or under meteorological conditions which could be expected to cause spray drift onto nearby susceptible plants, adjacent crops, crop lands or pastures. Equipment settings which produce fine droplets (150 microns or less), winds over 8 km/h, inversion conditions, still air and hot dry days all contribute to drift.

APPLICATION CHECKLIST
Do not treat weeds under poor growing or dormant conditions (such as occur in drought, waterlogging, disease, insect damage or following frosts) as reduced weed control may result. Reduced efficacy may also occur when treating weeds heavily covered with dust or silt.

Do not add additional surfactant, or mix with any other agricultural chemicals, herbicide oils, or other materials except as specifically directed on this label.

Roundup Biactive is absorbed by plant foliage and stems. Rainfall soon after application may wash the herbicide off the weeds, particularly if the weeds are not growing actively, under stress, or under conditions of low light intensity or darkness.

Delay treatment of plants wet with dew or rain, if water droplets run-off when plants are disturbed.

Do not disturb treated weeds by cultivation, sowing or grazing for one day after treatment of annual weeds and 7 days for perennial weeds, to ensure herbicide absorption.

A Withholding Period for grazing stock is not required. However, it is recommended that grazing of treated plants be delayed (as recommended above) to ensure herbicide absorption. Certain plants such as Soursob, St. John's Wort and Bracken, may be naturally toxic to stock. Where known toxic plants are present, grazing should be delayed until complete browning of treated plants has occurred.

Distributed by
Nufarm Australia Limited ACN 004 377 780
103-105 Pipe Road, Laverton North, VIC 3026
Tel: (03) 9282 1000 Fax: (03) 9282 1001

® Registered trademark of Monsanto Technology LLC, used under licence by Nufarm Australia Limited. Copyright Nufarm Australia Limited, May 2002 Ally and Glean are registered trademarks of El. Dupont de Nemours and Co. USA. Yield and Lorsban are registered trademarks of DowElanco. Stomp is a registered trademark of American Cyanamid Co. USA. Logran is a registered trademark of Ciba Geigy Ltd. Basle, SCH. Le-Mat is a registered trademarks of Bayer, Germany. Imidan is a registered trademark of Stauffer Chemical Co. USA. Perfekthion is a registered trademark of BASF. Sumithion is a registered trademark of Sumitomo Chemical Co. Japan. Harvade is a trademark of Uniroyal Co. Inc. Dropp is a registered trademark of AgrEvo. Micron is a registered trademark of Micron Sprayers Ltd, U.K.

ANNEX 107

Australia Roundup CT Label

CAUTION

KEEP OUT OF REACH OF CHILDREN
READ SAFETY DIRECTIONS BEFORE OPENING OR USING

Roundup® CT

Broadacre Herbicide by Monsanto

ACTIVE CONSTITUENT: 450 g/L GLYPHOSATE
(present as the isopropylamine salt)

GROUP M HERBICIDE

Water soluble herbicide for non-selective control of many annual and perennial weeds in conservation tillage situations.

IMPORTANT: READ THE ATTACHED BOOKLET BEFORE USING THIS PRODUCT

Contents:
5 Litres
10 Litres
20 Litres
55 Litres
110 Litres
115 Litres
200 Litres
400 Litres
500 Litres
1000 Litres
Bulk Litres

Distributed by:
Nufarm Australia Limited
ACN 004 377 780
103-105 Pipe Road
Laverton North, Victoria 3026
Tel: (03) 9282 1000
Fax: (03) 9282 1001

Nufarm

APVMA Approval No 31394/ *L/0506

Batch no.:
Date of manufacture:
Barcode

TANK MIXTURES/COMPATIBILITY
Roundup CT may be tank-mixed with the following herbicides, insecticides and additives. Read and follow all label directions, restraints, plant-back periods, withholding periods, regional use restrictions and safety directions for the tank mix products.

MIXING INSTRUCTIONS FOR ALL TANK MIXTURES
1. Fill the spray tank 1/3 to 1/2 full with clean water and start agitation.
2. Add Spraymate Liase where required.
3. Add recommended herbicide/insecticide/additive to the spray tank and mix thoroughly.
4. Add Roundup CT and the remaining water. Mix thoroughly.
5. Add surfactant, if required, near the end of the filling process to minimize foaming.
6. Always maintain adequate agitation during application and use the tank mix promptly.

TANK MIXTURES – HERBICIDES
Ally, Associate, Avadex Xtra, Nufarm Estercide 800, Express, Flame, Garlon 600, Glean, Hammer, Invader, Nufarm Kamba 500 (dicamba), Lusta, Logran 750WG, Logran B Power (ensure fully dispersed prior to addition of Roundup CT), Lontrel, Nufarm LV Estercide 600 (2,4-D ester), Nufarm LVE MCPA (MCPA LVE), MONZA®, Nugran, Flowable Nu-trazine, Nu-trazine 900 DF (DO NOT apply this tank mix for control of Barnyard grass or Liverseed grass), Rifle, Flowable Simazine, Nufarm Simazine 900 DF, Starane 200, Stomp, Striker, Surpass 300, and TriflurX (trifluralin). Other brands have not been tested.
*Spraymate Liase (Ammonium sulphate) may improve the performance of tank mixtures of Roundup CT and atrazine or simazine. See directions below.

STRIKER®
The addition of Striker at 75 mL/ha to recommended rates of Roundup CT prior to planting Wheat or Barley or prior to planting cotton will improve knockdown and increase the speed at which treated weeds develop visible symptoms of phytotoxicity.

TANK MIXTURES - INSECTICIDES
Roundup CT is compatible with the following insecticides: Imidan, Le-Mat, Lorsban 500, Pirate 300, Karate, Sumithion ULV, Talstar and emulsifiable concentrates of dimethoate and fenitrothion. Other insecticides have not been tested.

TANK MIXTURES - ADDITIVES
Spraymate® Liase (417 g/L Ammonium Sulphate liquid)
RATE: 2 L per 100 litres spray solution.
Spraymate Liase may be used as an adjuvant to alleviate the adverse effects of high levels of calcium, magnesium and bicarbonate ions in water. The addition of Spraymate Liase to Roundup CT, when used to control annual weeds, MAY improve the performance of Roundup CT under adverse environmental conditions such as cool cloudy weather. Spraymate Liase may also improve the performance of tank mixtures of Roundup CT and atrazine or simazine. Ammonium sulfate may be corrosive to metal parts of the sprayer. Thoroughly flush tanks, pumps and nozzles with water after use. Solubility and impurity profiles of other forms of ammonium sulphate can vary and may reduce the performance of Roundup CT or tank mixtures.

SURFACTANT ADDITION
Spraymate® LI 700® Surfactant
RATE: 250mL - 500 mL per 100L
The addition of Spraymate LI 700 surfactant MAY improve weed control. At rates of 300mL-500mL per 100L, Spraymate LI 700 may modify the droplet spectrum produced by CP and flat fan nozzles. This may reduce the proportion of FINE droplets produced by these nozzles.

Spraymate® Activator®
RATE: 70mL - 125 mL per 100L
General Purpose non-ionic surfactants may increase the production of FINE and VERY FINE droplets, which are prone to drift when used through certain nozzle types.

Wetter TX Surfactant
RATE: 200 mL /100L spray solution. Add when treating Annual Ryegrass, Silvergrass and Perennial grasses. Wetter TX is NOT a general purpose surfactant and should be used only where recommended.
DO NOT use spray oils, adjuvants or surfactants other than those recommended on this label.

APPLICATION
Roundup CT is a non-selective translocated herbicide. Direct spray contact, or even slight drift, may cause severe injury or destruction of any growing crop or other desirable plants including trees. Clean all equipment after use by thoroughly washing with water.

BOOM EQUIPMENT
Application of Roundup CT in spray volumes of 25-100 L/ha is recommended. Use nozzles that produce a MEDIUM or COARSE spray quality at the target (ASAE S572). Environmental conditions, including delta T and wind speed, and the size and density of the target weeds, should be taken into consideration when selecting nozzles. Boom height must be set to ensure double overlap of nozzle patterns at the top of the weed canopy.

AERIAL EQUIPMENT
Aerial equipment may be used to apply Roundup CT only in pasture or fallow situations prior to establishment of field crops, fodder crops, or new pasture, and for pre-harvest application to sorghum crops. DO NOT use in intensive horticultural cropping areas. Use recommended rates of Roundup CT specified in this label up to a maximum limit of 3.2L/ha.
For Micronair equipment, apply in a minimum spray volume of at least 20L/ha. Use nozzles that produce a MEDIUM to COARSE spray quality (ASAE S572) at the target are recommended. Swath width may need to be adjusted to take into account aircraft type, wind

conditions, target height and density. DO NOT apply Roundup CT by aircraft in temperatures above 30oC and increase spray output to at least 30L/ha if temperatures rise above 25oC. Avoid application when relative humidity falls below 35%. In multiple product tank mixes a minimum water volume of 50L/ha is recommended and local advice should be sought. Correct mixing order is important. Thoroughly wash aircraft, especially landing gear, after each day of spraying to remove herbicide residues.

Application on hilly terrain
Spraying height may vary. Increase water volume to 30-80 L/ha and use nozzles that produce a COARSE spray quality at the target (ASAE S572).

Application under hot conditions
High temperatures and/or low relative humidity cause excessive evaporation of spray droplets, which may reduce results. When temperature reaches 25°C, increase water volume to at least 30L/ha, and nozzles that produce a COARSE spray quality at the target (ASAE S572). DO NOT apply Roundup CT by aircraft when temperature is above 30°C.

PROTECTION OF CROP, NATIVE AND OTHER NON-TARGET PLANTS
Avoid contact with foliage, green stems or fruit of crops, desirable plants and trees, since severe injury or destruction may result.
DO NOT apply under weather conditions, or from spraying equipment, that may cause spray to drift onto nearby susceptible plants/crops, cropping lands or pastures.

PROTECTION OF WILDLIFE, FISH, CRUSTACEA AND ENVIRONMENT
Do NOT contaminate dams, rivers or streams with the product or used container. Do NOT apply to weeds growing in or over water. Do NOT spray across open bodies of water.

Distributed by
Nufarm Australia Limited
ACN 004 377 780
103-105 Pipe Road,
Laverton North, VIC, 3026
Tel: (03) 9282 1000
Fax: (03) 9282 1001

CONDITION OF SALE
Nufarm Australia Limited ("Nufarm ") shall not be liable for any loss, injury, damage or death whether consequential or otherwise whatsoever, or howsoever arising through negligence or otherwise in connection with the sale, supply, use or application of this product. The supply of this product is on the express conditions that the purchaser does not rely on Nufarm's skill or judgement in purchasing or using the same and every person dealing with this product does so at his own risk absolutely. No representative of Nufarm has any authority to alter these conditions.

® Roundup and MONZA are registered trademarks of Monsanto Technology LLC used under licence by Nufarm Australia Limited, Copyright Nufarm Australia Limited, April 2006.

Ally, Express and Glean are registered trademarks of El. Dupont de Nemours and Co. USA.. Lontrel, Garlon, Lorsban, Starane are registered trademarks of Dow Agrosciences LLC, USA. Flame, Stomp are registered trademarks of BASF. Karate is a registered trademark of Syngenta Ltd, UK. Logran is a registered trademark of Syngenta Participations AG. Dropp, Le-mat is a registered trademark of Bayer AG, Germany. Imidan is a registered trademark of Margarita Internacional Comercio. Sumithion is a registered trademark of Sumitomo Chemical Co. Japan. Hammer is a registered trademark of FMC (Chemicals) Pty Ltd. Talstar is a registered trademark of FMC Corporation, USA. Associate, Lusta, Invader, KAMBA, Nugran, Pirate, Rifle, Nufarm Surpass, TriflurX are registered trademarks of Nufarm Australia Limited. Avadex and Striker are registered trademarks of Nufarm Technologies USA Pty Ltd. Spraymate and LI 700 are registered trademarks of United Agri Products. Activator is a registered trademark of Loveland Industries Inc.

ANNEX 108

Australia Roundup PowerMAX Label

June 2005 Roundup PowerMAX™ - Front Label

CAUTION

KEEP OUT OF REACH OF CHILDREN
READ SAFETY INSTRUCTIONS BEFORE OPENING OR USING

Roundup PowerMAX™

Herbicide by Monsanto

ACTIVE CONSTITUENT : 540 g/L GLYPHOSATE
(present as the Potassium salt)

GROUP **M** HERBICIDE

Non selective herbicide for the control of many annual and perennial weeds

READ THE ATTACHED BOOKLET BEFORE USING THIS PRODUCT

N (Nufarm logo)

Distributed by
Nufarm Australia Limited ACN 004 377 780
103-105 Pipe Road, Laverton North, VIC 3026
Tel: (03) 9282 1000 Fax: (03) 9282 1001

Barcode

CONTENTS * L

APVMA Approval No. 55687/*L/0505

*** = 5, 10, 15, 20, 55, 110, 115, 200, 400, 450, 500, 1000**

Batch no. : **Date of manufacture :**

Air temperature and relative humidity
DO NOT apply ROUNDUP PowerMAX by aircraft at temperatures above 30ºC. Increase spray output to at least 30L/ha when temperatures rise above 25ºC. Avoid application when relative humidity falls below 35%.

AVOID DRIFT
DO NOT apply treatments with spraying equipment or under weather conditions which are likely to cause spray drift onto nearby susceptible crops, pastures or other sensitive plants. DO NOT apply treatments under very light (less than 4km/h) or inversion conditions or where wind speeds exceed 12km/h.

APPLICATION CHECK LIST

- Do not treat weeds under poor growing conditions due to moisture stress, waterlogging, severe frosting, insect damage etc. Reduced performance may also occur where weeds are covered with dust or silt.
- Do not add surfactants, adjuvants or other pesticides except as specifically directed on this label.
- Rain within 1 hour of application which causes run-off may require re-treatment. Rainfastness is reduced if weeds are not actively growing, under stress or conditions of low light intensity/darkness. The addition of Wetter TX may improve rainfastness on Winter annual weeds.
- A withholding period for grazing is not required. However, it is recommended that grazing of treated plants be delayed to ensure herbicide uptake. Certain plants such as Soursob, Variegated thistle, Sorghum and Johnson grass may be naturally toxic to stock when eaten in large quantities under certain conditions. Where plants are known to be toxic, grazing should be delayed until complete desiccation of treated plants has occurred.
- Apply treatments to weeds which have at least one true leaf (broadleaf weeds) or two leaves (grasses) to provide an adequate surface area for herbicide uptake.
- If heavy grazing has occurred, allow regrowth to 6-8 cm before spraying and use the higher rates recommended.

PROTECTION OF CROP, NATIVE AND OTHER NON-TARGET PLANTS

Avoid contact with foliage, green bark or stems, canes, laterals, suckers, fresh wounds, exposed non-woody roots, flowers or fruit of crops, desirable plants and trees, since severe injury or destruction may result.

DO NOT apply under weather conditions, or from spraying equipment, that may cause spray to drift onto nearby susceptible plants/crops, cropping lands or pastures.

PROTECTION OF WILDLIFE, FISH CRUSTACEA AND ENVIRONMENT

DO NOT contaminate dams, rivers or streams with the product or used container. DO NOT apply to weeds growing in or over water. DO NOT spray across open bodies of water.

N (Nufarm logo)

Distributed by
Nufarm Australia Limited ACN 004 377 780
103-105 Pipe Road, Laverton North, VIC 3026
Tel: (03) 9282 1000 Fax: (03) 9282 1001

®/ ™ Registered / trademark of Monsanto Technology LLC used under licence by Nufarm Australia Limited, Copyright Monsanto Australia Limited, August 2003. Ally, Express, Glean and Oust are registered trademarks of El. Dupont de Nemours and Co. USA. Eclipse, Flandor, Garlon, Lontrel, Lorsban, Starane, Surflan and Yield are registered trademarks of Dow AgroSciences LLC. Stomp and Flame are registered trademarks of BASF Agro B.V. Logran, Nugran and Solicam are registered trademarks of Syngenta Participations AG. Imidan is a registered trademark of Gowan Internacional Comercio E Servicos LDA. Perfekthion is a registered trademark of BASF Aktiengesellschaft. Sumithion is a registered trademark of Sumitomo Chemical Ltd. Karate is a registered trademark of Syngenta Ltd. Harvade is a trademark of Uniroyal Co. Inc. Dropp is a registered trademark of Aventis CropScience GmbH. Affinity is a registered trademark of FMC Corporation. Hammer is a registered trademark of FMC Chemicals Pty Ltd. Avadex and Striker are registered trademarks of Nufarm Technologies USA Pty Ltd. Associate, Estercide, Invader, Kamba, Nufarm Surpass, Pirate, and Rifle are registered trademarks of Nufarm Australia Limited.

ANNEX 109

Brazil Roundup Label

MONSANTO imagine™

Roundup

ROUNDUP WG
– TOXICOLOGICAL CLASSIFICATION IV
– SLIGHTLY TOXIC

ROUNDUP ORIGINAL AND ROUNDUP TRANSORB
– TOXICOLOGICAL CLASSIFICATION III
– MODERATELY TOXIC

- Do not allow minors to work in application.
[…]
- Do not wash packaging or equipment in lakes, springs, rivers or other bodies of water. […]

ANDEF

Roundup

Roundup : Roundup

Há 30 anos com você no campo. Isso é mais que tradição. É confiança.

O herbicida Roundup, que revolucionou a agricultura e se tornou ferramenta fundamental no dia-a-dia dos agricultores, está completando 30 anos. Com registro em 120 países, ele é o mais vendido no mundo para o controle de plantas daninhas em pré-plantio das lavouras e o maior parceiro do Plantio Direto.

O surgimento de Roundup se deu em 1970, com a síntese do glifosato, ingrediente ativo do herbicida. Em 1974 Roundup foi registrado pela primeira vez para uso na Malásia e no Reino Unido e dois anos depois nos Estados Unidos. O Brasil recebeu sua primeira amostra para testes em 1972 e em 1978 o produto, ainda importado, chegava ao País para ser comercializado. Ele passou a ser produzido no Brasil em 1984.

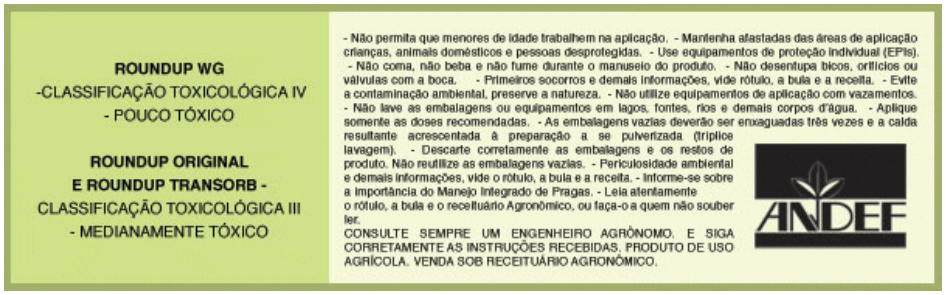
No Brasil a marca Roundup se transformou numa família de produtos. São eles Roundup Original, o produto pioneiro que passou a ser designado desta forma em 1999; Roundup WG, tecnologia granulada lançada em 1997; e Roundup Transorb, que com a sua inovadora tecnologia Transorb permite que o produto chegue mais rápido e em maior quantidade à raiz da planta daninha.

Os herbicidas da linha Roundup são largamente aceitos pelos agricultores por possuírem uma excelente eficácia agronômica, baixa toxicidade para o ser humano e reduzido impacto ambiental, em conformidade com avaliações feitas pelas autoridades de registro no Brasil, Ministério da Agricultura, Abastecimento e Pecuária (MAPA), Agência Nacional de Vigilância Sanitária (ANVISA) e Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA) e órgãos internacionais, como a Organização Mundial da Saúde (OMS), a Agência de Proteção Ambiental dos Estados Unidos (EPA) e pela comunidade científica internacional ao longo desses últimos 30 anos.

Nos Estados Unidos e em outros países, herbicidas à base de glifosato estão entre os poucos autorizados para uso em jardinagem, assim como ocorre na internacionalmente conhecida reserva ecológica de Galápagos e nas ruínas de Pompéia, na Itália.

http://www.monsanto.com.br/roundup/roundup/roundup.asprl

ANNEX 109



ROUNDUP WG
-CLASSIFICAÇÃO TOXICOLÓGICA IV
- POUCO TÓXICO

ROUNDUP ORIGINAL
E ROUNDUP TRANSORB -
CLASSIFICAÇÃO TOXICOLÓGICA III
- MEDIANAMENTE TÓXICO

- Não permita que menores de idade trabalhem na aplicação. - Mantenha afastadas das áreas de aplicação crianças, animais domésticos e pessoas desprotegidas. - Use equipamentos de proteção individual (EPIs). - Não coma, não beba e não fume durante o manuseio do produto. - Não desentupa bicos, orifícios ou válvulas com a boca. - Primeiros socorros e demais informações, vide rótulo, a bula e a receita. - Evite a contaminação ambiental, preserve a natureza. - Não utilize equipamentos de aplicação com vazamentos. - Não lave as embalagens ou equipamentos em lagos, fontes, rios e demais corpos d'água. - Aplique somente as doses recomendadas. - As embalagens vazias deverão ser enxaguadas três vezes e a calda resultante acrescentada à preparação a se pulverizada (tríplice lavagem). - Descarte corretamente as embalagens e os restos de produto. Não reutilize as embalagens vazias. - Periculosidade ambiental e demais informações, vide o rótulo, a bula e a receita. - Informe-se sobre a importância do Manejo Integrado de Pragas. - Leia atentamente o rótulo, a bula e o receituário Agronômico, ou faça-o a quem não souber ler.
CONSULTE SEMPRE UM ENGENHEIRO AGRÔNOMO. E SIGA CORRETAMENTE AS INSTRUÇÕES RECEBIDAS. PRODUTO DE USO AGRÍCOLA. VENDA SOB RECEITUÁRIO AGRONÔMICO.

ANDEF

Copyright © 2007 Monsanto Company | Legal Notice | Privacy Policy
Produtos para agricultura - sementes de soja, milho, algodão, hortaliças e sorgo. Biotecnologia para o campo e transgênicos.

http://www.monsanto.com.br/roundup/roundup/roundup.asprl

ANNEX 110

Canada Roundup Original Label

16-NOV-2007 2007-6202

GROUP	9	HERBICIDE

ROUNDUP ORIGINAL

Liquid Herbicide

AGRICULTURAL and INDUSTRIAL

CAUTION **IRRITANT**

WATER SOLUBLE HERBICIDE FOR NON-SELECTIVE WEED CONTROL

REGISTRATION NO. 13644 PEST CONTROL PRODUCTS ACT.

GUARANTEE: Glyphosate, 356 grams acid equivalent per litre present as isopropylamine salt.

READ THE LABEL BEFORE USING.

NET CONTENTS 10, 115, 450, 750 L, bulk

MONSANTO CANADA, INC.
900 – One Research Road
Winnipeg, Manitoba R3T 6E3

2006

3.5 STORAGE

Avoid contamination of seed, feed, and foodstuffs.
Soak up small amounts of spill with absorbent clays.

3.6 DISPOSAL

RECYCLABLE CONTAINERS:
Do not reuse this container for any purpose. This is a recyclable container, and is to be disposed of at a container collection site. Contact your local distributor/dealer or municipality for the location of the nearest collection site. Before taking the container to the collection site:
1) Triple- or pressure-rinse the empty container. Add the rinsings to the spray mixture in the tank.
2) Make the empty, rinsed container unsuitable for further use.
If there is no container collection site in your area, dispose of the container in accordance with provincial requirements.

RETURNABLE CONTAINERS:
Do not reuse container for any purpose. For disposal, this empty container may be returned to the point of purchase (distributor/dealer).

REFILLABLE CONTAINERS:
For disposal, this container may be returned to the point of purchase (distributor/dealer). It must be refilled by the distributor/dealer with the same product. Do not reuse this container for any other purpose.

For information on the disposal of unused, unwanted product, contact the manufacturer or the provincial regulatory agency. Contact the manufacturer and the provincial regulatory agency in case of a spill, and for clean-up of spills.

NOTICE

NOTICE TO USER: This pest control product is to be used only in accordance with the directions on the label. It is an offence under the *Pest Control Products Act* to use this product in a way that is inconsistent with the directions on the label. The user assumes the risk to persons or property that arises from any such use of this product.

DIRECTIONS FOR USE

4.0 GENERAL INFORMATION

Do not apply this product using aerial spray equipment except under conditions as specified within this label.

Observe buffer zones specified in Section 5.3

For tank mixtures, always follow the most restrictive label when applying.

Roundup Original Liquid Herbicide, a water soluble liquid, mixes readily with water for application as a foliage spray for the control or destruction of most herbaceous plants. It may be applied through most standard industrial or field type sprayers after dilution and thorough mixing with water in accordance with the booklet instructions.

This herbicide moves through the plant from the point of foliage contact to and into the root system. Visible effects on most annual weeds occur within 2 to 4 days but on most perennial weeds may not occur until 7 to 10 days. Extremely cool or cloudy weather at treatment time may slow down activity of this product and delay visual effects of control. Visible effects are a gradual wilting and yellowing of the plant which advances to complete browning of above ground growth and deterioration of underground plant parts.

Delay application until vegetation has emerged to the stages described for control of such vegetation under the annual and perennial weed control sections (7.0 and 8.0) of this booklet to provide adequate leaf surface to receive the spray. Unemerged plants arising from underground rhizomes or root stocks of perennials will not be affected by the spray and will continue to grow. For this reason best control of most perennial weeds is obtained when treatment is made at late growth stages approaching maturity.

Always use the higher rate of this product per hectare within the recommended range when weed growth is heavy or dense, or weeds are growing in an undisturbed (non-cultivated) area.

Do not treat weeds under poor growing conditions such as drought stress, disease or insect damage, as reduced weed control may result. Reduced results may also occur when treating weeds heavily covered with dust.

This product does not provide residual weed control. For subsequent residual weed control follow a label approved herbicide program. Read and carefully observe the cautionary statements and all other information appearing on the labels of all herbicides used.

Heavy rainfall immediately after application may wash the chemical off the foliage and a repeat treatment may be required. Do not apply if rainfall is forecast for the time of application.

Do not mix with any surfactant, pesticide, herbicide oils or any other material other than water unless specified in this booklet. For best results, spray coverage should be uniform and complete. Do not spray weed foliage to the point of runoff.

RESISTANCE-MANAGEMENT RECOMMENDATIONS

For resistance management, Roundup Original Liquid Herbicide is a Group 9 herbicide. Any weed population may contain or develop plants naturally resistant to Roundup Original Liquid Herbicide and other Group 9 herbicides. The resistant biotypes may dominate the weed

Clean sprayer and parts immediately after using this product by thoroughly flushing with water. Do not contaminate water sources by disposal of wastes or cleaning of equipment.

NOTE: Use of this product in any manner not consistent with this booklet may result in injury to persons, animals or crops, or other unintended consequences. Keep container closed to prevent spills and contamination.

5.2 MIXING AND APPLICATION EQUIPMENT INFORMATION

MIXING

For ground or industrial type sprayers, fill the spray tank with one-half the required amount of water. Add the proper amount of herbicide see "**Weed Control**" sections of this booklet (7, 8) and mix well before adding the remaining portion of water. Placing the filling hose below the surface of the liquid solution will prevent excessive foaming. Removing hose from tank immediately will avoid back siphoning into water source. Use of mechanical agitators may cause excessive foaming. Bypass lines should terminate at the bottom of the tank.

For use in knapsack sprayers, it is suggested that the proper amount of this herbicide be mixed with water in a larger container. Fill sprayer with the mixed solution.

APPLICATION EQUIPMENT

BOOM EQUIPMENT

For control of perennial weeds and woody brush and trees listed on this booklet using conventional boom equipment-- Apply this product in 50 to 300 litres of clean water per hectare as a broadcast spray using no more than 275 kPa pressure. See "**Weed Control**" sections of this booklet (7,8) for rates to control specific weeds.

For control of annual weeds listed on this booklet using conventional boom equipment--Apply this product in 50 to 100 litres of clean water per hectare as a broadcast spray, except as otherwise stated on this label using no more than 275 kPa pressure. See "**Weed Control**" sections of this booklet (7,8) for rates to control specific weeds.

HAND HELD AND HIGH VOLUME EQUIPMENT
(use coarse sprays only)

For control of weeds and woody brush and trees listed in the "Weed Controlled" section "6.0" of this label using knapsack sprayers or high volume spraying equipment utilizing handguns or other suitable nozzle arrangements--Unless otherwise specified, make a 1percent solution of this product in water (1 litre of this product in 100 litres of water) and apply to foliage of vegetation to be controlled. For best results, use a 2 percent solution (2 litres of this product in 100 litres of water) on harder to control perennials such as field bindweed, hemp dog-bane, milkweed and

Canada thistle.

Applications should be made on a spray-to-wet basis. Spray coverage should be uniform and complete. Do not spray to point of runoff. Hand gun applications should be properly directed to avoid spraying desirable plants.

SELECTIVE EQUIPMENT

Selective equipment such as **WIPER** and **ROLLER** applicators can be used for weed control in soy and dry beans, orchards, vineyards, cranberries, strawberries and non-crop areas. For information regarding use of this product with selective equipment, refer to **"Selective Equipment"** section of this label (9.12).

AERIAL EQUIPMENT

Aerial application can only be used for weed control in preharvest situations or industrial rights-of-way. Refer to sections 5.3, 9.9.2 and 10.2.2 for application information.

Directions for use
Apply only by fixed-wing or rotary aircraft equipment which has been functionally and operationally calibrated for the atmospheric conditions of the area and the application rates and conditions of this label. Ensure that the maximum boom width does not exceed 65% of the wing span. Nozzle type, size and orientation must be configured to deliver a droplet size VMD in the coarse (400-600 microns) or very coarse (600-1000) range.

Label rates, conditions and precautions are product specific. Read and understand the entire label before opening this product. Apply only at the rate recommended for aerial application on this label. Where no rate for aerial application appears for the specific use, this product cannot be applied by any type of aerial equipment.

Ensure uniform application. To avoid streaked, uneven or overlapped application, use appropriate marking devices, or equivalent electronic positioning systems (GPS). The use of a spotter plane is recommended.

Thoroughly wash aircraft, especially landing gear, after each day of spraying to remove residues of this product accumulated during spraying or from spills. **PROLONGED EXPOSURE OF THIS PRODUCT TO UNCOATED STEEL SURFACES MAY RESULT IN CORROSION AND POSSIBLE FAILURE OF THE PART. LANDING GEAR ARE MOST SUSCEPTIBLE.** The maintenance of an organic coating (paint) which meets aerospace specification MIL-C-38412 may prevent corrosion.

Use Precautions
Apply only when meteorological conditions at the treatment site allow for complete and even target crop coverage. Apply only under conditions of good practice specific to aerial application as outlined in the *National Aerial Pesticide Application Manual*, developed by the

Federal/Provincial/Territorial Committee on Pest Management and Pesticides.

Do not apply to any body of water. Avoid drifting of spray onto any body of water or other non-target areas. Specified buffer zones should be observed.

Do not angle nozzles forward into the airstream and do not increase spray volume by increasing nozzle pressure.

Operator Precautions
Do not allow the pilot to mix chemicals to be loaded onto the aircraft. Loading of premixed chemicals with a closed system is permitted.

It is desirable that the pilot have communication capabilities at each treatment site at the time of application.

The field crew and the mixer/loaders must wear chemical resistant gloves, coveralls and goggles or face shield during mixing/loading, cleanup and repair. Follow the more stringent label precautions in cases where the operator precautions exceed generic label recommendations on the existing ground boom label.

All personnel on the job site must wash hands and face thoroughly before eating and drinking. Protective clothing, aircraft cockpit and vehicle cabs must be decontaminated regularly.

Product Specific Precautions
Read and understand the entire label before opening this product. If you have questions, call the Monsanto Canada Custom Care Line at 1-800-667-4944 or obtain technical advice from the distributor or your provincial agricultural representative.

Application of this product must meet and/or conform to the following:

Volume: Apply the recommended rate in a minimum spray volume 30-100 litres per hectare.

5.3 BUFFER ZONES

i) **DO NOT** apply during periods of dead calm or when winds are gusty. **DO NOT** apply with spray droplets smaller than ASAE medium classification.

ii) Aerial Application: **DO NOT** apply when wind speed is greater than 16 km/h (preharvest) or 8 km/h (rights-of-way) at flying height at the site of application. **DO NOT** apply with spray droplets smaller than the ASAE coarse classification.

iii) Buffer Zones

The buffer zones specified in the table below are required between the point of direct application and the closest downwind edge of sensitive terrestrial habitats (such as

grasslands, forested areas, shelter belts, woodlots, hedgerows, pastures, rangelands and shrublands), and sensitive aquatic habitats (such as lakes, rivers, sloughs, ponds, coulees, prairie potholes, creeks, marshes, streams, reservoirs, and wetlands).

Method of Application	**Buffer Zones (metres) required for protection of:**		
	Aquatic Habitat		**Terrestrial Habitat**
Field sprayer*	15		15
Aerial (preharvest only)	25		55
Aerial** (rights-of-way only) Aircraft:	One Application Per Season	Two Applications Per Season (i.e. buffer zone below is for 2nd application)	-
Fixed Wing:	50	85	-
Helicopter:	20	35	-

*For field sprayers, buffer zones can be reduced by 70% when using shrouds or 30% when using cones.

When a tank mixture is used, consult the labels of the tank-mix partners and observe the largest (most restrictive) buffer zone of the products involved in the tank mixtures.

**Coarse ASAE (VMD=385.2 μm); Release height from aircraft <= 10 m.

6.0 WEEDS CONTROLLED

This product controls many annual and perennial grasses, broadleaf weeds, and woody brush and trees when applied as recommended and under conditions described. For information on how to control specific weeds including herbicide rate refer to the **"Annual Weed Control"** and **"Perennial Weed Control"** sections of this label (7.1, 8.1, respectively). The following is a partial list of weeds controlled:

6.1 ANNUAL WEEDS

Annual Grasses

Barnyard Grass
Echinochloa crusgalli
Blue Grass (annual)
Poa annua
Crab Grass (large)
Digitaria sanguinalis
Crab Grass (smooth)
Digitaria ischaemum
Downy Brome Grass

RESTRICTED USE

AERIAL PREHARVEST APPLICATION
PRAIRIE PROVINCES ONLY
(including PEACE RIVER REGION OF B.C.

NOTICE TO USER: This pest control product is to be used only in accordance with the directions on the label. It is an offence under the *Pest Control Products Act* to use this product in a way that is inconsistent with the directions on the label. The user assumes the risk to persons or property that arises from any such use of this product.

NATURE OF RESTRICTION: This product is to be used only in the manner authorized. For use only by aerial applicators and aerial application services approved by the provincial regulatory agency to apply this product with aerial application equipment. To qualify for consideration of provincial approval, the following requirements must be demonstrated to the provincial regulatory agency:

1. Aircraft used in the application of this product must have been configured and calibrated to acceptable standards at a recognized calibration (patternation) clinic within 20 months of the date of application. The spray system must not have been subjected to major changes (new nozzles, booms or configurations) since the calibration, and must meet critical drift management standards e.g. maximum boom width 65% of wing span; nozzle type, size and orientation to minimize drift and deliver droplet size VMD in the coarse (400 – 600 microns) or very coarse (600 – 1000 microns) range.
2. Aircraft used in the application of this product must carry a minimum of $25,000 drift insurance in addition to any provincial requirements for general comprehensive insurance coverage.
3. Applicators using this product must have successfully completed a ROUNDUP herbicide aerial application training course provided by Monsanto Canada Inc.
4. Aerial application services applying this product must employ on staff at least one pilot applicator with at least 250 hours of actual aerial application time and a minimum of 100 hours within the last 24 month period. All pilots who do not meet the minimum experience standard must work under the ***direct daily supervision*** of a qualified pilot.

DIRECTIONS FOR USE

Roundup Original Liquid Herbicide may be applied with aerial application equipment for control of quackgrass, Canada thistle, common milkweed, toadflax and dandelion, and season-long control of perennial sow thistle. Roundup Original Liquid Herbicide can be applied prior to harvest of wheat, barley (including malting barley), oats, canola (rapeseed), flax (including low linolenic acid varieties), lentils, peas, dry beans and

soybeans. **DO NOT apply to any crops if grown for seed production.**

This treatment may also provide harvest management benefits, by drying down crop and weed vegetative growth, for example, where late flushes of annual weeds, green vegetative crop growth, or late tillering may interfere with harvest operations.

EXTREMELY COOL, WET AND/OR CLOUDY WEATHER CONDITIONS BETWEEN THE TIME OF APPLICATION AND THE ANTICIPATED HARVEST DATE MAY SLOW DOWN ACTIVITY OF THIS PRODUCT, THEREBY DELAYING CROP DRYDOWN AND HARVEST DATE.

Roundup Original Liquid Herbicide should be applied at 2.5 L/ha in 20 – 50 L/ha of clean water with aerial application equipment. Apply only when the crop has 30% or less grain moisture content. This stage typically occurs 7 to 14 days before harvest. Consult the table "**Guidelines for Timing of Preharvest Applications**" (Section 9.9.1) for visual indicators of this stage in each crop. For the best weed control results quackgrass should be actively growing and have at least 4 to 5 green leaves. Canada thistle and perennial sow thistle should be actively growing and at or beyond the bud stage for best results. Common milkweed should be at the bud to bloom stage and actively growing for best results. Applications for weed control (not for harvest management) must be made at the correct stage of both weed and crop growth.

Apply only during the period 7 – 14 days before harvest to ensure best weed control and to maximize harvest management benefits. Earlier application may reduce crop yield and/or quality, and may lead to excess glyphosate residues in the crop.

9.10 TREE PLANTINGS

Shelterbelts and Nursery Stock (Woody Ornamentals)

This product may be used to control listed annual or perennial weeds prior to planting, or as a post directed spray in established nurseries or shelterbelts of the following species:

Deciduous	**Coniferous**
Ash - *Fraxinus spp.*	Fir - *Abies spp.*
Caragana - *Caragan spp.*	Juniper - *Junipus spp.*
Cherry - *Prunus spp.*	Pine - *Pinus spp.*
Elm - *Ulmus spp.*	Spruce - *Picea spp.*
Lilac - *Syringa spp.*	Yew - *Taxus spp.*
Maple - *Acer spp.*	
Mountain Ash - *Sorbus spp.*	
Poplar - *Populus spp.*	
Russian Olive - *Elaeagnus spp.*	

ANNEX 111

Canada Vision Silviculture Herbicide Label

GROUP	9	HERBICIDE

VISION SILVICULTURE HERBICIDE

COMMERCIAL

CAUTION **IRRITANT**

REGISTRATION NO. 19899 PEST CONTROL PRODUCTS ACT

GUARANTEE: Glyphosate 356 grams acid equivalent per litre, present as isopropylamine salt

Water soluble herbicide for silvicultural sites

READ THE LABEL BEFORE USING.

MONSANTO CANADA INC.
900 – One Research Road
Winnipeg, Manitoba R3T 6E3
(204) 985-1000
1-800-667-4944
2007

(FRANCAIS AU VERSO)

1.0 PRECAUTIONS

KEEP OUT OF REACH OF CHILDREN.
MAY CAUSE EYE IRRITATION.
HARMFUL IF SWALLOWED.
Avoid contact with eyes or prolonged contact with skin.

1.1 FIRST AID

IF IN EYES, IMMEDIATELY flush eyes with plenty of water for at least 15 minutes. Call a physician or contact a poison control centre **IMMEDIATELY**.
IF ON SKIN, IMMEDIATELY flush with plenty of water. Remove contaminated clothing. Wash clothing before re-use.
IF SWALLOWED, this product will cause gastro-intestinal irritation. **IMMEDIATELY** dilute by swallowing water or milk. Call a physician or contact a poison control centre **IMMEDIATELY**.

Take container, label or product name and Pest Control Registration number with you when seeking medical attention.

1.2 TOXICOLOGICAL INFORMATION

Treat symptomatically.

1.3 NOTICE

Read NOTICE before buying or using. If notice terms are not acceptable, return at once unopened.

Not for reformulation or repackaging

NOTICE TO USER: This pest control product is to be used only in accordance with the directions on the label. It is an offence under the *Pest Control Products Act* to use this product in a way that is inconsistent with the directions on the label. The user assumes the risk to persons or property that arises from any such use of this product.

1.4 PHYSICAL OR CHEMICAL HAZARDS

Spray solutions of this product should be mixed, stored and applied only in stainless steel, aluminum, fiberglass, plastic and plastic-lined steel containers.
DO NOT MIX, STORE OR APPLY THIS PRODUCT OR SPRAY SOLUTIONS OF THIS PRODUCT IN GALVANIZED STEEL OR UNLINED STEEL (EXCEPT STAINLESS STEEL) CONTAINERS OR SPRAY TANKS. This product or spray solutions of this product react with such containers and tanks to produce hydrogen gas which may form a highly combustible gas mixture. This gas mixture could flash or explode, causing serious personal injury, if ignited by open flame, spark, welder's torch, lighted cigarette or other ignition source.

1.5 STORAGE

Store product in original container only.
Avoid contamination of seed, feed and foodstuffs.

1.6 SPILLS

Soak up small amounts with absorbent clays.
Sweep or scoop up spilled materials and dispose of in an approved landfill.
Wash down surfaces (floors, truckbeds, streets, etc.) with detergent and water solution.

1.7 ENVIRONMENTAL HAZARDS

Avoid direct applications to any body of water.
Do not contaminate water by disposal of waste or cleaning of equipment.

1.8 DISPOSAL

RECYCLABLE CONTAINERS:
Do not reuse this container for any purpose. This is a recyclable container, and is to be disposed of at a container collection site. Contact your local distributor/dealer or municipality for the location of the nearest collection site. Before taking the container to the collection site:
1) Triple- or pressure-rinse the empty container. Add the rinsings to the spray mixture in the tank.
2) Make the empty, rinsed container unsuitable for further use.
If there is no container collection site in your area, dispose of the container in accordance with provincial requirements.

RETURNABLE CONTAINERS:
Do not reuse this container for any other purpose. For disposal, this empty container may be returned to the point of purchase (distributor/dealer).

REFILLABLE CONTAINERS:
For disposal, this container may be returned to the point of purchase (distributor/dealer). It must be refilled by the distributor/dealer with the same product. Do not reuse this container for any other purpose.

For information on the disposal of unused, unwanted product, contact the manufacturer or the provincial regulatory agency. Contact the manufacturer and the provincial regulatory agency in case of a spill, or for the clean-up of spills.

immediately will avoid back siphoning into to water source. Use of mechanical agitators may cause excessive foaming. By-pass lines should terminate at the bottom of the tank. For use in knapsack sprayers, it is suggested that the proper amount of this herbicide be mixed with water in a larger container. Fill sprayer with the mixed solution.

NOTE: REDUCED RESULTS MAY OCCUR IF WATER CONTAINING SOIL IS USED, SUCH AS WATER FROM PONDS AND UNLINED DITCHES.

3.2 APPLICATION INSTRUCTIONS

APPLY THESE SPRAY SOLUTIONS IN PROPERLY MAINTAINED AND CALIBRATED EQUIPMENT CAPABLE OF DELIVERING DESIRED VOLUMES.
HAND GUN APPLICATIONS SHOULD BE PROPERLY DIRECTED TO AVOID SPRAYING DESIRABLE PLANTS.

AVOID DRIFT--Drift may cause damage to any vegetation contacted for which treatment is not intended. Applications in wind conditions in excess of local and/or provincial aerial spray regulations are not recommended.

To prevent injury to adjacent vegetation, appropriate buffer zones must be maintained.

Do not apply directly to any body of water populated with fish or used for domestic purposes. Do not use in areas where adverse impact on domestic water or aquatic species is likely.

3.2.1 APPLICATION RATES

To control or suppress herbaceous weeds, woody brush and trees, apply 3 to 6 litres of this product per hectare using aerial, ground boom or boomless, or mist blower equipment, or apply as a 1 to 2 percent solution using hand-held high volume equipment. Use the 6 litres rate for control of maple, alder or willow species. For control of perennial herbaceous weeds in site preparation applications using aerial, ground boom or boomless, or mist blower equipment, apply 7 to 12 litres of this product per hectare as directed in the recommended volume of clean water to the foliage of actively growing vegetation.

For specific rates for wick or wiper applicators, see the "Selective Equipment" section of this label.

3.2.2 AERIAL EQUIPMENT

Apply only by fixed-wing or rotary aircraft equipment which has been functionally and operationally calibrated for the atmospheric conditions of the area and the application rates and conditions of this label. Label rates, conditions and precautions are product specific. Read and understand the entire label before opening this product. Apply only at the rate(s) recommended for aerial application on this label in 20 to 100 litres of water per hectare. For control of perennial weeds in site preparation applications using 7 to 12 litres per hectare of this product, use 50 to 100 litres of water per hectare. Where no rate for aerial application appears for the specific use, this

product cannot be applied by any type of aerial equipment. As density of vegetation increases, spray volume should be increased within the recommended range to ensure complete coverage.

Ensure uniform application. To avoid streaked, uneven or overlapped application, use appropriate marking devices, or equivalent electronic positioning systems (GPS).

Thoroughly wash aircraft, especially landing gear, after each day of spraying to remove residues of this product accumulated during spraying or from spills. **PROLONGED EXPOSURE OF THIS PRODUCT TO UNCOATED STEEL SURFACES MAY RESULT IN CORROSION AND POSSIBLE FAILURE OF THE PART. LANDING GEAR ARE MOST SUSCEPTIBLE.** The maintenance of an organic coating (paint) which meets aerospace specification MIL-C-38412 may prevent corrosion.

Use Precautions
Apply only when meteorological conditions at the treatment site allow for complete and even crop coverage. Apply only under conditions of good practice specific to aerial application as outlined in the *National Aerial Pesticide Application Manual*, developed by the Federal/Provincial/Territorial Committee on Pest Management and Pesticides.

Do not apply to any body of water. Avoid drifting of spray onto any body of water or other non-target areas. Specified buffer zones should be observed.

Coarse sprays are less likely to drift. Therefore, avoid combinations of pressure and nozzle type that will result in the production of fine particles (mist). Do not angle nozzles forward into the airstream and do not increase spray volume by increasing nozzle pressure. Do not spray during periods of dead calm or when wind velocity and direction pose a risk of spray drift. Do not spray when the wind is blowing towards a nearby sensitive crop, garden, terrestrial habitat (such as a shelter belt) or aquatic habitat.

Operator Precautions
Do not allow the pilot to mix chemicals to be loaded onto the aircraft. Loading of premixed chemicals with a closed system is permitted.

It is desirable that the pilot have communication capabilities at each treatment site at the time of application.

The field crew and mixer/loaders must wear chemical resistant gloves, coveralls and goggles or face shield during mixing/loading, cleanup and repair. Follow the more stringent label precautions in cases where the operator precautions exceed the generic label recommendations on the existing ground boom label.

All personnel on the job site must wash hands and face thoroughly before eating or drinking. Protective clothing, aircraft cockpit and vehicle cabs must be decontaminated regularly.

3.2.3 BOOM EQUIPMENT

For control of herbaceous weeds and woody brush and trees listed in the "Vegetation Controlled" section of this label using conventional boom equipment--Apply this product in 100 to 300 litres of clean water per hectare as a broadcast spray using no more pressure than 275 kPa.

3.2.4 BOOMLESS EQUIPMENT

For control of herbaceous weeds, woody brush and trees listed in the "Vegetation Controlled" section of this label using boomless equipment such as cluster nozzles--Apply this product in 100-350 litres of clean water per hectare as a broadcast spray using no more pressure than 275 kPa.

3.2.5 HAND HELD AND HIGH VOLUME EQUIPMENT (USE COARSE SPRAYS ONLY)

For control of herbaceous weeds, woody brush and trees listed in the "Vegetation Controlled" section of this label using knapsack sprayers or high volume spraying equipment utilizing handguns or other suitable nozzle arrangements.

Applications should be made on a spray-to-wet basis. Spray coverage should be uniform and complete. Do not spray to point of runoff.

3.2.6 MIST BLOWER EQUIPMENT

For control of herbaceous weeds, woody brush and trees listed in the "Vegetation Controlled" section of this label--Use the recommended rate of this product in at least 200 litres of water per hectare.

4.0 VEGETATION CONTROLLED

AVOID CONTACT WITH FOLIAGE, GREEN STEMS, OR FRUIT OF NON-TARGET CROPS, SINCE DAMAGE TO THESE PLANTS MAY RESULT.

A PARTIAL LIST OF PERENNIAL HERBACEOUS WEEDS, WOODY BRUSH AND TREE SPECIES CONTROLLED INCLUDES:

4.1 PERENNIAL GRASSES / SEDGES

Blue Grass (Canada)
Poa compressa
Blue Grass (Kentucky)
Poa pratensis
Foxtail Barley
Hordeum jubatum
Quackgrass
Agropyron repens

ANNEX 112

Cosmoagro, S.A., *Cosmo-Flux 411F*

A non-ionic stereospecific adjuvant composed of a non-phytotoxic paraffinic oil and stereospecific surfactant mixture

Guaranteed composition

Alcohol ethoxylate (linear alcohol) + aryl ethoxylate	17.00%
Liquid isoparaffin	83.00%
Total	100%

Contains 1000g of Active Ingredients per liter of commercial product

ACTION

It is a non-ionic stereospecific adjuvant that substantially modifies the biological activity of agrochemicals and permits emulsions and dispersions to remain stable for a longer period.

It improves the adherence and uniformity of the emulsified mixture, controlling evaporation and hydrolysis of the active ingredient by completely covering it, which guarantees a uniform concentration of the active ingredient per area unit. Adding the adjuvant **COSMO-FLUX 411F** to the application of insecticides, fungicides and herbicides prepared in mixtures of mineral or vegetable oil has been shown to have the ability to increase the efficiency of these products. Its effectiveness is four (4) times greater than conventional spraying oils due to synergism between the paraffinic oil and the stereospecific surfactant.

Its molecules are biodegradable in accordance with international standards of the Agencies (FDA) that regulate the use of pesticides in food and its release into the environment (EPA).

REASONS FOR USING COSMO-FLUX 411 F

- Better adherence, reduces being washed away by the rain.
- Reduces evaporation and being blown away by the wind (drift).
- Maintains the size of a microdrop with each active component
- Helps extend the biological activity spectrum of agrochemicals

PREPARATION OF THE MIXTURE

For liquid EC agrochemicals, add the amount of **COSMOFLUX 411F** [sic] per total volume of the mixture to the pre-mixture. Next, add the pre-mixture to the tank with the required amount of water for application and stir well to mix the components together. With powder agrochemicals, first mix them with water and then add the required dose of **COSMO-FLUX 411F** per total volume of the mixture to the tank, stir well.

Coadyuvante estereoespecífico de carácter no-iónico constituido por la combinación de aceite parafínico no-fitotóxico y tensoactivos estereoespecíficos.

Composición Garantizada

Alcoholes lineales etoxilados + aril etoxilado	17.00%
Isoparafinas Líquidas	83.00%
Total	100%

Contiene 1000 grs. de Ingredintes Activos por litro de producto comercial.

ACCION

Es un coadyuvante NO-IONICO estereoespecífico que modifica sustancialmente la actividad biológica de los agroquímicos, además permite que las emulsiones y dispersiones se mantengan estables por más tiempo.

Mejora la adherencia y uniformidad de la mezcla emulsionada, controlando la evaporización e hidrólisis del activo con cubrimiento total que garantiza una concentración homogénea del activo por unidad de área. La adición del coadyuvante **COSMO-FLUX 411F** en la aplicación de insecticidas, fungicidas y herbicidas formulado en mezclas de aceites minerales o vegetales, ha demostrado tener la propiedad de incrementar la eficiencia de estos productos.

Su efectividad es cuatro (4) veces mayor que los aceites de aspersión convencionales por el sinergismo entre el aceite parafinico y el tensoactivo estereoespecífico.

Sus moléculas son biodegradables cumpliendo con las normas internacionales de las Agencias (FDA) que regulan el uso de pesticidas en los alimentos y su liberación al medio ambiente (EPA).

RAZONES PARA USAR COSMO-FLUX 411F

- Mejor adherencia, reduciendo el lavado por lluvia.
- Reduce la evaporación y arrastre por viento (deriva).
- Conserva el tamaño de la microgota con cada componente activo.
- Ayuda a extender el espectro de actividad biológica de los agroquímicos.

PREPARACION DE LA MEZCLA :

A los agroquímicos líquidos EC, adicione en premezcla la cantidad de **COSMOFLUX 411F** por volumen total de mezcla. Seguidamente adicione la premezcla al tanque con el agua requerida para la aplicación y con buena agitación mezcle los componentes.

Con los agroquímicos en polvo, éstos se mezclan con agua primero, para luego adicionar la dosis de **COSMO-FLUX 411 F** requerida por volumen total de mezcla al tanque, sometiendo la preparación a una buena agitación.

VIDEOS
BOLETINES TECNICOS
SOLUCIONES COSMOAGRO
DIFERENTES CULTIVOS
MAS DETALLES
SINTOMAS DE DEFICIENCIA
TABLA DE FUNCION DE NUTRIENTES

ir atrás

ANNEX 113

Colombia Cosmo-Flux 411F Label

[P. 1]

LOT (illegible) NOV 2007 EXP. NOV 2009
IMPORTED BY TRIADA EMA S.A. ECUADOR BRANCH MAG 3199076

COSMOAGRO ®
Creative Technology with Ecological Sense

COSMO-FLUX® 411F

NON-IONIC ADJUVANT,
EMULSIFIABLE CONCENTRATE
FOR AGRICULTURAL USE
ICA Sales Registration No. 2186
For COSMOAGRO S.A.
GUARANTEED COMPOSITION

ACTIVE INGREDIENTS:	Grams per liter at 20° C
Alcohol ethoxylate (linear alcohol) + aryl ethoxylate	170.0 g/l
ADDITIVE INGREDIENTS:	
Liquid isoparaffins	83%
Total	100.00%

LOT No.:
FORMULATION DATE:
EXPIRATION DATE:

Net Content: 1 Liter

ANNEX 113

Manufactured by: TRIADA EMA S.A.
Ciudadela Internacional del Pacífico, B 15. Km. 6, Via Airport Yumbo,
Palmira
Tel.: +57 (2) 280 0660, Fax: +57 (2) 280 0670
Webpage: www.cosmoagro.com
MADE IN COLOMBIA
08-03-2007

TOXICOLOGICAL CATEGORY IV
SLIGHTLY TOXIC
“PRECAUTION”

[PAGE 2]

"READ LABEL BEFORE USING THIS PRODUCT"
KEEP OUT OF REACH OF CHILDREN

PRECAUTIONS AND WARNINGS FOR USE

COSMO-FLUX® 411F is the mixture of a non-phytotoxic paraffinic oil with advanced non-ionic tensoactives.

First Aid:
Immediately take off contaminated clothing, wash with plenty of water and soap, and follow these instructions:

Symptoms of poisoning	Follow instructions on the agrochemical label used in the mixture, since COSMO-FLUX® 411F is not a pesticide but an adjuvant.
Ingestion	Do not induce vomiting.
Skin contact	Wash with plenty of water and soap.
Inhalation	Symptomatic treatment
Eye contact	Rinse with plenty of clean water or with eye solution for 15 minutes.

INSTRUCTIONS FOR USE AND HANDLING:

COSMO-FLUX® 411F is a non-ionic adjuvant intended for use in mixtures with fungicide products used to control the black sigatoka (*Mycosphaerella Fijiensis var difformis*) on banana and plantain plants, also with insecticides for the control of the coffee borer beetle (*Hypothenemus Hampei, ferrari*), and with herbicides in the control of weeds according to the technical criteria of an Agricultural Engineer.

PREPARATION OF THE MIXTURE:

- For liquid agrochemicals, directly add the required amount of **COSMO-FLUX® 411F** per total volume of the mixture. Next, add to the mixing tank the required amount of water for the application and agitate well to mix the components together.
- With powder agrochemicals, first mix them with water and then add to the tank the required dose of **COSMO-FLUX® 411F** per total volume of the mixture, agitating the mixture well.
- **COSMO-FLUX® 411F** is soluble in mineral and vegetable oils, dispersible in water, forming a good emulsion.

Medical attention	Follow symptomatic treatment.

IN CASE OF POISOINING, IMMEDIATELY CALL A DOCTOR OR TAKE PATIENT TO THE DOCTOR AND SHOW HIM THIS LABEL

Measures for environmental protection:
Absorb any spill with lime, sawdust, sand or any other absorbent material. Then bury the contaminated material and the empty containers in an area where there is no risk of water contamination.

Product Storage and Handling:
The product must be stored in a safe, cool and dry place, far from food and medicines. It should be kept tightly closed and in its original packaging.

After using the contents, rinse this container three times and pour the water in the application mixture, and then destroy it.

WARNING: "No container used to hold pesticides should be used to hold food or drinking water".

DOSE:	Banana and Plantain (Black Sigatoka)	Coffee (Borer Beetle)	Herbicide
Product	Volume (%) of total mixture	L/Ha	L/Ha
COSMO-FLUX® 411F	0.9	0.75 – 1.0	0.5 – 1.0
Liquid isoparaffins	44		
Active Ingredient	(*)		
Water	Until volume is completed		

(*) Prescribed by an Agricultural Engineer

COMPATIBILITY:
COSMO-FLUX® 411F is compatible with most agrochemicals such as Propiconazole, Tridemorf, Mancozeb, Benomyl, Melathion, Fenthion, Pirimiphos, Fenitrothion, Clorpyriphos, Permethrin, among others. However, it is recommended that compatibility tests be done before use

GUARANTEE:
"The manufacturer guarantees that the physico-chemical characteristics of the product correspond to those listed on the label, and that through the official sales registration, it was verified that it is suitable for the purposes recommended herein in accordance with the specifications for use".

IMPORTANT: Verify the imprint, dotted letters in ink, of the lot number and expiration date, on the container.

Sales Registration	
Colombia ICA 2186	Venezuela MAC 1116
Bolivia MAG 208	Ecuador MAG 3199076

COSMOAGRO®
Creative Technology with Ecological Sense

LOTE [illegible] ELAB NOV.2007 VENC NOV.2009
IMP POR TRIADA EMA S.A SUC ECUADOR MAG 3199076
COSMOAGRO®
TECNOLOGIA CREATIVA CON SENTIDO ECOLOGICO
COSMO-FLUX® 411F
COADYUVANTE NO IONICO,
CONCENTRADO EMULSIONABLE
DE USO AGRICOLA
Registro de Venta ICA No. 2186
A nombre de COSMOAGRO S.A.
COMPOSICIÓN GARANTIZADA
INGREDIENTES ACTIVOS: gramos por litro a 20°C
Alcoholes Lineales Etoxilados + Aril Etoxilado 170.0 g/l
INGREDIENTES ADITIVOS:
Isoparafinas Liquidas 83%
Total 100.00%
LOTE No.:
FECHA DE FORMULACIÓN:
FECHA DE VENCIMIENTO:
Contenido Neto: 1 Litro
Fabricado por: TRIADA EMA S.A.
Ciudadela Internacional del Pacifico, B 15. Km. 6 Vía Yumbo Aeropuerto, Palmira
Tel.: +57 (2) 280 0660, Fax: +57 (2) 280 0670
Página Web: www.cosmoagro.com
INDUSTRIA COLOMBIANA
08-03-2007
CATEGORIA TOXICOLOGICA IV
LIGERAMENTE TOXICO
"PRECAUCION"

ANNEX 113

"LEA LA ETIQUETA ANTES DE USAR EL PRODUCTO"
MANTENGASE FUERA DEL ALCANCE DE LOS NIÑOS

PRECAUCIONES Y ADVERTENCIAS DE USO:

COSMO-FLUX ® 411F es una mezcla de un aceite mineral parafinico, no fitotóxico, con tensoactivos no iónicos de alta tecnología.

Primeros Auxilios:
Quitese la Ropa contaminada inmediatamente, bañese con abundante agua y jabón, siga las siguientes instrucciones:

Síntomas de Intoxicación	Observar lo indicado en la etiqueta del agroquímico a utilizar en la mezcla, ya que COSMO-FLUX®411F no es un plaguicida sino un coadyuvante.
Ingestión	No induzca vómito.
Contacto Con la piel	Lavar con abundante agua y jabón.
Inhalación	Tratamiento sintomático.
Contacto Con los ojos	Lavar con abundante agua limpia o con solución para lavado de ojos durante 15 minutos.
Tratamiento medico	Seguir tratamiento sintomático.

EN CASO DE INTOXICACIÓN, LLAME AL MEDICO INMEDIATAMENTE O LLEVE EL PACIENTE AL MÉDICO Y MUÉSTRELE ESTA ETIQUETA

Medidas para la protección del medio ambiente:
Absorba cualquier derrame con cal, aserrín, arena o cualquier otro material absorbente. Entierre después el material contaminado y los envases vacíos en un área donde no exista peligro de contaminación de aguas.

Almacenamiento y Manejo del Producto:
El producto se debe almacenar en un lugar seguro, fresco y seco, lejos de alimentos y drogas. Se debe mantener bien cerrado y en su empaque original.
Después de usar el contenido, enjuague tres veces este envase y vierta el agua en la mezcla de aplicación, luego destruyalo.

ADVERTENCIA: "Ningún envase que haya contenido plaguicidas deberá utilizarse para conservar alimentos o agua potable".

IMPORTANTE: Verifique la impresión en letra de puntos de tinta del numero del lote y de la fecha de vencimiento, en el envase.

INSTRUCCIONES DE USO Y MANEJO:

COSMO-FLUX®411F es un coadyuvante de característica no iónica para usar en mezcla con productos fungicidas usados en el control de la Sigatoka negra (Mycosphaerella Fijiensis var difformis) en banano y plátano, también con los insecticidas para el control de la broca del café (Hypothenemus Hampei, ferrari), y con los herbicidas en el control de malezas de acuerdo con el criterio técnico de un ingeniero agrónomo.

PREPARACIÓN DE MEZCLA:
- Con agroquímicos líquidos, adicionar directamente la cantidad de **COSMO-FLUX ® 411F** requerida por el volumen total de mezcla. Seguidamente adicione al tanque de mezcla la cantidad de agua requerida para la aplicación y con buena agitación, mezcle los componentes.
- Con los agroquimicos en polvo, primero mezclar con agua y luego adicionar la dosis de **COSMO- FLUX ®411F** requerida por el volumen total de mezcla al tanque, sometiendo la preparación a una buena agitación.
- **COSMO- FLUX ®411F** es soluble en aceites minerales y vegetales, dispersable en agua, formando una buena emulsión.

DOSIS:	Banano y Platano (Sigatoka Negra)	Café (Broca)	Herbicida
Producto	Volumen (%) de mezcla total	L/Ha	L/Ha
COSMO-FLUX®411F	0.9	0.75 - 1.0	0.5 - 1.0
Isoparafinas Liquidas	44		
Ingrediente activo	(*)		
Agua	Hasta completar volumen		

(*) Prescrito por un Ingeniero Agrónomo

COMPATIBILIDAD:
COSMO-FLUX ®411F es compatible con la mayoria de agroquimicos como Propiconazol, Tridemorf, Mancozeb, Benomil, Melathion, Fenthion, Pirimifos, Fenitrothion, Clorpiriphos, Permetrina, entre otros, sin embargo se recomienda antes de su utilización efectuar pruebas de compatibilidad.

GARANTÍA:
"El fabricante garantiza que las características físico-químicas del producto corresponden a las anotadas en la etiqueta y que mediante registro oficial de venta se verifico que es apto para los fines aquí recomendados de acuerdo con las indicaciones de empleo".

Registros de Venta	
Colombia ICA 2186	Venezuela MAC 1116
Bolivia MAG 208	Ecuador MAG 3199076

COSMOAGRO®
TECNOLOGIA CREATIVA CON SENTIDO ECOLOGICO

E00602

ANNEX 114

Cosmo-Flux 411F Safety Data Sheet

[PAGE 1]

Quality System	[logo] COSMOAGRO	14-May-2003
	Safety Data Sheet	
	Commercial Name **COSMO-FLUX® 411F**	

1. Chemical Product and Company Identification

Commercial Name: COSMO-FLUX 411F
Formulation Code: 07102

Company Identification

Producer	Triada EMA S.A. Palmira, Valle del Cauca, Colombia Zona Franca del pacífico, Bodega 15B	Tel.: +(092)272 3232 Fax: +(092)271 9977
Distributor	Cosmoagro S.A. Palmira, Valle del Cauca, Colombia Calle 42 #30-39	Tel.: +(092)271 4995 Fax: +(092)271 9576

2. Composition: Information about the Ingredients

Chemical Characteristics

Type of formulation	Mixture of mineral oil and non-ionic surfactants with coupling agents
Use	Non-ionic adjuvant for agricultural Use

Active Ingredient(s)	Linear alcohol ethoxylate Aryl ethoxylate
Additive Ingredient(s)	Liquid isoparaffins

The active ingredients comply with EPA regulations and are exempt from tolerance under 40 CFR 180.1001 (c), (e)

3. Hazard Identifications

Health Risks
Slight

Environmental risk in case of accident (spills/leaks)
Harmful to aquatic organisms, fish and algae

4. First-Aid Measures

In any event, please consult a Doctor!

Eye contact: Wash with clean, purified water until irritation disappears or use an eye solution. If irritation persists, seek medical attention.

[PAGE 2]

Skin Contact: Wash with plenty of water; use soap if available. Remove heavily contaminated clothing, including shoes, and wash well before using.

Inhalation: Using appropriate breathing apparatus, remove the person from the site into fresh air and call a doctor.

Ingestion: Do not induce vomiting, keep the person at rest. Get immediate medical attention.

5. Measures for extinguishing Fires

Flash Point: Above 149°C
Self-ignition temperature: approximately 420°F / 120°C

Means of extinguishing
Appropriate Means of extinguishing: Water spray, dry chemical, CO_2 foam

Fire-fighting
Special hazards during fire-fighting: Combustion products are toxic and irritating.

Protective equipment for Fire-fighting
In a fire, use a self-contained breathing apparatus

PRODUCT NOT CLASSIFIED AS FLAMMABLE, ITS DECOMPOSITION PRODUCTS UNDER FIRE CONDITIONS ARE CO AND CO_2

6. Accidental Release Measures	
Personal Precautions	For personal protection see section 8
Methods for Cleaning up	Absorb with sand, earth or with a similar absorbent

7. Handling and Storage

Electrostatic Accumulation Hazard: Yes, there is danger of it, use proper procedure for ground connection
Storage Temperature, °F / °C: Room temperature
Loading / Unloading Temperature, °F / °C: Room temperature
Storage / Transportation, mmHg: Atmospheric

Handling Information

Safety Category according to I.S.G (International Shipping of Goods):	Not Applicable
Personal Precaution Measures:	Use breathing apparatus, gloves, eye protection
Technical Precautions:	Those recommended for agrochemical use
Spills:	Absorb with sand, earth or with a similar absorbent

Quality System	COSMOAGRO **Safety Data Sheet** **Commercial Name** **COSMO-FLUX® 411F**	14-May-2003

8. Exposure controls, personal protection

Personal Protection
Hand Protection:
Disposable gloves

Eye Protection:
Safety goggles

9. Physico-Chemical Properties

Appearance at 25° C	Liquid
Color	Yellowish
Flash Point	149° C
Specific weight at 20° C	0.84 g/ml
Solubility in water at 25° C	Dispersible, forming a quick emulsion
Solubility	
Mineral oils	Soluble
Vegetable oils	Soluble
Organic solvents (used in agrochemical formulations)	soluble
Viscosity at 25° C	35 cP
Superficial tension	25 – 28 Din/cm
pH	6.0 – 8.0

10. Stability and Reactivity

Homogeneity
Excellent.

Persistence
Over 24 hours.

Compatibility with Active Ingredients
Compatible.

Speed of Mixture
Fast.

Adherence
Excellent.

Quality System	[logo] COSMOAGRO	14-May-2003
	Safety Data Sheet	
	Commercial Name **COSMO-FLUX® 411F**	

11. Toxicological information

Ministry of Health (Republic of Colombia) Classification
TOXICOLOGICAL CATEGORY IV
SLIGHTLY TOXIC (Green band)

Classification as a Poison
Not classified

Eye irritation in rabbits (according to the application of Kay D. Calandra)
Slight irritation after being applied for 24 hours without diluting.

Human Skin Sensitization
Low degree of toxicity, frequent or prolonged contact may cause irritation and produce dermatitis. Control measures are to be observed for the handling of this type of product.

12. Ecological information

Ecotoxicity
Toxic for fish, algae and daphnia. If proper handling conditions are maintained, there should not be any ecological problems.

13. Product Disposal Considerations
Exposure to liquid, vapors, mists or smoke should be minimized. Do not store or mix with strong oxidizing agents such as liquid chlorine or concentrated oxygen.
In the event of a spill, pay attention to measures specified in section 6.
Product Disposal: Place product in airtight and properly labeled bags.

14. Transport information

Special conditions for transport

Use resistant and properly labeled containers.

15. Regulatory information

Classification	Does not require classification
Risk Phrases	(R36/37) Wear suitable protective clothing and gloves (R61) Follow special instructions / safety data sheets (R52) Harmful to aquatic organisms (S2) Keep out of the reach of children (D01) Wash immediately substances from skin and eyes

16. Other information:

The information in this safety data sheet is provided in good faith and represents what is known about the product at the time of publishing. Recommendations for its use and application are based on trials

[PAGE 5]

conducted by COSMOAGRO, but its use and application in each specific case must be evaluated to determine the appropriateness of its use.

COSMOAGRO guarantees that the physico-chemical characteristics of the product correspond to those listed on the label, and that through opinion on efficacy No. 2186 of 19 April 1993, issued by ICA (Colombian Agricultural Institute), it was verified that it is suitable for the purposes recommended therein, in accordance with the specifications for use, but assumes no responsibility for how it may be used, since its handling is beyond its control.

This product must be used with the recommendation of an Agricultural Engineer or a Technical Assistant.

COSMOAGRO and COSMO-FLUX 411F are registered trademarks of COSMOAGRO.

Sistema de Calidad	COSMOAGRO®	14-mayo-2003
	Hoja de información de Seguridad	
	Nombre Comercial **COSMO-FLUX® 411F**	

1. Identificación del producto Químico y de la Compañía

Nombre Comercial: COSMO-FLUX 411F
Código de Formulación: 07102

Identificación de la Compañía

Compañía productora	Triada EMA S.A. Palmira, Valle del cauca, Colombia Zona Franca del pacífico. Bodega 15B	Tel + (092)2723232 Fax + (092) 2719977
Compañía Comercializadora	Cosmoagro S.A. Palmira, Valle del Cauca, Colombia Calle 42 # 30-39	Tel + (092)2714995 Fax + (092)2719576

2. Composición: Información sobre los Ingredientes

Característica Química

Tipo de formulación	Mezcla de aceite mineral y surfactantes No-Iónicos con agentes de acoplamiento.
Uso	Coadyuvante No-Ionico de Uso agrícola.
Ingrediente Activo(s)	Alcoholes Lineales Etoxilados Aril Etoxilados
Ingrediente Aditivo (s)	Isoparafinas liquidas

Los ingredientes activos cumplen con normas de regulación EPA y son exentos de las tolerancias 40 CFR 180.1001 (c), (e).

3. Identificación de peligros

Peligros para la salud
Ligeros

Peligros para el ambiente en caso de accidente (derrame / escape)
Perjudicial para organismos acuáticos, peces y algas.

4. Medidas de Primeros Auxilios

¡En cualquier caso consulte a un Medico!

Contacto con los ojos: Lave con agua limpia y potable hasta que desaparezca la irritación o utilice una solución lavadora de ojos. Si la irritación persiste, acuda al médico.

ANNEX 114

Sistema de Calidad	COSMOAGRO®	14-mayo-2003
	Hoja de información de Seguridad	
	Nombre Comercial **COSMO-FLUX® 411F**	

Contacto con la Piel: lavar con abundante agua; usar jabón si dispone de él. Despojarse de ropas fuertemente contaminadas, incluyendo zapatos, y lavar bien antes de usar.

Inhalación: Usando protección respiratoria adecuada, retire a la persona del sitio para que respire aire fresco y llame al médico.

Ingestión: No induzca vómito, mantener a la persona en reposo. Requerir ayuda médica inmediatamente.

5. Medidas para extinción de Incendios

Flash Point: Mayor de 149°C
Temperatura de Autoignición: 420 °F / 210 °C Aproximado.

Medios de Extinción
Medios Apropiados de Extinción: Niebla de Agua, Químico seco, Espuma de CO_2.

Extinción de Incendios
Peligros especiales durante la extinción de Incendios: Los productos de combustión son tóxicos e irritantes.

Equipo protector para la extinción de Incendios
En un incendio debe usarse equipo con respiración autónoma.

PRODUCTO NO CALSIFICADO COMO INFLAMABLE, SUS PRODUCTOS DE DESCOMPOSICIÓN BAJO CONDICIONES DE FUEGO SON CO Y CO_2

6. Medidas para escape accidental

Precauciones personales Para protección personal ver sección 8

Métodos de limpieza Absorber con arena, tierra, o un absorbente similar.

7. Manejo y Almacenamiento

Peligro de Acumulación Electrostática: Si, existe peligro, use el procedimiento adecuado para conectar a tierra.
Temperatura de almacenamiento, °F / °C: Ambiente
Temperatura de Carga / Descarga, °F / °C: Ambiente
Temperatura de almacenamiento/ Transporte, mmHg: Atmosférico

Información sobre el manejo

Categoría de seguridad de acuerdo a la I.S.G: No Aplicable
(International Shipping of Goods)

Medidas de precaución personal:	Use respiradores, guantes, protección en ojos
Precauciones Técnicas:	Las recomendadas para el uso de agroquímicos
Derrames:	Absorber con arena, tierra, o con un absorbente similar.

Sistema de Calidad	COSMOAGRO®	14-mayo-2003
	Hoja de información de Seguridad	
	Nombre Comercial **COSMO-FLUX® 411F**	

8. Controles de exposición, protección personal

Protección personal
Protección para las manos:
Guantes desechables.

Protección para ojos:
Gafas

9. Propiedades Físico- Químicas

Apariencia a 25°C	Líquido
Color	Amarillento
Punto de llama (Flash Point)	149°C
Peso específico a 20°C	0.84 g/ml.
Solubilidad en agua a 25°C	Dispersable, formando una rápida emulsión.
Solubilidad	
Aceites minerales	Soluble
Aceites vegetales	Soluble
Solventes orgánicos. (Usados en La formulación de agroquímicos)	soluble
Viscosidad a 25 °C	35 cP
Tensión Superficial	25 – 28 Din/cm
pH	6.0 – 8.0

10. Estabilidad y Reactividad

Homogeneidad
Excelente.

Persistencia
Mayor de 24 Horas.

Compatibilidad con Ingredientes activos
Compatible.

Velocidad de Mezcla
Rápida.

Adherencia
Excelente.

ANNEX 114

Sistema de Calidad	COSMOAGRO®	14-mayo-2003
	Hoja de información de Seguridad	
	Nombre Comercial **COSMO-FLUX® 411F**	

11. Información Toxicológica

Clasificación Ministerio de Salud. (República de Colombia)
CATEGORÍA TOXICOLOGICA IV
LIGERAMENTE TOXICO. (Franja Verde)

Clasificación como veneno
No clasificado

Irritación en ojos de conejo (de acuerdo a la aplicación de Kay D. Calandra)
Leve Irritación después de aplicado por 24 Horas sin diluir.

Sensibilidad en piel humana
Bajo grado de toxicidad, el contacto frecuente o prolongado puede causar irritación y producir dermatitis. Se debe conservar las medidas de control para el manejo de este tipo de productos.

12. Información Ecológica

Ecotoxicidad
Tóxico para peces, algas y dafnias. Manteniendo las condiciones adecuadas de manejo, no deben esperarse problemas ecológicos.

13. Consideraciones sobre la disposición del Producto
Se debe minimizar las exposiciones a líquidos, vapores, nieblas o humos. No almacene o mezcle con oxidantes fuertes como cloro líquido u oxígeno concentrado.
En caso de derrame, prestar atención a las medidas especificadas en el punto 6.
Eliminación del Producto. Recoger el producto en bolsas herméticas y debidamente marcadas.

14. Información sobre transporte
Condiciones especiales para transporte
Utilizar recipientes resistentes y marcados debidamente.

15. Información reglamentaria

Clasificación	No requiere clasificación
Frases de Riesgo	(R36/37) Utilice ropa de protección adecuada y guantes
	(R61) Observe las instrucciones especiales/ hojas de información de seguridad.
	(R52) perjudicial para organismos acuáticos
	(S2) Mantenga fuera del alcance de los niños
	(D01) Lavar inmediatamente las sustancias de la piel y de los ojos.

16. información Adicional:
La información suministrada en esta hoja de seguridad es de buena fe y obedece a los conocimientos que se tienen del producto al momento de la edición. Las recomendaciones sobre el uso y aplicación son basadas en

Sistema de Calidad	COSMOAGRO®	14-mayo-2003
	Hoja de información de Seguridad	
	Nombre Comercial **COSMO-FLUX® 411F**	

experiencias realizadas por COSMOAGRO, pero el uso y aplicación en cada caso especifico debe ser evaluado para determinar la conveniencia de su uso.

COSMOAGRO garantiza que las características físico químicas del producto corresponden a las anotadas en la etiqueta y que mediante concepto de eficacia Nº 2186 del 19 de Abril de 1993 emitido por el ICA (Instituto Colombiano Agropecuario) se verifico que es apto para los fines recomendados, de acuerdo con las indicaciones de empleo, pero no asume responsabilidad por el uso que de el se haga, porque su manejo está fuera de su control.

Este producto debe emplearse con la recomendación de un Ingeniero Agrónomo o Asistente Técnico.
COSMOAGRO y COSMO-FLUX 411F son marcas registradas de COSMOAGRO.

ANNEX 115

Colombia Roundup SL Label

NET CONTENTS: Approx. 1 Litre
NET WEIGHT: Approx. 1.24 kg
LOT No.: 0804002
DATE OF FORMULATION: APRIL 2008
EXPIRY DATE: 5 years after the formulation date
MAXIMUM SALE PRICE:
LABEL APPROVAL DATE: 24 July 2001

Formulated by:
C.A.C Ltd. and S.C.A. Co.
Calle 100 No. 7-33
Torre A piso19
A.A.: 56014 –
Telephone: 650 0650
Bogota, D.C.,
Colombia

SALE REGISTRATION ICA No. 0756

MONSANTO

- **SYSTEMIC HERBICIDE**
- **NON-SELECTIVE**
- **CONCENTRATED, WATER SOLUBLE**
- **AGRICULTURAL USE**

GUARANTEED COMPOSITION:
Active Ingredient
Isopropylamine Salt of N-phosphonomethyl glycine: 480 grams per liter of formulation at 20°C (equivalent to 360 grams per liter of acid glyphosate)
Additive Ingredients
Surfactant and water to complete the litre.

ANNEX 115

PRECAUTIONS AND USAGE WARNINGS
KEEP OUT OF REACH OF CHILDREN.

Do not store or transport with seeds and food for human or animal consumption. Do not store in living areas. Keep locked in a dry and ventilated place in the original packaging. Use glasses, gloves, rubber boots and protective clothing during use and application. Do not smoke, eat or drink while preparing or applying this product. Rinse empty containers three times and empty them into the spray tank. Puncture and destroy the containers. **No container which has held pesticides should be used to store food or drinking water.** Apply under calm wind conditions. Avoid contact with eyes and skin. Causes irritation. Upon completion of work, change clothes and wash with plenty of soap and water. Do not contaminate water sources. Do not apply to or pour surplus product directly over water bodies. During application, avoid allowing the product to fall on leaves or green parts of the stems of crops. Suspend the application if rain is imminent.

FIRST AID:

- In the event of contact with eyes, wash them immediately with plenty of water for 15 minutes.
- If it falls on the skin, wash with plenty soap and water.
- If ingested, drink water to dilute it. **Call a doctor immediately or bring the patient to a doctor and show them a copy of this label.**

ANTIDOTE:

There is no specific antidote. Apply a gastric wash, avoiding pulmonary aspiration and administer symptomatic treatment. Possible damage to mucus membranes.

TOXICOLOGICAL
CATEGORY IV
SLIGHTLY TOXIC
CAUTION

RECOMMENDATIONS FOR AERIAL APPLICATION

- Volume / ha: 50-75 L/ha
- Size of droplets: 250-400 microns
- Number of drops: For a systemic product such as Roundup, a few large drops are preferable, roughly 20 per cm^2 (square centimeter)
- Nozzles and micronairs should not exceed 75% of the wingspan to avoid displacement of droplets by the wing vortex.
- Equipment pressure: With Roundup, pressures of 20 and 30 psi should be used.
- Environmental conditions
  Outside temperature: No greater than 29° Centigrade.
  Relative humidity: >60%
  Windspeed: <7 Km/hour. – 1.94 m/s
  Apply after ensuring that there are no thermal inversions (temperature differences between the ground and the air).
- Flight altitude: 2 m. above the crop.
- Higher altitudes increase the risk of drift, and increase the evaporation of the mixture applied.
- Width of pass: Depends on the aircraft and the equipment used (between 14 and 18 m)
- Nozzles: D-12 diffuser 45 or 56 at an angle of 135° toward the back or fan nozzles: 6504 – 8004 – 1104 (Spraying system)

COMPATIBILITY

Do not mix **ROUNDUP SL** with contact herbicides. The tank mixtures of residual herbicides formulated as soluble powders or concentrated suspensions can reduce the efficacy on perennial weeds.

RESPONSIBILITY INFORMATION

*The manufacturer guarantees the that physio-chemical properties of the product correspond to what is listed, as noted on this label and that through the Official Sales Registry it has been verified to be suitable for the purposes recommended here, according to the indications for use.

Roundup SL ®

CONTENIDO NETO: 1 litro aprox.
PESO BRUTO: 1.24 Kg. Aprox.
LOTE No.: 0804002
FECHA DE FORMULACIÓN: ABRIL-2008
FECHA DE VENCIMIENTO: 5 años después de la fecha de formulación
PRECIO MÁXIMO AL PUBLICO:
FECHA APROBACION ROTULADO: 24 Julio 2001

Formulado por:
C.A.C. Ltda y Cia. S.C.A.
Calle 100 No. 7-33 Torre A piso 19
A.A.: 56014 - Teléfono: 650 0650
Bogotá, D.C., Colombia

REGISTRO DE VENTA ICA No. 0756

MONSANTO

•HERBICIDA SISTÉMICO •NO SELECTIVO
•CONCENTRADO SOLUBLE EN AGUA
•USO AGRÍCOLA

COMPOSICIÓN GARANTIZADA:
Ingrediente Activo
Sal isopropilamina de N-fosfonometil glicina: 480 gramos por litro de formulación a 20°C (equivalente a 360 gramos por litro de ácido glifosato)
Ingredientes aditivos:
Surfactante y agua hasta completar un litro.

PRECAUCIONES Y ADVERTENCIAS DE USO:
MANTÉNGASE FUERA DEL ALCANCE DE LOS NIÑOS.
No almacene ni transporte con semillas y alimentos de consumo humano o animal. No almacene en casa de habitación. Guárdelo bajo llave en un lugar seco y ventilado en su envase original. Use gafas, guantes, botas de caucho y ropa protectora durante el manipuleo y la aplicación. No fume, coma o beba mientras realiza la preparación y aplicación de este producto. Enjuague tres veces los envases vacíos y vierta su contenido en el tanque de aspersión. Perfore y destruya los envases. **Ningún envase que haya contenido plaguicidas deberá usarse para conservar alimentos o agua potable.** Aplique con viento en calma. Evite el contacto con los ojos y la piel. Causa irritación. Al terminar, cámbiese de ropa y báñese con abundante agua y jabón. No contamine las fuentes de agua. No aplique ni vierta sobrantes de este producto directamente sobre los cuerpos de agua. Durante la aplicación, evite que el producto caiga sobre las hojas o partes verdes del tallo de los cultivos. Suspenda la aplicación si la lluvia es inminente.

PRIMEROS AUXILIOS:
•En caso de contacto con los ojos, lávelos inmediatamente con abundante agua durante 15 minutos.
•Si cae sobre la piel, báñese con abundante agua y jabón.
•Si es ingerido, beba agua para diluirlo. **Llame al médico inmediatamente o lleve al paciente al médico muéstrele una copia de esta etiqueta.**

ANTÍDOTO:
No tiene antídoto especifico. Aplicar lavado gástrico evitando broncoaspiración y suministrar tratamiento sintomático. Posible daño a las mucosas

CATEGORIA TOXICOLOGICA IV
LIGERAMENTE TOXICO
PRECAUCION

ANNEX 115

LEA BIEN ESTA ETIQUETA ANTES DE USAR EL PRODUCTO

En caso de emergencia toxicológica llame en Bogotá al Servicio de Respuesta Inmediata de ATMI (24 horas), a los teléfonos (1) 643 4690 o al 01 8000 916818 o de 8 a.m. a 5 p.m. a C.A.C. Ltda y Cia. S.C.A. al teléfono 650 0650

ANTES DE USAR EL PRODUCTO CONSULTE CON UN INGENIERO AGRÓNOMO

INFORMACIÓN GENERAL

ROUNDUP SL en un herbicida no selectivo, de aplicación post-emergente y acción sistémica, recomendado para el control de la mayoría de las malezas anuales y perennes. El herbicida que cae en el suelo es inactivado inmediatamente mediante una reacción química que ocurre con las arcillas sin dejar residuos que puedan afectar las siembras posteriores, ni tampoco penetrar por las raíces de los cultivos ya establecidos. No es volátil. Los riesgos de causar daños a los cultivos vecinos se reducen considerablemente cuando las aplicaciones se realizan con el viento en calma, dirigido a las malezas y utilizando pantalla protectora para evitar que las gotas de aspersión caigan sobre las partes verdes de las plantas deseables.

MALEZAS QUE CONTROLA:

•**Malezas anuales: Amaranthus spp**. (bledos), **Bidens pilosa** (masiquía), **Borreria laevis** (botoncillo), **Cenchrus spp.** (cadillos), **Commelina diffusa** (siempreviva), **Cyperus spp.** (cortaderas), **Digitaria sanguinalis** (guardarocío), **Echinochloa colonum** (liendre-puerco), **Eleusine indica** (pata de gallina), **Euphorbia hirta** (yerba de sapo), **Fimbristylis annua** (barba de indio), **Galinsoga ciliata** (guasca), **Ipomoea spp.** (batatillas), **Ischaemum rugosum** (falsa caminadora), **Jussiaea linifolia** (clavito), **Kallstroemia maxima** (atarraya), **Oriza sativa** (arroz rojo), **Portulaca oleracea** (verdolaga), **Physalis angulata** (uchuva), **Rottborllia cochinchinensis** (caminadora) y **Tradescantia cummanensis** (siempreviva morada).

•**Malezas perennes: Andropogon bicornis** (rabo de zorro), **Axonopus micay** (pasto micay), **Brachiaria mutica** (pasto pará), **Cynodon dactylon** (pasto argentina), **Cyperus rotundus** (coquito), **Cyperus spp.** (cortaderas), **Imperata cilindrica** (guayacana), **Panicum maximum** (Pasto guinea), **Paspalum conjugatum** (yerba agria), **Paspalum virgatum** (pajón o masiega), **Paspalum fasciculatum** (gramalote), **Paspalum paniculatum** (granadilla) y **Pennisetum clandestinum** (pasto kikuyo), **Pennisetum purpureum** (pasto elefante), **Sorghum halepens**e (pasto johnson) y **Tnypha angustifolia** (enea, junco).

INSTRUCCIONES DE USO:

-Aplique 2 a 3 litros de **ROUNDUP SL** para el control de malezas anuales y de 4 a 6 litros para el control de malezas perennes en los cultivos mencionados más adelante.
-Realice la aplicación durante la época de lluvias, sobre malezas que se encuentren en crecimiento activo.

El herbicida ROUNDUP SL se recomienda en los siguientes casos:

•Antes de la siembra de cualquier cultivo anual o perenne para el control de malezas difíciles como el "coquito", "arroz rojo", "pasto kikuyo" y otras especies perennes. Espere entre 3 y 7 días después del tratamiento para iniciar la labranza del suelo y la siembra.
•Después de la siembra de cultivos perennes como plátano, banano, cacao, café, palma africana, cítricos y otros frutales. Durante el primer año se recomienda platear alrededor de los árboles y utilizar pantalla protectora para evitar el contacto con los cultivos.
•Regulador de crecimiento: Como madurante, para aumentar el contenido de sacarosa en la caña aplique 0.75 a 1.5 litros por hectárea a las 6 a 8 semanas antes de la cosecha y como desecante en sorgo aplique 1 litro por hectárea cuando los granos del tercio superior de la panoja estén coloreados y los del tercio inferior hayan pasado del estado lechoso al estado pastoso.
Este tratamiento no se recomienda para cultivos destinados a la producción de semilla.
•Areas no cultivadas: Seleccione la dosis de acuerdo con el tipo de malezas presentes.

RECOMENDACIONES PARA APLICACIONES AÉREAS

- Volúmen / ha : 50 - 75 ltrs/ha
- Tamaño de gotas : 250 - 400 micras
- Número de gotas : Para un producto sistémico como Roundup es preferible pocas gotas grandes, alrededor de 20 por cm^2 (centímetro cuadrado)
- Las boquillas y micronairs no deben superar el 75% de la envergadura de las alas para evitar el desplazamiento de las gotas por el vortice de las alas.
- Presión del equipo : Con Roundup se debe usar presiones de 20 y 30 psi.
-Condiciones ambientales

Temperatura ambiental : No mayor a 29° centígrados.
Humedad Relativa : >60%
Velocidad del viento : <7Km/hora - 1,94 m/seg.
Aplicar cuando se esté seguro de que no existen inversiones térmicas (Diferentes temperaturas entre suelo y aire)
- Altura de vuelo : 2 m. sobre el cultivo.
Alturas mayores favorecen el riesgo de deriva y aumentan la evaporación de la mezcla aplicada.
- Ancho de pasada : Depende de la aeronave y del equipo utilizado (Entre 14 y 18 m)
-Boquillas D-12 difusor 45 o 56 en ángulo de 135° hacia atrás o boquillas de abanico: 6504 - 8004 - 1104 (Spraying System)

COMPATIBILIDAD:

No mezcle **ROUNDUP SL** con herbicidas de contacto. Las mezclas del tanque con herbicidas residuales formulados como polvos mojables o suspensiones concentradas pueden reducir la eficacia sobre gramíneas perennes.

INFORMACIÓN SOBRE RESPONSABILIDAD:

*El fabricante garantiza que las características físico-químicas del producto corresponden a las anotadas en esta etiqueta y que mediante Registro Oficial de Venta se verificó que es apto para los fines aquí recomendados de acuerdo con las indicaciones de empleo.

7 701700 000019 1

ANNEX 116

Ecuador Ranger 480 Label

RANGER 480 – Herbicide by MONSANTO

"READ THE LABEL BEFORE USING THE PRODUCT"
"KEEP IN A CLOSED PLACE OUT OF THE REACH OF CHILDREN"
NON-SELECTIVE, POST-EMERGENT, SYSTEMIC HERBICIDE
WATER-SOLUABLE CONCENTRATE (SL) – AGRICULTURAL USE

Active Ingredient:
Glyphosate…….480 g/L

RANGER 480 is a non-selective herbicide with post-emergent application and systemic action for the control of most annual and perennial weeds.

PRECAUTIONS: This product is harmful in the case of inhalation or ingestion. Prolonged contact with the eyes or skin causes irritation. **During the preparation and use of the product, DO NOT SMOKE, EAT or DRINK. Avoid:** Inhalation or ingestion and direct contact with clothes, skin, eyes and mouth. **Wear:** Proper protective clothing, such as overalls, gloves, rubber boots, and a mask. **BEFORE EATING, DRINKING or SMOKING:** Remove contaminated clothes, wash exposed skin well with plenty of water.

WARNINGS: Do not contaminate with the product, its waste or empty containers: lakes, rivers, ponds, streams and other water sources. Store

the product in the original, labeled package, and keep it hermetically sealed. Do not use this package for any other purpose. Do not re-package or deposit the contents in other packages. Store the product in a safe place, away from food, children, and animals. Avoid allowing the spray to be carried by the wind into neighboring areas or crops. Before destroying the package, rinse it with water (quarter part of the contents) at least three times, and then deposit the rest in the application equipment. Bury the empty, destroyed package in a pit designed for that purpose.

FIRST AID INSTRUCTIONS AND ADVICE FOR DOCTORS: In the event of inhalation, keep the person in a ventilated place away from the application site. In the event of ingestion, make the patient drink two glasses of water, and do not induce vomiting. In the event of contamination to the skin or clothing, remove contaminated clothing and wash the affected part with plenty of soap and water. In case of contact with the eyes, wash them thoroughly with water for at least 15 minutes and under a continuous flow. Consult a doctor and show this label. **SYMPTOMS:** External contact causes burning or irritation of the eyes, mucous membranes, mouth or throat. If ingested, the early symptoms can include nausea and an upset stomach. **DIAGNOSIS:** A blood and urine exam can help to confirm the absorption of the product. The results can be confirmed by analytic methods. **TREATMENT:** There is no specific antidote. Treatment is symptomatic. Do not induce vomiting, and do not give an unconscious person anything to drink.

For more information, contact: BBR Representaciones Co. Ltd. Quito.
Telephone: (593-2) 2562680

FORMULATING MANUFACTURER:
C.A.C. Ltd. and S.C.A. Co.
Calle 100 No. 7-33 Torre A Piso 19
Bogota D.C., Colombia
Telephone: (57-1)-650-0650 A.A. No. 56-014

NET CONTENTS: 1 LITER
Registered trademark of Monsanto

IMPORTER AND DISTRIBUTOR
EQUAQUIMICA
GUAYAQUIL: Av. J.S. Castillo and Av. Juan Tanca Marengo, km. 1.8

REGISTERED IMPORTER:

BBR Representaciones Co. Ltd.
Av. Patria and Amazonas, Edificio Patria 640,
5 Piso, Quito, Ecuador
Telephone: (593-2) 256-2680

METHOD OF USE:

Calibrate spraying equipment before application to achieve a uniform distribution of the recommended dose. Spray weeds while they are in a vigorous state of growth. **RANGER 480** herbicide can be applied using a full range of nozzles, such as the TJ-8001, TJ-8003, or TJ 8004 or equivalents, which give a volume of water between 100 and 400 L/ha. The application of **RANGER 480** is recommended for:

General weed control before the planting of annual or perennial crops: For planting without soil preparation, wait for 2 to 3 days after application. For planting with preparation of the soil, wait between three and seven days after the treatment to begin soil preparation.

Weed management control in perennial, established crops such as banana (*musa sapientum)*, **African palm** *(elaeis guineensis)***, coffee** *(coffea Arabica)* **and citrus fruits** *(citrus spp.)***:** Apply using a protective screen to avoid contact with green foliage of crops.

General weed control in non-cultivated areas, such as field borders, irrigation channels, etc.

PREPARATION OF MIXES: Fill the spray tank halfway to capacity, add the required quantity of **RANGER 480,** and continue adding water until the tank is full.

WEED CONTROL AND DOSES: Annual weeds: 1.2 to 2 liters of **RANGER 480** per hectare. Wild Oats *(Avena fatua)*, Cortadera (*Cyperus diffuses)*, golodrina (*boerhaavia erecta)*, botoncillo *(Borreria laevis)*, cadillo *(Canchrus brownii)*, guardarocio (*Digitaria sanguinalis*), pata de gallina *(eleusine indica)*, paja de patillo *(Echinochloa colonum),* arrocillo *(Fimbrystilis annua),* caminadora *(Rottboellia exaltata)*, falsa caminadora *(ischaemum rugosum)*, paja mona *(Leptochloa filiformis*), red rice *(Oryza sativa)*, bledo (*Amarantilus spp)*, pegador *(Bidens pilosa)*, siempreviva (*Commelina diffusa)*, lechosa *(Euphorbia spp)*, clavo de agua *(Jussiaea linifolia)*, verdolaga *(Portulaca oleracea*), totora *(Typha augustfolia).*

Perrenial weeds: 3 to 4 liters of **RANGER 480** per hectare. Cortaderas *(cyperus spp)*, pasto para *(Brachiaria mutica)*, batatilla *(Ipomoea spp)*, pasto Argentina *(Cynodon dactylon)*, cabazonillo *(Cyperus ferax)*, coquito *(Cyperus rotundus)*, pasto guinea *(Panicum maximum)*, gramalote *(Paspalum fascicultarum)*, kikuyo *(Pennisetum)*, escoba *(Sida app)*, pasto Johnson *(Sorghum halepense):* for localized applications, use solutions of **RANGER 480** of 1% to 2% with spray nozzles TJ-8001 and TJ-8002, respectively.

Frequency of application: RANGER 480 can be applied at any time of cultivation and as many times as necessary; therefore, there is no restriction. **Interval between last application and harvest:** 7 days. **Period of reentry for people and animals into the treated areas:** 2 hours after the product has been applied, when it has penetrated the foliage.

COMPATIBILITY: Do not mix **RANGER 480** with contact herbicides. Mixtures with residual herbicides, such as substitute urea, triazines, etc, can reduce their activity. Do not add surfactant, as the appropriate quantity is already contained in this product.

Registration MAG: 039-H

Lot No. 17 05 03

Date of formulation: May 2007

Expiry Date: May 2012

This herbicide is subject to the requirements outlined in Law No. 073, Official Registry 442 of 1990 – 05 – 22

CONSUMER ADVISORY: The manufacturer guarantees the composition and quality of the product. The manufacturer is not responsible for imprudent, excessive or unnecessary use of the product on the part of the consumer.

CATEGORY IV

"LEA LA ETIQUETA ANTES DE USAR EL PRODUCTO"
"CONSERVESE EN LUGAR CERRADO FUERA DEL ALCANCE DE LOS NIÑOS"
HERBICIDA POST-EMERGENTE SISTEMICO NO SELECTIVO
CONCENTRADO SOLUBLE EN AGUA (SL) - USO AGRÍCOLA

RANGER 480®
Herbicida de MONSANTO

Ingrediente Activo: Glifosato.....480 g/l

RANGER® 480 es un herbicida no selectivo, de aplicación post-emergente y acción sistémica, para el control de la mayoría de las malezas anuales y perennes.

PRECAUCIONES: El producto es nocivo en caso de inhalación e ingestión. El contacto prolongado con los ojos o la piel causa irritación. **Durante la preparación y utilización del producto NO FUMAR - COMER o BEBER. Evitar:** La inhalación e ingestión y el contacto directo con la ropa, piel, ojos y boca. **Usar:** Ropa protectora adecuada como overol, guantes y botas de caucho, careta y mascarilla. **ANTES DE COMER - BEBER O FUMAR:** Sacarse la ropa contaminada, lavarse bien las partes expuestas de la piel con abundante agua.

FRASES DE ADVERTENCIA: No contaminar con el producto, sus desechos o envases vacíos: lagos, ríos, estanques, arroyos y otras fuentes de agua. Conservar el producto en el envase original etiquetado y cerrado herméticamente. No usar este envase para ningún otro fin. No reenvasar o depositar el contenido en otros envases. Conservar el producto en un lugar seguro, lejos de los alimentos, los niños y los animales. Evite que la llovizna de la atomización sea acarreada por el viento a áreas o cultivos vecinos. Antes de destruir el envase, enjuagarlo con agua (cuarta parte del contenido) por lo menos tres veces y luego depositar el resto en el equipo de aplicación. Enterrar el envase vacío y destruido en una fosa diseñada para el efecto.

INSTRUCCIONES PARA PRIMEROS AUXILIOS Y CONSEJOS PARA LOS MÉDICOS: En caso de inhalación, mantenga a la persona en un lugar ventilado fuera del sitio de aplicación. En caso de ingestión, haga beber al paciente dos vasos con agua y no induzca al vómito. En caso de contaminación con la piel o ropa debe eliminarse la ropa contaminada, y la parte afectada, lavarse con abundante agua y jabón. Si el contacto es con los ojos, lávelos abundantemente con agua, por lo menos durante 15 minutos y a flujo continuo. Consultar con un médico y mostrarle la etiqueta. **LOS SÍNTOMAS:** Por contacto externo, causa ardor o irritación en los ojos, membrana de la mucosa, boca o garganta. Por ingestión, los síntomas tempranos pueden incluir náuseas y malestar estomacal. **EL DIAGNÓSTICO:** El examen de sangre y de orina pueden ayudar a confirmar la absorción del producto. Con métodos analíticos se confirman los resultados. **EL TRATAMIENTO:** No existe antídoto específico. Su tratamiento es sintomático. No induzca al vómito ni dé nada de tomar a una persona inconsciente.

Para mayor información dirigirse a: BBR Representaciones Cía. Ltda. Quito. Teléfonos: (593-2) 2562680

FABRICANTE FORMULADOR:
C.A.C. Ltda y Cía, S.C.A.
Calle 100 No. 7-33 Torre A Piso 19
Bogotá D.C., Colombia
Teléfono: (57-1)-650-0650 A. A. No. 56-014

CONTENIDONETO: 1 LITRO

® Marca Registrada de Monsanto

MONSANTO

IMPORTADOR Y DISTRIBUIDOR
ECUAQUIMICA
La mano amiga
GUAYAQUIL: Av. J. S. Castillo y Av. Juan Tanca Marengo Km. 1.8

IMPORTADOR REGISTRADO:
BBR Representaciones Cía Ltda
Av. Patria y Amazonas, Edificio Patria 640,
5º Piso, Quito, Ecuador
Teléfono: (593-2)-256-2680

P.V.P.

CUIDADO

ANNEX 116

MODO DE EMPLEO:

Calibre el equipo de aspersión antes de la aplicación para conseguir una distribución uniforme de la dosis recomendada. Realice la aspersión sobre malezas en estado de crecimiento vigoroso. El herbicida **RANGER® 480** puede ser aplicado utilizando boquillas de abanico plano como la TJ-8001, TJ-8002, TJ-8003 o TJ-8004 ó sus equivalentes, lo que dará un volumen de agua entre 100 a 400 l/ha. Las aplicaciones de **RANGER® 480** se recomiendan para:

Control general de malezas antes de la siembra de los cultivos anuales o perennes: Para la siembra sin labranza espere de dos a tres días después de la aplicación. Para la siembra con labranza del suelo espere entre tres y siete días después del tratamiento para iniciar la preparación del suelo.

Control dirigido de malezas en cultivos perennes establecidos como banano (*Musa sapientum*), palma africana (*Elaeis guineensis*), café (*Coffea arabica*) y cítricos (*Citrus spp*): Aplique utilizando pantalla protectora para evitar el contacto con el follaje verde del cultivo.

Control general de malezas en áreas no cultivadas como bordes de cultivo, canales de riego, etc.

PREPARACIÓN DE MEZCLAS: Llene el tanque de aspersión hasta la mitad de su capacidad, añada la cantidad requerida de **RANGER® 480,** continúe luego la adición de agua hasta llenar el tanque.

MALEZAS QUE CONTROLA Y DOSIS: Malezas anuales: Dosis 1.2 a 2 litros de **RANGER® 480** por hectárea. Avena silvestre (*Avena fatua*), cortadera (*Cyperus diffusus*), golodrina (*Boerhaavia erecta*), botoncillo (*Borreria laevis*), cadillo (*Canchrus brownii*), guardarocio (*Digitaria sanguinalis*), pata de gallina (*Eleusine indica*), paja de patillo (*Echinochloa colonum*), arrocillo (*Fimbrystilis annua*), caminadora (*Rottboellia exaltata*), falsa caminadora (*Ischaemum rugosum*), paja mona (*Leptochloa filiformis*), arroz rojo (*Oryza sativa*), bledo (*Amaranthus spp*), pegador (*Bidens pilosa*), siempreviva (Commelina diffusa), lechosa (*Euphorbia spp*), clavo de agua (*Jussiaea linifolia*), verdolaga (*Portulaca oleracea*), totora (*Typha augustifolia*).

Malezas perennes: Dosis 3 a 4 litros de **RANGER®480** por hectárea. Cortaderas (*Cyperus spp*), pasto pará (*Brachiaria mutica*), batatilla (*Ipomoea spp*), pasto argentina (*Cynodon dactylon*), cabezonillo (*Cyperus ferax*), coquito (*Cyperus rotundus*), pasto guinea (*Panicum maximum*), gramalote (*Paspalum fascicultarum*), kikuyo (*Pennisetum*), escoba (*Sida spp*), pasto Johnson (*Sorghum halepense*): para las aplicaciones localizadas utilice soluciones de **RANGER®480** al 1% y 2% con boquillas de abanico TJ-8001 y TJ-8002 respectivamente.

Frecuencia de aplicación: **RANGER®480**se puede aplicar en cualquier época del cultivo y cuantas veces sea necesario, por lo tanto no tiene restricción. **Intervalo entre última aplicación y la cosecha**: 7 días. **Período de reingreso de personas y animales a las áreas tratadas**: 2 horas después de aplicado el producto, cuando éste haya penetrado en el follaje.

COMPATIBILIDAD: No mezcle **RANGER®480** con herbicidas de contacto. Las mezclas con herbicidas residuales como úreas sustituidas, triazinas, etc., Pueden reducir su actividad. No agregue surfactante debido a que contiene la cantidad apropiada.

Registro MAG: 039-H

Fecha de Formulación: MAY. 2007

LoteNo.: 17 05 03

FechadeVencimiento: MAY. 2012

7 701700 000507

Este herbicida está sujeto a los requisitos señalados por la Ley No. 073, Registro Oficial 442 de 1990 - 05 - 22

AVISO COMPRADOR: El fabricante garantiza la composición y la calidad del producto. No se responsabiliza por el uso imprudente, excesivo o indebido por parte del consumidor.

CATEGORÍA IV

ANNEX 117

Germany Roundup TURBO Label

[PAGE 29]

- 680 g/kg glyphosate
- Water soluble granular formulation
- Ammonium salt formulated on the basis of patented Transorb™ technology

[…]

[PAGE 30]

[…]

Warning

Risk of serious eye damage

Keep away from food, drinks and animal feed.

Xi

irritant

N

Hazardous to the environment

Dosierungstabelle für den Einsatz von Roundup® UltraMax in getragenen Spritzgeräten

- Bei Anwendungen mit der Rückenspritze ist i. d. R. eine 3%ige Spritzlösung ausreichend, d. h. 30 ml Roundup® UltraMax pro Liter Spritzbrühe.
- Die Aufwandmenge ändert sich entsprechend der Unkrautzusammensetzung.
- Bei schwerbekämpfbaren Unkräutern kann entweder die Roundup® UltraMax Aufwandmenge erhöht oder die Spritzgeschwindigkeit muss reduziert werden.

Aufwandmenge 4 L/ha entsprechen 0,4 mL/m² z. B. gegen ein- und zweikeimblättrige Unkräuter (s. a. Wirkungsspektrum)

Wasser-aufwandmenge [L]	Roundup® UltraMax [mL]	Zu behandelnde Fläche m²
1	30	75
2	60	150
3	90	225
4	120	300
5	150	375
10	300	750

Aufwandmenge 8 L/ha entsprechen 0,8 mL/m² gegen schwerbekämpfbare Unkräuter z. B. Winde-Arten

Wasser-aufwandmenge [L]	Roundup® UltraMax [mL]	Zu behandelnde Fläche m²
1	30	37,5
2	60	75
3	90	112,5
4	120	150
5	150	187,5
10	300	375

Dosierungstabelle für den Einsatz von Roundup® UltraMax in handgetragenen Streichgeräten

- Alternativ zur Spritzanwendung kann Roundup® UltraMax im Streichverfahren mit einer 33%igen Lösung genutzt werden.
- Dies empfiehlt sich besonders bei schwerbekämpfbaren Unkräutern, Schadgehölzen oder zur Stockausschlagbehandlung.
- Die maximal zugelassene Aufwandmenge beträgt 0,8 mL Roundup® UltraMax/m².

	Wasser-aufwandmenge [mL]	Roundup® UltraMax [mL]	Gesamtlösung [mL]
Streichstabfüllung 0,4 L	260	130	390
Streichstabfüllung 0,6 L	400	200	600
1 L Vorratslösung	666	333	999

Roundup® TURBO

Herbizid zur Anwendung auf dem Acker- und Grünland, auf Stilllegungsflächen, im Wein- und Kernobstbau, auf Nichtkulturland und auf Wegen und Plätzen.

- 680 g/kg Glyphosat
- wasserlösliche Granulatformulierung
- Ammoniumsalz, auf Basis der patentierten Transorb™ Technologie formuliert
- Regenfest nach 1 Stunde
- Umbruch bei Quecke nach 5 Tagen möglich
- Wirksamkeit bis in die Wurzelspitzen
- Keine Abstandsauflagen zu Oberflächengewässern (Ländervorgaben beachten)
- Keine Abstandsauflage zu Nichtzielpflanzen. In Gebieten ohne ausreichenden Anteil an Kleinstrukturen für Saumstrukturen > 3 m 50% Antidrift, sonst 20 m Abstand

ANNEX 117

Wirkstoff

680 g/kg Glyphosat
als Glyphosat Salz (747 g/kg)

Formulierung

wasserlösliches Granulat (SG)

Packungsgrößen

10 kg

Hinweise

- Gefahr ernster Augenschäden
- Giftig für Wasserorganismen, kann in Gewässern längerfristig schädliche Wirkung haben.
- Darf nicht in die Hände von Kindern gelangen.
- Bei der Arbeit nicht essen, trinken, rauchen.
- Von Nahrungsmitteln, Getränken und Futtermitteln fernhalten.
- Bei Berührung mit den Augen gründlich mit Wasser abspülen und Arzt konsultieren.
- Abfälle und Behälter müssen in gesicherter Weise beseitigt werden.
- Schutzbrille/Gesichtsschutz tragen.
- Bei Verschlucken sofort ärztlichen Rat einholen und Verpackung oder Etikett vorzeigen.
- Zur Vermeidung einer Kontamination der Umwelt geeigneten Behälter verwenden.
- Jeden unnötigen Kontakt mit dem Mittel vermeiden. Missbrauch kann zu Gesundheitsschäden führen.
- Dicht abschließende Schutzbrille tragen beim Umgang mit dem unverdünnten Mittel.

Xi
reizend

N
Umweltgefährlich

Zulassungsinhaber und Vertrieb

Monsanto Agrar Deutschland GmbH
Vogelsanger Weg 91
D-40470 Düsseldorf
Tel.: 0211-36 75-0

Nr. 4960-00

Notfallnummer

Telefon: (Deutschland) 0211-36 75-0
Telefon: (Belgien) 0032-3-568.5123

Entsorgung

Leere Verpackungen nicht weiterverwenden. Leere und sorgfältig gereinigte Verpackungen an den autorisierten Sammelstellen im Rahmen des IVA-Entsorgungskonzeptes PAMIRA abgeben. Informationen zu Zeitpunkt und Ort der Sammlungen erhalten Sie von Ihrem Händler. Produktreste nicht dem Hausmüll beigeben, sondern in Originalverpackungen bei den entsorgungspflichtigen Körperschaften anliefern. Weitere Auskünfte erhalten Sie bei der Stadt- oder Kreisverwaltung.

Ein Herbizid von Monsanto

Roundup® TURBO

I. Allgemeines

Wirkungsweise

Roundup® TURBO ist ein nichtselektives Blattherbizid mit systemischer Wirkung. Es wird über die grünen Teile der Pflanze aufgenommen und mit Hilfe des Saftstromes in der gesamten Pflanze, einschließlich der unterirdischen Pflanzenteile (Rhizome), verteilt. Daher werden neben einjährigen Unkraut- und Ungrasarten auch mehrjährige Unkraut- und Ungrasarten nachhaltig bekämpft.

Anwendungsbedingungen

Roundup® TURBO kann während der gesamten Vegetationsperiode eingesetzt werden. Der Einsatz kann sogar vor oder nach kurzen Nachtfrösten bis -4°C erfolgen.
Es ist darauf zu achten, dass die zu bekämpfenden Unkrautarten genügend aufnahmefähige Blattmasse gebildet haben müssen und ausreichend benetzt werden. Zur nachhaltigen Bekämpfung von hartnäckigen, breitblättrigen Unkräutern wird die Anwendung im Blühstadium empfohlen. Bei anhaltender Trockenheit oder bei hohen Temperaturen, verbunden mit extrem niedriger Luftfeuchtigkeit, können Wirkstoffaufnahme und -ableitung beeinträchtigt werden. Bei diesen, wie auch anderen nicht optimalen Anwendungsbedingungen sind Verringerungen der empfohlenen Aufwandmenge nicht angeraten. Anwendung nach Regen oder bei Tau auf feuchtem, aber nicht tropfnassen Unkrautbestand möglich!

Aufwandmengen

- Die *Produkt*-Aufwandmengen richten sich nach Art und Größe der zu bekämpfenden Unkräuter.
- Niedrige *Wasser*-Aufwandmengen bis max. 200 l/ha begünstigen die Wirkung.

Wirkungsgeschwindigkeit

Je aktiver die Pflanzen wachsen, um so schneller wird der Wirkstoff in der Pflanze verteilt. Bei normalwüchsiger Witterung tritt innerhalb von ca. einer Woche die sichtbare Wirkung von Roundup® TURBO ein. Die Pflanzen welken, werden gelb und vertrocknen später vollständig. Ein witterungsbedingt langsamer Eintritt von Wirkungssymptomen hat auf die Nachhaltigkeit der Wirkung keinen Einfluss.

Nützlinge

NB6641 Das Mittel wird bis zu der höchsten durch die Zulassung festgelegten Aufwandmenge oder Anwendungskonzentration, falls eine Aufwandmenge nicht vorgesehen ist, als *nicht bienengefährlich* eingestuft (B4).

NN165 Das Mittel wird als nicht schädigend für Populationen der Art *Poecilus cupreus* (Laufkäfer) eingestuft.

NN170 Das Mittel wird als nicht schädigend für Populationen der Art *Chrysoperla carnea* (Florfliege) eingestuft.

NN1842 Das Mittel wird als nicht schädigend für Populationen der Art *Aphidius rhopalosiphi* (Brackwespe) eingestuft.

Bodenbearbeitung

- Ab 1 Tag bei *einjährigen Unkräutern* bis zum 4-Blatt-Stadium möglich.
- Ab 5 Tagen z. B. bei *Quecke* oder *ausdauernden Unkräutern* möglich, auch wenn Symptome noch nicht sichtbar sind.
- Ab 7 Tagen bei *ungünstigen Bedingungen* (z. B. kühle Witterung) möglich.

Schüttgewicht

1 kg Roundup® TURBO = ca. 1,70 l
(nach einmaligem Aufklopfen des Messbechers)
1 l = ca. 590 g Roundup® TURBO

ANNEX 118

Germany Roundup UltraMax Label

[PAGE 5]

The new standard. Roundup® UltraMax belongs to the latest Roundup® generation.

[…]

- 450 g/L glyphosate
- Liquid formulation
- Isopropylamine salt with a new highly concentrated surfactant

[…]

[PAGE 6]

[…]

Warning

- Toxic to water organisms; can have long-term toxic effects on bodies of water.

[…]

- Avoid all unnecessary contact with the agent. Misuse can lead to health problems.

Roundup® UltraMax

Der neue Maßstab. Roundup® UltraMax gehört zur neuesten Roundup®-Generation.

HERBIZID ZUR ANWENDUNG IM FREILAND AUF DEM ACKER- UND GRÜNLAND, IM GEMÜSEBAU, AUF STILLLEGUNGSFLÄCHEN, IM FORST, WEIN- UND OBSTBAU, AUF WEGEN UND PLÄTZEN, AUF NICHTKULTURLAND, IN BAUMSCHULEN UND IM ZIERPFLANZENBAU.

- 450 g/l Glyphosat
- Flüssigformulierung
- Isopropylaminsalz mit neuem hochkonzentrierten Netzmittel
- Regenfest nach 1 Stunde
- Wirksamkeit bis in die Wurzelspitzen
- Hohe Anwendersicherheit, weder haut- noch augenreizend
- Nicht bienengefährlich und nicht fischgiftig
- Keine Abstandsauflage zu Oberflächengewässern (Ländervorgaben beachten!)
- Keine Abstandsauflage zu Nichtzielpflanzen. In Gebieten ohne ausreichenden Anteil an Kleinstrukturen für Saumstrukturen >3m 50% Antidrift, sonst 20m Abstand

ANNEX 118

Wirkstoff

450 g/l Glyphosat
als Glyphosat Salz (607 g/l)

Formulierung

wasserlösliches Konzentrat (SL)

Packungsgrößen

1 L, 5 L, 20 L, 120 L, 640 L

Hinweise

- Schädlich für Wasserorganismen, kann in Gewässern längerfristig schädliche Wirkungen haben.
- Abfälle und Behälter müssen in gesicherter Weise beseitigt werden.
- Jeden unnötigen Kontakt mit dem Mittel vermeiden. Missbrauch kann zu Gesundheitsschäden führen.
- Für Kinder unzugänglich aufbewahren.
- Zur Vermeidung von Risiken für Mensch und Umwelt ist die Gebrauchsanleitung einzuhalten.
- Universal-Schutzhandschuhe (Pflanzenschutz) tragen beim Umgang mit dem unverdünnten Mittel.
- Standardschutzanzug (Pflanzenschutz) und festes Schuhwerk (z. B. Gummistiefel) tragen bei der Ausbringung/Handhabung des anwendungsfertigen Mittels.
- Frostfrei lagern.
- Hohe Anwendersicherheit, nicht haut- und augenreizend
- Keine Bodenwirkung
- Nicht schädlich für viele nützliche Insekten
- Nicht bienengefährlich
- Keine Wasserschutzgebietsauflage

Zulassungsinhaber und Vertrieb

Monsanto Agrar Deutschland GmbH
Vogelsanger Weg 91
D-40470 Düsseldorf
Tel.: 02 11 - 36 75 - 0

Nr. 5191-00

Notfallnummer

Telefon: (Deutschland) 02 11 - 36 75 - 0
Telefon: (Belgien) 00 32 - 3 - 5 68. 51 23

Entsorgung

Leere Verpackungen nicht weiterverwenden. Leere und sorgfältig gespülte Verpackungen an den autorisierten Sammelstellen im Rahmen des IVA-Entsorgungskonzeptes PAMIRA abgeben. Informationen zu Zeitpunkt und Ort der Sammlungen erhalten Sie von Ihrem Händler. Produktreste nicht dem Hausmüll beigeben, sondern in Originalverpackungen bei den entsorgungspflichtigen Körperschaften anliefern. Weitere Auskünfte erhalten Sie bei der Stadt- oder Kreisverwaltung.

Ein Herbizid von Monsanto

Roundup® UltraMax

I. Allgemeines

Wirkungsweise

Roundup® UltraMax ist ein nichtselektives Blattherbizid mit systemischer Wirkung. Es wird über die grünen Teile der Pflanze aufgenommen und mit Hilfe des Saftstromes in der gesamten Pflanze, einschließlich der unterirdischen Pflanzenteile (Rhizome), verteilt. Daher werden neben einjährigen Unkraut- und Ungrasarten auch mehrjährige Unkraut- und Ungrasarten nachhaltig bekämpft.

Anwendungsbedingungen

Roundup® UltraMax kann während der gesamten Vegetationsperiode eingesetzt werden. Der Einsatz kann sogar vor oder nach kurzen Nachtfrösten bis -4°C erfolgen. Es ist darauf zu achten, dass die zu bekämpfenden Unkrautarten genügend aufnahmefähige Blattmasse gebildet haben müssen und ausreichend benetzt werden. Zur nachhaltigen Bekämpfung von hartnäckigen, breitblättrigen Unkräutern wird die Anwendung im Blühstadium empfohlen. Bei anhaltender Trockenheit oder bei hohen Temperaturen, verbunden mit extrem niedriger Luftfeuchtigkeit, können Wirkstoffaufnahme und -ableitung beeinträchtigt werden. Bei diesen, wie auch anderen nicht optimalen Anwendungsbedingungen sind Verringerungen der empfohlenen Aufwandmenge nicht angeraten. Anwendung nach Regen oder bei Tau auf feuchtem, aber nicht tropfnassen Unkrautbestand möglich!

Aufwandmengen

- Die *Produkt*-Aufwandmengen richten sich nach Art und Größe der zu bekämpfenden Unkräuter.
- Niedrige *Wasser*-Aufwandmengen bis max. 200 l/ha begünstigen die Wirkung.

Wirkungsgeschwindigkeit

Je aktiver die Pflanzen wachsen, um so schneller wird der Wirkstoff in der Pflanze verteilt. Bei normalwüchsiger Witterung tritt innerhalb von ca. einer Woche die sichtbare Wirkung von Roundup® UltraMax ein. Die Pflanzen welken, werden gelb und vertrocknen später vollständig. Ein witterungsbedingt langsamer Eintritt von Wirkungssymptomen hat auf die Nachhaltigkeit der Wirkung keinen Einfluss.

Nützlinge

NB6641

Das Mittel wird bis zu der höchsten durch die Zulassung festgelegten Aufwandmenge bzw. Anwendungskonzentration als *nicht bienengefährlich* eingestuft (B4).

NN165

Das Mittel wird als nicht schädigend für Populationen der Art *Poecilus cupreus* (Laufkäfer) eingestuft.

NN170

Das Mittel wird als nicht schädigend für Populationen der Art *Chrysoperla carnea* (Florfliege) eingestuft.

Bodenbearbeitung

- Ab 1 Tag bei einj. Unkräutern bis 4-Blattstadium möglich.
- Ab 7 Tage z. B. bei Quecke oder ausdauernden Unkräutern möglich.
- Ab 10 Tage bei ungünstigen Bedingungen (z. B. kühle Witterung) möglich.

II. Anwendungsgebiete

Von der Zulassungsbehörde festgesetzte Anwendungsgebiete

Kultur/Objekt	Schadorganismus/Zweck
Ackerbaukulturen	Ein- und zweikeimblättrige Unkräuter
Baumschulgehölzpflanzen	Ein- und zweikeimblättrige Unkräuter
Futtererbse, Ackerbohne	Sikkation
Gemüsekulturen	Ein- und zweikeimblättrige Unkräuter
Lagergetreide (Gerste, Hafer, Roggen, Triticale, Weizen)	Ein- und zweikeimblättrige Unkräuter, Sikkation
Getreide (Gerste, Hafer, Roggen, Triticale, Weizen)	Ein- und zweikeimblättrige Unkräuter

ANNEX 119

Italy Roundup 450 Plus

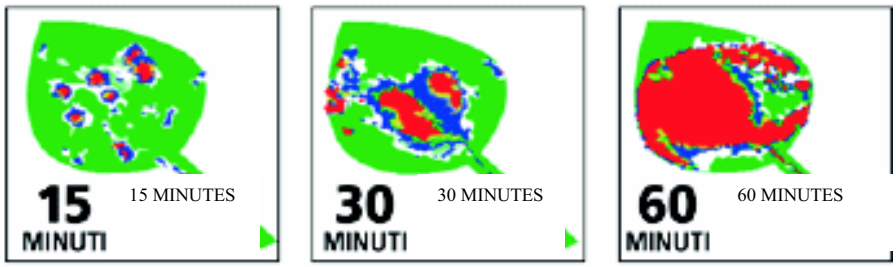
MONSANTO ITALIA

Roundup 450Plus

[...]

Classification: R52-53 (harmful to aquatic organisms, it can cause negative effects for the aquatic environment in the long term)

[…]



After 60 minutes, the lethal dose of Roundup is already inside the plant.

MONSANTO ITALIA

Roundup 450Plus

La Differenza Inizia Dall'etichetta

In Questa Sezione

- - -

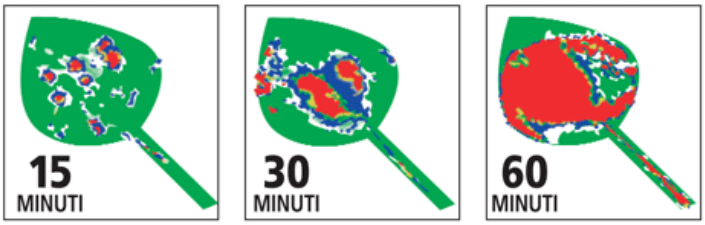
11418 del 23 luglio 2002

-

25% PIU' CONCENTRTO RISPETTO AI COMUNI 360 g/l

NUOVA FORMULA:

TRANSORB II TECHNOLOGY



Dopo 60 minuti la dose letale di Roundup
è già all'interno della pianta.

BENEFICI E VANTAGGI DELLA TECNOLOGIA TRANSORB II:

-

ANNEX 119

-
-
-
-

-
-
-

-

Tutto questo è il nuovo
Roundup®
450Plus
100%
DI SODDISFAZIONE
E DI FLESSIBILITÀ

ANNEX 120

Japan Roundup Agrochemical Registration

registration

Ministry of Agriculture, Forestry and Fisheries, Agrochemical Registration

Content
2. Roundup (sold only in Hokkaido): Agrochemical Registration Number, Ministry of Agriculture, Forestry and Fisheries Registration No. 14360 (As of April 2005)

Cautions on effects and chemical damage
16) Serious chemical damage arises when the chemical solution is placed in contact with crops or useful plants, so be careful that they are not exposed.
(18) Be careful not to make errors in the usage amount, usage period, usage method, etc. when using this product and in the case of first-time use, in particular, it is best to have guidance from affiliated institutions, such as a pest control office.
(21) Sufficient caution is to be exercised so that this product is not dispersed or allowed to flow into a water supply or culturing pond.

農林水産省　農薬登録内容

2.ラウンドアップ（北海道のみで販売）:農薬登録番号 農林水産省登録第14360号　（平成17年04現在）

散布処理

作物名又は適用場所	適用雑草名	使用時期	使用量		本剤の使用回数	使用方法	グリホサートを含む農薬の総使用回数
			薬量	希釈水量			
果樹類（パイナップルを除く）	スギナ	雑草生育盛期但し収穫7日前まで	2000mL/10a	少量散布 25～50L/10a	3回以内	雑草木葉散布	3回以内
	一年生雑草	雑草生育期但し収穫7日前まで	250～500mL/10a	通常散布 50～100L/10a 少量散布 25～50L/10a			
	多年生雑草		500～1000mL/10a				
	つる性多年生雑草 ササ類 落葉雑かん木	生育盛期以降（夏～秋期）但し収穫7日前まで	1000mL/10a				
水田耕起前 水田畦畔 水田刈跡	一年生雑草	雑草生育期（耕起前では耕起の10日以前）（水田畦畔は収穫14日前まで）	250～500mL/10a		水田畦畔:2回以内 その他:1回		水田畦畔:2回以内 その他:1回
	多年生雑草		500～1000mL/10a				
移植水稲（不耕起栽培）	一年生及び多年生雑草	湛水前30～5日	500mL/10a	50L/10a			
直播水稲（乾田耕起栽培）		雑草生育期（耕起直後～出芽前）		少量散布 25～50L/10a	1回		2回以内
直播水稲（乾田不耕起栽培）		雑草生育期（は種30日前～出芽前）					
だいず	畑地一年生雑草	雑草生育期（は種10日以前）	250～500mL/10a	通常散布 50～100L/10a 少量散布 25～50L/10a	2回以内		
豆類（種実、ただしだいず、らっかせいを除く）					1回		1回
キャベツ はくさい だいこん かんしょ		雑草生育期（耕起7日以前）					
麦類（小麦を除く）		雑草生育期（耕起10日以前）					
小麦 さとうきび（春植え）	畑地多年生雑草		500～1000mL/10a				
茶	一年生雑草	雑草生育期（春～夏期。但し、摘採7日前まで）	250～500mL/10a		休耕田:2回以内 桑・花木:4回以内		休耕田:2回以内 桑・花木:4回以内
花木		雑草生育期（但し桑では発芽前又は夏切後発芽前）					
桑・休耕田							
桑・休耕田	多年生雑草		500～1000mL/10a				
	一年生雑草	耕起造成前雑草生育期	250～500mL/10a				

牧野、草地（更新・造成）	多年生雑草	（更新・造成の10日以前）	500～1000mL/10a		1回		1回
	一年生及び多年生雑草	耕起整地後（雑草発生揃期）は種10日前～は種当日	250～500mL/10a				
すぎ・ひのき（下刈り代用）	ススキ、ササ類、クズ等の多年生雑草落葉雑かん木	雑草生育期（5～6月）	500mL/10a	少量散布15～20L/10a	3回以内		3回以内
造林地（地ごしらえ）		生育盛期以降（夏～秋期）	1000mL/10a	少量散布20～30L/10a			

塗布処理

作物名又は適用場所	適用雑草名	使用時期	希釈倍数	使用液量	本剤の使用回数	使用方法	グリホサートを含む農薬の総使用回数
かんきつ、りんご、なし、かき、ぶどう、くり、もも	一年生及び多年生雑草	雑草生育期但し収穫7日前まで	3～6倍	3～6L/10a	3回以内	雑草木葉塗布	3回以内
水田畦畔		雑草生育期但し収穫14日前まで			2回以内		2回以内
桑		雑草生育期			4回以内		4回以内
芝（ラフ等）					3回以内		3回以内
すぎ・ひのき（下刈り代用）	ススキ、ササ類、クズ等の多年生雑草落葉雑かん木		3倍	3L/10a			

注入処理

作物名又は適用場所	適用雑草名	使用時期	希釈倍数	使用液量	本剤の使用回数	使用方法	グリホサートを含む農薬の総使用回数
林地	クズ	春期又は秋期	原液又は2倍液	1～2mL/株	－	株頭注入処理	－
	クズ・フジ等のつる類	春期～秋期		つる径使用量（mL/株）（2.0cm以下 0.5, 2.1～3.0cm 1.0 3.1～4.0cm 1.5 4.1～5.0cm 2.0 ）		つる注入処理	
	落葉雑かん木間伐するすぎ、ひのき	3月～10月		1mL/ヶ数（樹径　ヶ所数）（10cm以下 2～3, 10～20cm 4～8, 20cm以上　10 ）		立木注入処理	

農耕地以外での散布処理

作物名又は適用場所	適用雑草名	使用時期	使用量		本剤の使用回数	使用方法	グリホサートを含む農薬の総使用回数
			薬量	希釈水量			

公園、堤とう、駐車場、道路、運動場、宅地、のり面、鉄道等	一年生雑草	雑草生育期	500mL/10a	通常散布 50～100L/10a 少量散布 25～50L/10a	3回以内	雑草木葉散布	3回以内
	多年生雑草		1000mL/10a				
	クズ等のつる性多年生雑草 ササ類 落葉雑かん木	生育盛期以降	1000～2000mL/10a				
	スギナ	生育盛期	2000mL/10a	少量散布 25～50L/10a			

農耕地以外での塗布処理

作物名又は適用場所	適用雑草名	使用時期	希釈倍数	使用液量	本剤の使用回数	使用方法	グリホサートを含む農薬の総使用回数
公園、堤とう、駐車場、道路、運動場、宅地、のり面、鉄道等	一年生及び多年生雑草	雑草生育期	3倍	3～6L/10a	3回以内	雑草茎葉塗布	3回以内

極少水量処理

作物名又は適用場所	適用雑草名	使用時期	使用量		本剤の使用回数	使用方法	グリホサートを含む農薬の総使用回数
			薬量	希釈水量			
かんきつ、りんご、なし	一年生及び多年生雑草	雑草生育期 但し収穫7日前まで	400～600mL/10a	4～6L/10a	3回以内	雑草木茎葉散布	3回以内
水田畦畔		雑草生育期 但し収穫14日前まで			2回以内		2回以内
公園、堤とう、駐車場、道路、運動場、宅地、のり面等		雑草生育期			3回以内		3回以内

効果・薬害の注意

(1) 本剤はグリホサートを含む農薬であるので、他のグリホサートを含む農薬の使用回数と合わせ、作物ごとの総使用回数の範囲内で使用すること。

(2) 泥などで濁った水は効果を低下させるので本剤の調製には用いないこと。

(3) 展着剤の加用の必要はない。

(4) 本剤は土壌中で速やかに不活性化するので、雑草の発生前処理効果はない。

(5) 本剤は散布時の雑草の草丈や茎葉面積が大きい程、効果が確実となるので、散布前に雑草の地上部を刈り払わないこと。

(6) 本剤は通常2～14日で効果が発現し、効果完成までさらに日数を要するので、誤って再散布しないこと。

(7) 土壌が流亡したり、くずれたりする恐れのある所（ノリ面など）では塗布処理が望

ましい。

(8) スギナ防除に際しては、スギナの生育期を過ぎた時期での散布及びスギナが他雑草の中に埋没しているような条件では効果が劣ることがあるので、適期にスギナにかかるように注意して散布すること。

(9) 一年生広葉雑草、または多年生雑草のうちススキ、スギナ、セイタカアワダチソウ等を主対象に使用する場合、所定範囲の多めの薬量を使用すること。

(10) 処理後6時間以内の降雨は効果を低下させることがあるので、天候を良く見極めてから散布すること。

(11) 通常散布の場合は、下記の希釈倍率の散布液を調製して散布すると便利である。一年生雑草（200～400 倍）、多年生雑草（100 倍）、つる性の多年生雑草、ササ類、落葉雑かん木類（50倍）、スギナ(12.5～25倍)。

(12) 直播水稲に使用する場合は、稲の出芽後に散布すると薬害の恐れがあるので、必ず出芽前までに散布すること。

(13) 少量散布、極少水量処理の場合は、それぞれ専用のノズルを用いて、雑草木の葉面に均一に散布すること。

(14) 塗布処理における注意事項
1)本処理では雑草の葉面に塗布器具で軽くなでるように直接塗布すること。
2)芝生で散布処理をする場合、雑草と芝生の高低の差等を利用して雑草茎葉部にのみ塗布すること。誤って芝生に付着すると薬害を生ずるので十分に注意すること。

(15) 注入処理における注意事項
1)クズには株頭にナタなどで傷をつけ、薬液がよくしみ込むように注入処理する。
2)クズ･フジ等つる類のつる注入処理に使用する場合は、地際近く(50cm程度)の1～3ヵ所にナタ等でつるに傷をつけてから切口に薬液が十分付着するように処理すること。
3)落葉雑かん木には、樹幹の回りに等間隔にナタ目を入れ、薬液を注入処理する。

(16) 農作物や有用植物に薬液が付着すると、激しい薬害が生ずるので、かからないよう十分注意すること。

(17) 本剤の調製及び保管に際しては合成樹脂の内層のない鋼鉄製（ステンレスを除く）の容器類は使用しないこと。なお散布液を調製した容器及び散布器具は、使用後十分に水洗いすること。

(18) 本剤の使用に当たっては使用量、使用時期、使用方法等を誤らないように注意し、特に初めて使用する場合には病害虫防除所等関係機関の指導を受けることが望ましい。

(19) 適用作物群に属する作物又はその新品種に本剤をはじめて使用する場合は、使用者の責任において事前に薬害の有無を十分確認してから使用すること。なお、病害虫防除所等関係機関の指導を受けることが望ましい。

(20) 散布器具･容器の洗浄水は、河川等に流さず、周囲に影響のない地点を選定して、土壌表面に散布する等の処理を行ない、空容器等は水産動物に影響を与えないよう適切に処理すること。

(21) 水源池、養殖池等に本剤が飛散･流入しないよう十分に注意すること。

トップページ　1.ラウンドアップ ハイロード

トランゾーブ採用
吸収移行
パワーアップ!
枯らす力
が違う!
しかも
土に安心!

ANNEX 121

Japan Roundup Product Safety Data Sheet

Date sheet

Product safety data sheet

(Product name) Roundup® herbicide

Active ingredients:
Glyphosate, N-(phosphonomethyl)glycine, isopropylamine salt (isopropylammonium=-(phosphonomethyl) glycinate) ……41.0%

(Hazard classification)

Hazards:

Anticipated exposure routes: inhalation and skin contact

Eyes:
According to toxicity tests, Roundup herbicide may cause eyes to be painful, bloodshot, or to tear.

Skin:
According to toxicity tests, Roundup herbicide will cause symptoms ranging from mild toxicity to irritation.

Accidental ingestion:
According to toxicity tests, Roundup herbicide demonstrates mild toxicity. In cases in which a small amount is ingested (one mouthful or less), significant symptoms of toxicity are not observed. In cases in which similar products have been ingested, there have been reports of gastrointestinal discomfort, nausea, vomiting, and diarrhea, accompanied by oral irritation. In cases of oral ingestion of large volumes of similar products, there have been reports of a drop in blood pressure and pulmonary edema.

(Hazard information)

Surfactant:
The surfactant that is a component of Roundup herbicide may cause eye and skin irritation, and there is a possibility that the irritating property of this product is due to such properties of the surfactant.

Date sheet
ラウンドアップ ハイロード
ラウンドアップ 除草剤の紹介
ラウンドアップ 除草剤製品一覧
正しい使い方の 基本編
雑草・雑かん木類 別の正しい使い方
利用場面別の 正しい使い方
家庭園芸向け製品
なんでもQ&A
製品データシート
農林水産省 農薬登録内容
おすすめリンク
トップページへ
製品安全データシート
ラウンドアップ® 除草剤
【製造者情報】
【製品名】
【物質の特定】
【危険・有害性の分類】
【応急措置】
【火災時の措置】
【漏出時の措置】
【取扱い及び保管上の注意】
【暴露防止措置】
【物理 / 化学的性質】
【危険性情報】
【有害性情報】
【環境影響情報】
【輸送上の注意】
【廃棄上の注意】
【適用法令】
【その他】
ラウンドアップハイロード™除草剤
【製造者情報】
【製品名】
【物質の特定】
【危険・有害性の分類】
【応急措置】
【火災時の措置】
【漏出時の措置】
【取扱い及び保管上の注意】
【暴露防止措置】
【物理 / 化学的性質】
【危険性情報】
【有害性情報】
【環境影響情報】
【輸送上の注意】
【廃棄上の注意】
【適用法令】
【その他】
トランゾープ採用
吸収移行パワーアップ!
枯らす力が違う!しかも土に安心!

ANNEX 121

ラウンドアップ®除草剤

【製造者情報】

作成者

会社名	モンサント・カンパニー
住所	800 North Lindbergh St. Louis, MO 63167, U.S.A.
緊急連絡先（電話番号	コレクトコール）
	314-694-4000（米国）
緊急時以外の問い合わせ先（電話番号）	
	1-800-332-3111（米国）

日本法人

会社名	日本モンサント株式会社
住所	東京都中央区銀座４－１０－１０ （銀座山王ビル8F）
電話番号	03-6226-6080
ファックス番号	03-3546-6191

連絡先（輸入販売元）

会社名	日産化学工業株式会社
住所	東京都千代田区神田錦町3-7-1
電話番号	**0120-20-9374（フリーダイヤル）** 03-3296-8151（農業化学品事業部）
ファックス番号	03-3296-8016

MSDS番号：S00012445
作成日：1999年6月
改訂日：2002年7月

【製品名】 ラウンドアップ®除草剤
類似名：MON 78742

【物質の特定】

単一製品・混合物の区分: 混合物

化学名及び含有量*

有効成分；
グリホサート、N-ホスホノメチルグリシン イソプロピル
アミン塩（イソプロピルアンモニウム=-（ホスホノメチル）
グリシナート） …… 41.0%

水、界面活性剤； …… 59.0%

100.0%

成分	CAS登録番号	%(重量)
グリホサート イソプロピルアミン塩	38641-94-0	41.0%
界面活性剤**		6.0%

国連分類： なし(危険物に該当しない)

* 化学物質管理促進法(PRTR法)における第一種又は第二種指定化学物質に該当する化学物質は含まれていない。

** モンサント社の商業上の秘密のため化学名を記載しない。

メニューへ戻る

ANNEX 121

ラウンドアップ®除草剤

【製造者情報】

作成者

会社名	モンサント・カンパニー
住所	800 North Lindbergh St. Louis, MO 63167, U.S.A.
緊急連絡先（電話番号	コレクトコール）
	314-694-4000（米国）
緊急時以外の問い合わせ先（電話番号）	
	1-800-332-3111（米国）

日本法人

会社名	日本モンサント株式会社
住所	東京都中央区銀座４－１０－１０ （銀座山王ビル8F）
電話番号	03-6226-6080
ファックス番号	03-3546-6191

連絡先（輸入販売元）

会社名	日産化学工業株式会社
住所	東京都千代田区神田錦町3-7-1
電話番号	**0120-20-9374（フリーダイヤル）** 03-3296-8151（農業化学品事業部）
ファックス番号	03-3296-8016

MSDS番号：S00012445
作成日：1999年6月
改訂日：2002年7月

【製品名】 ラウンドアップ®除草剤
類似名：MON 78742

【物質の特定】

単一製品・混合物の区分: 混合物

化学名及び含有量*

有効成分；
グリホサート、N-ホスホノメチルグリシン イソプロピル
アミン塩（イソプロピルアンモニウム=-（ホスホノメチル）
グリシナート） …… 41.0%

水、界面活性剤； …… 59.0%

100.0%

成分	CAS登録番号	%(重量)
グリホサート イソプロピルアミン塩	38641-94-0	41.0%
界面活性剤**		6.0%

国連分類： なし(危険物に該当しない)

* 化学物質管理促進法(PRTR法)における第一種又は第二種指定化学物質に該当する化学物質は含まれていない。

** モンサント社の商業上の秘密のため化学名を記載しない。

メニューへ戻る

ANNEX 121

ラウンドアップ®除草剤

【製造者情報】

作成者

会社名	モンサント・カンパニー
住所	800 North Lindbergh St. Louis, MO 63167, U.S.A.
緊急連絡先（電話番号	コレクトコール）
	314-694-4000（米国）
緊急時以外の問い合わせ先（電話番号）	
	1-800-332-3111（米国）

日本法人

会社名	日本モンサント株式会社
住所	東京都中央区銀座４－１０－１０ （銀座山王ビル8F）
電話番号	03-6226-6080
ファックス番号	03-3546-6191

連絡先（輸入販売元）

会社名	日産化学工業株式会社
住所	東京都千代田区神田錦町3-7-1
電話番号	**0120-20-9374（フリーダイヤル）** 03-3296-8151（農業化学品事業部）
ファックス番号	03-3296-8016

MSDS番号：S00012445
作成日：1999年6月
改訂日：2002年7月

【製品名】 ラウンドアップ®除草剤
類似名：MON 78742

【物質の特定】

単一製品・混合物の区分: 混合物

化学名及び含有量*

有効成分；
グリホサート、N-ホスホノメチルグリシン イソプロピル
アミン塩（イソプロピルアンモニウム=-（ホスホノメチル）
グリシナート） …… 41.0%

水、界面活性剤； …… 59.0%

100.0%

成分	CAS登録番号	%(重量)
グリホサート イソプロピルアミン塩	38641-94-0	41.0%
界面活性剤**		6.0%

国連分類： なし(危険物に該当しない)

* 化学物質管理促進法(PRTR法)における第一種又は第二種指定化学物質に該当する化学物質は含まれていない。

** モンサント社の商業上の秘密のため化学名を記載しない。

メニューへ戻る

ANNEX 121

【危険・有害性の分類】

分類基準に該当しない。

外観及び臭気: 無臭ないし、かすかなアミン様臭いのする透明粘稠なこはく色液体

有害性:

予想される暴露経路: 吸入及び皮膚接触

眼 : ラウンドアップ除草剤は毒性試験によると眼の痛み、充血及び流涙を起こす可能性がある。

皮膚 : ラウンドアップ除草剤は毒性試験によると皮膚に軽度の毒性ないし 刺激性を示す。

誤飲 : ラウンドアップ除草剤は毒性試験によると軽度な毒性を示す。少量を飲みこんだ場合(1口以下)有意な毒性症状は認められない。類似の製剤を飲み込んだ場合は口の刺激を伴う胃腸の不快感、吐気、嘔吐及び下痢が報告されている。類似の製品の大量の経口摂取では血圧低下及び肺浮腫が報告されている。

吸入 : データはない。

慢性毒性: ラウンドアップ除草剤の有効成分グリホサートの慢性経口投与では、実験動物に腫瘍を引き起こさない。

IARC 、NTPまたはOSHAの発がん物質リストにはない。米国環境保護庁はグリホサートをカテゴリーE(人間に発がん性はない)に分類している。詳細については有害性情報の項参照。

【応急措置】

目に入った場合: ただちに多量の水で最低15分以上洗眼する。医師の手当を受ける。

飲み込んだ場合: 直ちに水または牛乳を飲んで希釈する。医師の手当を受ける。

メニューへ戻る

【危険・有害性の分類】

分類基準に該当しない。

外観及び臭気: 無臭ないし、かすかなアミン様臭いのする透明粘稠なこはく色液体

有害性:

予想される暴露経路: 吸入及び皮膚接触

眼 : ラウンドアップ除草剤は毒性試験によると眼の痛み、充血及び流涙を起こす可能性がある。

皮膚 : ラウンドアップ除草剤は毒性試験によると皮膚に軽度の毒性ないし 刺激性を示す。

誤飲 : ラウンドアップ除草剤は毒性試験によると軽度な毒性を示す。少量を飲みこんだ場合(1口以下)有意な毒性症状は認められない。類似の製剤を飲み込んだ場合は口の刺激を伴う胃腸の不快感、吐気、嘔吐及び下痢が報告されている。類似の製品の大量の経口摂取では血圧低下及び肺浮腫が報告されている。

吸入 : データはない。

慢性毒性: ラウンドアップ除草剤の有効成分グリホサートの慢性経口投与では、実験動物に腫瘍を引き起こさない。

IARC 、NTPまたはOSHAの発がん物質リストにはない。米国環境保護庁はグリホサートをカテゴリーE(人間に発がん性はない)に分類している。詳細については有害性情報の項参照。

【応急措置】

目に入った場合: ただちに多量の水で最低15分以上洗眼する。医師の手当を受ける。

飲み込んだ場合: 直ちに水または牛乳を飲んで希釈する。医師の手当を受ける。

メニューへ戻る

ANNEX 121

【火災時の措置】

消火剤　：　水、泡、ドライケミカル及び炭酸ガス消火剤又は他のB類の消火剤

消火方法　：　蒸気ミスト又は本製品の燃焼物に暴露するおそれのある消防員やその 他の人々は、完全な防護服及び自給式呼吸装置を身につける。器具は使用後よく洗浄する。

特殊な燃焼または爆発の危険：なし

【漏出時の措置】

漏出物の除去にあたっては、ゴム製の長靴又はオーバーシューズの着用を含む防護及び安全上の注意をはらう。[曝露防止措置]を参照。

床に漏出した液は隔離又はせき止めてベントナイト等の鉱物質に吸収させる。吸収した鉱物質を集め、金属製ドラムに入れ、廃棄上の注意の項に従って処分する。床をよく拭き業務用の強力な洗剤で水とともに洗浄する。

漏出物がしみこんだ土は掘り出して、金属製ドラムに入れ廃棄上の注意の項に従って処分する。

漏出した容器は漏出していない容器と分けて、容器とその内容物をドラム又は漏出しない容器に入れ廃棄上の注意に従って処分する。回収した漏出液も同様に処分する。

【取扱い及び保管上の注意】

取扱い：

・眼及び衣服との接触をさける。

・取扱い後は、石けんと水で良く洗う。

・水域又は表流水及び平均満潮水位以下の潮間沼沢地に直接散布しない。

・廃液または散布器具の洗浄液を水域に流して汚染しないようにする。

保　管：

・保管、廃棄に際し、水、食料、飼料又は種子との混在がないようにする。

メニューへ戻る

【火災時の措置】

消火剤　：　水、泡、ドライケミカル及び炭酸ガス消火剤又は他のB類の消火剤

消火方法　：　蒸気ミスト又は本製品の燃焼物に暴露するおそれのある消防員やその 他の人々は、完全な防護服及び自給式呼吸装置を身につける。器具は使用後よく洗浄する。

特殊な燃焼または爆発の危険：なし

【漏出時の措置】

漏出物の除去にあたっては、ゴム製の長靴又はオーバーシューズの着用を含む防護及び安全上の注意をはらう。[曝露防止措置]を参照。

床に漏出した液は隔離又はせき止めてベントナイト等の鉱物質に吸収させる。吸収した鉱物質を集め、金属製ドラムに入れ、廃棄上の注意の項に従って処分する。床をよく拭き業務用の強力な洗剤で水とともに洗浄する。

漏出物がしみこんだ土は掘り出して、金属製ドラムに入れ廃棄上の注意の項に従って処分する。

漏出した容器は漏出していない容器と分けて、容器とその内容物をドラム又は漏出しない容器に入れ廃棄上の注意に従って処分する。回収した漏出液も同様に処分する。

【取扱い及び保管上の注意】

取扱い：

・眼及び衣服との接触をさける。

・取扱い後は、石けんと水で良く洗う。

・水域又は表流水及び平均満潮水位以下の潮間沼沢地に直接散布しない。

・廃液または散布器具の洗浄液を水域に流して汚染しないようにする。

保　管：

・保管、廃棄に際し、水、食料、飼料又は種子との混在がないようにする。

メニューへ戻る

ANNEX 121

【火災時の措置】

消火剤　：　水、泡、ドライケミカル及び炭酸ガス消火剤又は他のB類の消火剤

消火方法　：　蒸気ミスト又は本製品の燃焼物に暴露するおそれのある消防員やその 他の人々は、完全な防護服及び自給式呼吸装置を身につける。器具は使用後よく洗浄する。

特殊な燃焼または爆発の危険：なし

【漏出時の措置】

漏出物の除去にあたっては、ゴム製の長靴又はオーバーシューズの着用を含む防護及び安全上の注意をはらう。[曝露防止措置]を参照。

床に漏出した液は隔離又はせき止めてベントナイト等の鉱物質に吸収させる。吸収した鉱物質を集め、金属製ドラムに入れ、廃棄上の注意の項に従って処分する。床をよく拭き業務用の強力な洗剤で水とともに洗浄する。

漏出物がしみこんだ土は掘り出して、金属製ドラムに入れ廃棄上の注意の項に従って処分する。

漏出した容器は漏出していない容器と分けて、容器とその内容物をドラム又は漏出しない容器に入れ廃棄上の注意に従って処分する。回収した漏出液も同様に処分する。

【取扱い及び保管上の注意】

取扱い：

・眼及び衣服との接触をさける。

・取扱い後は、石けんと水で良く洗う。

・水域又は表流水及び平均満潮水位以下の潮間沼沢地に直接散布しない。

・廃液または散布器具の洗浄液を水域に流して汚染しないようにする。

保　管：

・保管、廃棄に際し、水、食料、飼料又は種子との混在がないようにする。

メニューへ戻る

【暴露防止措置】

暴露防止機器:

眼の保護:	ラウンドアップ除草剤は眼の保護のための特別な保護具を必要としない。眼に接触しないための適切な措置を取ること。
皮膚の保護:	ラウンドアップ除草剤は、皮膚の保護のための特別な保護具を必要としない。
呼吸による暴露防止:	希釈しない製品の取扱い: 希釈していないラウンドアップを通常の方法で取扱っても気中暴露の可能性は低い。製造時に多量の製品が露出した場合あるいは濃厚な蒸気やミストを発生するような作業に従事するときは呼吸器の保護具を着用すること。適切な保護具の選択にあたってはレスピレーターの製造メーカーに相談する。NIOSH/OSHAあるいはレスピレーターの製造メーカーの指定した使用範囲内で使用のこと。 製品ラベルに従った希釈液の散布: ラウンドアップの散布用希釈液の散布にあたっては、レスピレーターは必要ではない。
換気設備対策:	特別な対策は必要としない。

暴露指針:

暴露基準

	産業衛生学会	OSHA PEL	ACGIH TLV
グリホサート	なし	なし	なし
界面活性剤	なし	なし	なし

【物理／化学的性質】*

外観 :透明粘稠色液体

臭気 :ほとんど無臭ないし、わずかにアミン様臭

pH :4.6 (1%液)

比重 :1.17

*: これらの値は検査に基づく数値であって、ばらつきのある可能性がある。
これらの値は保証値あるいは、規格値ではない。

メニューへ戻る

ANNEX 121

【暴露防止措置】

暴露防止機器:

眼の保護:	ラウンドアップ除草剤は眼の保護のための特別な保護具を必要としない。眼に接触しないための適切な措置を取ること。
皮膚の保護:	ラウンドアップ除草剤は、皮膚の保護のための特別な保護具を必要としない。
呼吸による暴露防止:	希釈しない製品の取扱い: 希釈していないラウンドアップを通常の方法で取扱っても気中暴露の可能性は低い。製造時に多量の製品が露出した場合あるいは濃厚な蒸気やミストを発生するような作業に従事するときは呼吸器の保護具を着用すること。適切な保護具の選択にあたってはレスピレーターの製造メーカーに相談する。NIOSH/OSHAあるいはレスピレーターの製造メーカーの指定した使用範囲内で使用のこと。 製品ラベルに従った希釈液の散布: ラウンドアップの散布用希釈液の散布にあたっては、レスピレーターは必要ではない。
換気設備対策:	特別な対策は必要としない。

暴露指針:

暴露基準

	産業衛生学会	OSHA PEL	ACGIH TLV
グリホサート	なし	なし	なし
界面活性剤	なし	なし	なし

【物理／化学的性質】*

外観 :透明粘稠色液体

臭気 :ほとんど無臭ないし、わずかにアミン様臭

pH :4.6 (1%液)

比重 :1.17

*: これらの値は検査に基づく数値であって、ばらつきのある可能性がある。
これらの値は保証値あるいは、規格値ではない。

メニューへ戻る

【危険性情報】(安定性・反応性)

引火点:	93.3℃ (200° F)以上　方法: TCC
発火点:	測定せず
化学的安定性:	本製品は、通常の保管条件において少なくとも5年間安定である。
避けるべき条件:	なし
他の物質との混合安定性:	本製品および溶液の混合、保存又は散布のためには、ステンレススチール、アルミニウム、ファイバーグラス、プラスチック又はプラスチックの内層の容器内で行うこと。 メッキをした又は内層のない鋼鉄製の容器又は散布器具(ステンレススチールを除く)を用いて混合、保管又は散布しないこと。これらの容器に、本製品を入れると引火性の水素ガスの混合気体を生ずることがある。この混合気体は引火、爆発の可能性があり、裸火、スパーク、溶接火花、煙草、その他の火気により人身事故の要因となりうる。
分解物の危険性:	なし。
重合による危険性:	なし。本製品はアルカリ物質と反応し、発熱する可能性がある。重合の可能性はないが、酸アルカリ反応による中和熱を発生することはありうる。

【有害性情報】

単回投与(急性)毒性:

経　口　:	ラットLD50　＞　5,000 mg／kg マウスLD50　＞　5,000 mg／kg
経　皮　:	ラットLD50　＞　2,000 mg／kg
眼一次刺激性:	中等度の刺激
皮膚一次刺激性:	軽度の刺激
皮膚感作性 :	モルモットを用いた反復投与による試験では、皮膚感作性は認められなかった。
吸入毒性 :	わずかな毒性(ラット4時間 LC50 > 2.2 mg/L 到達可能な最高気中濃度)

ラウンドアップの成分についてモンサント社が実施した試験データ:

グリホサートイソプロピルアミン塩(62%)すなわちMON0139を用いた毒性試験のデータ:

MON0139の反復経口投与(6ケ月)により犬にわずかな体重増加抑制が認められた。MON0139の反復経皮投与(3週間)によりウサギにおいて認められた影響は皮膚一次刺激性だけであった。

グリホサートすなわちラウンドアップの有効成分についての毒性に関する情報は以下の通り入手可能である。

グリホサートの反復投与(90日間)の結果マウスにおいて体重増加の抑制が認められたが、ラットにおいては、何等投与に関連する作用は

認められなかった。皮膚に対する反復投与(3週間)の結果、ウサギにおける主要な作用は軽微な皮膚刺激にとどまった。皮膚に対する反復投与にもかかわらずモルモットにおける皮膚感作性は、認められなかった。神経系に対する作用は、ニワトリに対する遅延神経毒性(反復経口投与)あるいはラットにおけるコリンエステラーゼ阻害(単回経口投与)を含め認められていない。長期にわたるグリホサートの(2ケ年)混餌投与試験の結果マウスの体重増加の減少及び肝組織に対する影響が高用量群において見られた。

ラットにおける1つの長期(2ケ年)混餌投与試験において体重増加の減少及び眼の病変が高用量群において認められたが、2回目の試験では認められなかった。これらの試験においてグリホサートによる腫瘍の発生は認められなかった。これらの慢性毒性試験の結果から米国環境保護庁(EPA)は、グリホサートを催腫瘍性につきカテゴリーE(人間に対する発がん性がない)に分類した。グリホサートをラット及びウサギの妊娠期に母獣に対する毒性を生ずる用量で経口投与しても奇形の発生は認められなかった。グリホサートをラットの2世代にわたり極めて高用量で混餌投与した。母獣に毒性を生じた高用量で、仔動物に毒性が認められた。これよりも低い用量で実施されたラットにおける3世代繁殖試験ではラットの雌雄の繁殖能力に影響を与えないことが明らかになった。動物・動物細胞あるいはバクテリアの細胞を用いた標準的試験系においてグリホサートは遺伝毒性を生じなかった。

界面活性剤:	ラウンドアップ除草剤の成分である界面活性剤は眼及び皮膚に刺激性を生ずる可能性があり、本剤の刺激性は界面 活性剤のこうした性質による可能性がある。

メニューへ戻る

【危険性情報】(安定性・反応性)

引火点:	93.3℃ (200° F)以上　方法: TCC
発火点:	測定せず
化学的安定性:	本製品は、通常の保管条件において少なくとも5年間安定である。
避けるべき条件:	なし
他の物質との混合安定性:	本製品および溶液の混合、保存又は散布のためには、ステンレススチール、アルミニウム、ファイバーグラス、プラスチック又はプラスチックの内層の容器内で行うこと。 メッキをした又は内層のない鋼鉄製の容器又は散布器具(ステンレススチールを除く)を用いて混合、保管又は散布しないこと。これらの容器に、本製品を入れると引火性の水素ガスの混合気体を生ずることがある。この混合気体は引火、爆発の可能性があり、裸火、スパーク、溶接火花、煙草、その他の火気により人身事故の要因となりうる。
分解物の危険性:	なし。
重合による危険性:	なし。本製品はアルカリ物質と反応し、発熱する可能性がある。重合の可能性はないが、酸アルカリ反応による中和熱を発生することはありうる。

【有害性情報】

単回投与(急性)毒性:

経　口　:	ラットLD50　＞　5,000 mg／kg マウスLD50　＞　5,000 mg／kg
経　皮　:	ラットLD50　＞　2,000 mg／kg
眼一次刺激性:	中等度の刺激
皮膚一次刺激性:	軽度の刺激
皮膚感作性 :	モルモットを用いた反復投与による試験では、皮膚感作性は認められなかった。
吸入毒性 :	わずかな毒性(ラット4時間 LC50 > 2.2 mg/L 到達可能な最高気中濃度)

ラウンドアップの成分についてモンサント社が実施した試験データ:

グリホサートイソプロピルアミン塩(62%)すなわちMON0139を用いた毒性試験のデータ:

MON0139の反復経口投与(6ケ月)により犬にわずかな体重増加抑制が認められた。MON0139の反復経皮投与(3週間)によりウサギにおいて認められた影響は皮膚一次刺激性だけであった。

グリホサートすなわちラウンドアップの有効成分についての毒性に関する情報は以下の通り入手可能である。

グリホサートの反復投与(90日間)の結果マウスにおいて体重増加の抑制が認められたが、ラットにおいては、何等投与に関連する作用は

認められなかった。皮膚に対する反復投与(3週間)の結果、ウサギにおける主要な作用は軽微な皮膚刺激にとどまった。皮膚に対する反復投与にもかかわらずモルモットにおける皮膚感作性は、認められなかった。神経系に対する作用は、ニワトリに対する遅延神経毒性(反復経口投与)あるいはラットにおけるコリンエステラーゼ阻害(単回経口投与)を含め認められていない。長期にわたるグリホサートの(2ケ年)混餌投与試験の結果マウスの体重増加の減少及び肝組織に対する影響が高用量群において見られた。

ラットにおける1つの長期(2ケ年)混餌投与試験において体重増加の減少及び眼の病変が高用量群において認められたが、2回目の試験では認められなかった。これらの試験においてグリホサートによる腫瘍の発生は認められなかった。これらの慢性毒性試験の結果から米国環境保護庁(EPA)は、グリホサートを催腫瘍性につきカテゴリーE(人間に対する発がん性がない)に分類した。グリホサートをラット及びウサギの妊娠期に母獣に対する毒性を生ずる用量で経口投与しても奇形の発生は認められなかった。グリホサートをラットの2世代にわたり極めて高用量で混餌投与した。母獣に毒性を生じた高用量で、仔動物に毒性が認められた。これよりも低い用量で実施されたラットにおける3世代繁殖試験ではラットの雌雄の繁殖能力に影響を与えないことが明らかになった。動物・動物細胞あるいはバクテリアの細胞を用いた標準的試験系においてグリホサートは遺伝毒性を生じなかった。

界面活性剤:	ラウンドアップ除草剤の成分である界面活性剤は眼及び皮膚に刺激性を生ずる可能性があり、本剤の刺激性は界面 活性剤のこうした性質による可能性がある。

メニューへ戻る

【環境影響情報】

MON78742は代表的水生生物に対し、低毒性を示した。短期試験では、わずかな毒性を魚類(コイ48、96時間LC50 25.4mg/L)及び水生無脊椎動物(オオミジンコ Daphnia magna 24時間LC50 7.64mg/L、同3時間LC50 1000mg/L)に示した。

湛水水田条件におけるコイの毒性試験では供試したどの濃度でも死亡は認められなかった。供試濃度は通常の散布より生ずる濃度と同じかより高い濃度であった。試験期間は96時間であった。

【輸送上の注意】

取扱い保管の項の注意事項及び除草剤の一般的注意事項を守ること。

国連分類及び国連番号: 普通物につき該当せず。

【廃棄上の注意】

本製品使用に伴う廃棄物で使用に適さないか、または化学的に再利用できない物は農薬の廃棄の許可されている合法的な方法で適切に処理すること。

空容器には蒸気と製品の残留物が残っている。容器を洗浄するか破棄するまでは製品ラベルの注意事項を守ること。本容器の近くで切断、または溶接作業を行わないこと。

容器を再利用しないこと。容器を3回洗浄し、

(1) 市町村が回収・処分しているところでは、定められた方法により処分する。

(2) 農薬の空容器を適正に回収処分するシステムが確立しているところでは、当該システムにより処分する。

(3) 農家等農薬空容器の排出事業者が、自ら産業廃棄物業者に処理を委託する。

【適用法令】

農薬取締法: 除草剤、農林水産省 登録 第14360号

化 審 法: 既存化学物質 N-(ホスホノメチル)グリシン

【その他】

本安全データシートは製品ラベル(製品の容器に添付されている)とは別の目的で作成されたものである。安全データシートは、健康、安全、環境の保全に関する重要な情報を多量の製品を本剤の本来目的とする使用とは別に取扱う作業者、その雇用者及び緊急対策要員に対し提供するために用意されている。

一方、製品ラベルは通常に使用方法を具体的に示す情報を提供するものである。

農薬の使用、保管及び廃棄については、製品ラベルに従うこと、また、使用保管及び廃棄についての必要にして適切な注意事項は製品ラベルに表示されている。製品ラベルに表示されていない方法による使用は脱法行為である。

ANNEX 121

ここに記載する情報及び注意事項（以下「情報」という）は、上記の日付の時点で正確なものと信じ提示したものであるが、モンサント社は、情報の完全性又は正確性を断言するものではない。情報は、それを受け取る者が、それを利用する前に自己の目的に適しているかどうかを自分で判断するという条件に基づいて供給されるものである。情報の使用によって又はこれを信頼したために何らかの性質の被害が発生しても、モンサント社はいかなる場合も被害に対する責任を負わない。本文書に掲載した情報又は情報が言及した製品に関して、その市場性、特定の用途への適合性、又はその他の性質について、暗示的にも、ここに断言又は保証するものではない。

財団法人　日本中毒情報センター

散布作業中や散布後に異常を感じた場合は、直ちに医師の手当を受けて下さい。処置法などで不明なことは、医師から下記に電話してお尋ね下さい。

中毒110番	ダイヤルQ2 （3分300円）	医療機関専用 有料電話 （一件につき2,000円）
大　阪 （365日・24時間対応）	0990-50-2499	0727-26-9923
つくば （365日・9～21時対応）	0990-52-9899	0298-51-9999

メニューへ戻る

【環境影響情報】

MON78742は代表的水生生物に対し、低毒性を示した。短期試験では、わずかな毒性を魚類(コイ48、96時間LC50 25.4mg/L)及び水生無脊椎動物(オオミジンコ Daphnia magna 24時間LC50 7.64mg/L、同3時間LC50 1000mg/L)に示した。

湛水水田条件におけるコイの毒性試験では供試したどの濃度でも死亡は認められなかった。供試濃度は通常の散布より生ずる濃度と同じかより高い濃度であった。試験期間は96時間であった。

【輸送上の注意】

取扱い保管の項の注意事項及び除草剤の一般的注意事項を守ること。

国連分類及び国連番号: 普通物につき該当せず。

【廃棄上の注意】

本製品使用に伴う廃棄物で使用に適さないか、または化学的に再利用できない物は農薬の廃棄の許可されている合法的な方法で適切に処理すること。

空容器には蒸気と製品の残留物が残っている。容器を洗浄するか破棄するまでは製品ラベルの注意事項を守ること。本容器の近くで切断、または溶接作業を行わないこと。

容器を再利用しないこと。容器を3回洗浄し、

(1) 市町村が回収・処分しているところでは、定められた方法により処分する。

(2) 農薬の空容器を適正に回収処分するシステムが確立しているところでは、当該システムにより処分する。

(3) 農家等農薬空容器の排出事業者が、自ら産業廃棄物業者に処理を委託する。

【適用法令】

農薬取締法: 除草剤、農林水産省 登録 第14360号

化 審 法: 既存化学物質 N-(ホスホノメチル)グリシン

【その他】

本安全データシートは製品ラベル(製品の容器に添付されている)とは別の目的で作成されたものである。安全データシートは、健康、安全、環境の保全に関する重要な情報を多量の製品を本剤の本来目的とする使用とは別に取扱う作業者、その雇用者及び緊急対策要員に対し提供するために用意されている。

一方、製品ラベルは通常に使用方法を具体的に示す情報を提供するものである。

農薬の使用、保管及び廃棄については、製品ラベルに従うこと、また、使用保管及び廃棄についての必要にして適切な注意事項は製品ラベルに表示されている。製品ラベルに表示されていない方法による使用は脱法行為である。

ANNEX 121

ここに記載する情報及び注意事項（以下「情報」という）は、上記の日付の時点で正確なものと信じ提示したものであるが、モンサント社は、情報の完全性又は正確性を断言するものではない。情報は、それを受け取る者が、それを利用する前に自己の目的に適しているかどうかを自分で判断するという条件に基づいて供給されるものである。情報の使用によって又はこれを信頼したために何らかの性質の被害が発生しても、モンサント社はいかなる場合も被害に対する責任を負わない。本文書に掲載した情報又は情報が言及した製品に関して、その市場性、特定の用途への適合性、又はその他の性質について、暗示的にも、ここに断言又は保証するものではない。

財団法人　日本中毒情報センター

散布作業中や散布後に異常を感じた場合は、直ちに医師の手当を受けて下さい。処置法などで不明なことは、医師から下記に電話してお尋ね下さい。

中毒110番	ダイヤルQ2 （3分300円）	医療機関専用 有料電話 （一件につき2,000円）
大　阪 （365日・24時間対応）	0990-50-2499	0727-26-9923
つくば （365日・9～21時対応）	0990-52-9899	0298-51-9999

メニューへ戻る

【環境影響情報】

MON78742は代表的水生生物に対し、低毒性を示した。短期試験では、わずかな毒性を魚類(コイ48、96時間LC50 25.4mg/L)及び水生無脊椎動物(オオミジンコ Daphnia magna 24時間LC50 7.64mg/L、同3時間LC50 1000mg/L)に示した。

湛水水田条件におけるコイの毒性試験では供試したどの濃度でも死亡は認められなかった。供試濃度は通常の散布より生ずる濃度と同じかより高い濃度であった。試験期間は96時間であった。

【輸送上の注意】

取扱い保管の項の注意事項及び除草剤の一般的注意事項を守ること。

国連分類及び国連番号: 普通物につき該当せず。

【廃棄上の注意】

本製品使用に伴う廃棄物で使用に適さないか、または化学的に再利用できない物は農薬の廃棄の許可されている合法的な方法で適切に処理すること。

空容器には蒸気と製品の残留物が残っている。容器を洗浄するか破棄するまでは製品ラベルの注意事項を守ること。本容器の近くで切断、または溶接作業を行わないこと。

容器を再利用しないこと。容器を3回洗浄し、

(1) 市町村が回収・処分しているところでは、定められた方法により処分する。

(2) 農薬の空容器を適正に回収処分するシステムが確立しているところでは、当該システムにより処分する。

(3) 農家等農薬空容器の排出事業者が、自ら産業廃棄物業者に処理を委託する。

【適用法令】

農薬取締法: 除草剤、農林水産省 登録 第14360号

化 審 法: 既存化学物質 N-(ホスホノメチル)グリシン

【その他】

本安全データシートは製品ラベル(製品の容器に添付されている)とは別の目的で作成されたものである。安全データシートは、健康、安全、環境の保全に関する重要な情報を多量の製品を本剤の本来目的とする使用とは別に取扱う作業者、その雇用者及び緊急対策要員に対し提供するために用意されている。

一方、製品ラベルは通常に使用方法を具体的に示す情報を提供するものである。

農薬の使用、保管及び廃棄については、製品ラベルに従うこと、また、使用保管及び廃棄についての必要にして適切な注意事項は製品ラベルに表示されている。製品ラベルに表示されていない方法による使用は脱法行為である。

ANNEX 121

ここに記載する情報及び注意事項（以下「情報」という）は、上記の日付の時点で正確なものと信じ提示したものであるが、モンサント社は、情報の完全性又は正確性を断言するものではない。情報は、それを受け取る者が、それを利用する前に自己の目的に適しているかどうかを自分で判断するという条件に基づいて供給されるものである。情報の使用によって又はこれを信頼したために何らかの性質の被害が発生しても、モンサント社はいかなる場合も被害に対する責任を負わない。本文書に掲載した情報又は情報が言及した製品に関して、その市場性、特定の用途への適合性、又はその他の性質について、暗示的にも、ここに断言又は保証するものではない。

財団法人　日本中毒情報センター

散布作業中や散布後に異常を感じた場合は、直ちに医師の手当を受けて下さい。処置法などで不明なことは、医師から下記に電話してお尋ね下さい。

中毒110番	ダイヤルQ2 （3分300円）	医療機関専用 有料電話 （一件につき2,000円）
大　阪 （365日・24時間対応）	0990-50-2499	0727-26-9923
つくば （365日・9～21時対応）	0990-52-9899	0298-51-9999

メニューへ戻る

【環境影響情報】

MON78742は代表的水生生物に対し、低毒性を示した。短期試験では、わずかな毒性を魚類(コイ48、96時間LC50 25.4mg/L)及び水生無脊椎動物(オオミジンコ Daphnia magna 24時間LC50 7.64mg/L、同3時間LC50 1000mg/L)に示した。

湛水水田条件におけるコイの毒性試験では供試したどの濃度でも死亡は認められなかった。供試濃度は通常の散布より生ずる濃度と同じかより高い濃度であった。試験期間は96時間であった。

【輸送上の注意】

取扱い保管の項の注意事項及び除草剤の一般的注意事項を守ること。

国連分類及び国連番号: 普通物につき該当せず。

【廃棄上の注意】

本製品使用に伴う廃棄物で使用に適さないか、または化学的に再利用できない物は農薬の廃棄の許可されている合法的な方法で適切に処理すること。

空容器には蒸気と製品の残留物が残っている。容器を洗浄するか破棄するまでは製品ラベルの注意事項を守ること。本容器の近くで切断、または溶接作業を行わないこと。

容器を再利用しないこと。容器を3回洗浄し、

(1) 市町村が回収・処分しているところでは、定められた方法により処分する。

(2) 農薬の空容器を適正に回収処分するシステムが確立しているところでは、当該システムにより処分する。

(3) 農家等農薬空容器の排出事業者が、自ら産業廃棄物業者に処理を委託する。

【適用法令】

農薬取締法: 除草剤、農林水産省 登録 第14360号

化 審 法: 既存化学物質 N-(ホスホノメチル)グリシン

【その他】

本安全データシートは製品ラベル(製品の容器に添付されている)とは別の目的で作成されたものである。安全データシートは、健康、安全、環境の保全に関する重要な情報を多量の製品を本剤の本来目的とする使用とは別に取扱う作業者、その雇用者及び緊急対策要員に対し提供するために用意されている。

一方、製品ラベルは通常に使用方法を具体的に示す情報を提供するものである。

農薬の使用、保管及び廃棄については、製品ラベルに従うこと、また、使用保管及び廃棄についての必要にして適切な注意事項は製品ラベルに表示されている。製品ラベルに表示されていない方法による使用は脱法行為である。

ANNEX 121

ここに記載する情報及び注意事項（以下「情報」という）は、上記の日付の時点で正確なものと信じ提示したものであるが、モンサント社は、情報の完全性又は正確性を断言するものではない。情報は、それを受け取る者が、それを利用する前に自己の目的に適しているかどうかを自分で判断するという条件に基づいて供給されるものである。情報の使用によって又はこれを信頼したために何らかの性質の被害が発生しても、モンサント社はいかなる場合も被害に対する責任を負わない。本文書に掲載した情報又は情報が言及した製品に関して、その市場性、特定の用途への適合性、又はその他の性質について、暗示的にも、ここに断言又は保証するものではない。

財団法人　日本中毒情報センター

散布作業中や散布後に異常を感じた場合は、直ちに医師の手当を受けて下さい。処置法などで不明なことは、医師から下記に電話してお尋ね下さい。

中毒110番	ダイヤルQ2 （3分300円）	医療機関専用 有料電話 （一件につき2,000円）
大　阪 （365日・24時間対応）	0990-50-2499	0727-26-9923
つくば （365日・9～21時対応）	0990-52-9899	0298-51-9999

メニューへ戻る

【環境影響情報】

MON78742は代表的水生生物に対し、低毒性を示した。短期試験では、わずかな毒性を魚類(コイ48、96時間LC50 25.4mg/L)及び水生無脊椎動物(オオミジンコ Daphnia magna 24時間LC50 7.64mg/L、同3時間LC50 1000mg/L)に示した。

湛水水田条件におけるコイの毒性試験では供試したどの濃度でも死亡は認められなかった。供試濃度は通常の散布より生ずる濃度と同じかより高い濃度であった。試験期間は96時間であった。

【輸送上の注意】

取扱い保管の項の注意事項及び除草剤の一般的注意事項を守ること。

国連分類及び国連番号: 普通物につき該当せず。

【廃棄上の注意】

本製品使用に伴う廃棄物で使用に適さないか、または化学的に再利用できない物は農薬の廃棄の許可されている合法的な方法で適切に処理すること。

空容器には蒸気と製品の残留物が残っている。容器を洗浄するか破棄するまでは製品ラベルの注意事項を守ること。本容器の近くで切断、または溶接作業を行わないこと。

容器を再利用しないこと。容器を3回洗浄し、

(1) 市町村が回収・処分しているところでは、定められた方法により処分する。

(2) 農薬の空容器を適正に回収処分するシステムが確立しているところでは、当該システムにより処分する。

(3) 農家等農薬空容器の排出事業者が、自ら産業廃棄物業者に処理を委託する。

【適用法令】

農薬取締法: 除草剤、農林水産省 登録 第14360号

化 審 法: 既存化学物質 N-(ホスホノメチル)グリシン

【その他】

本安全データシートは製品ラベル(製品の容器に添付されている)とは別の目的で作成されたものである。安全データシートは、健康、安全、環境の保全に関する重要な情報を多量の製品を本剤の本来目的とする使用とは別に取扱う作業者、その雇用者及び緊急対策要員に対し提供するために用意されている。

一方、製品ラベルは通常に使用方法を具体的に示す情報を提供するものである。

農薬の使用、保管及び廃棄については、製品ラベルに従うこと、また、使用保管及び廃棄についての必要にして適切な注意事項は製品ラベルに表示されている。製品ラベルに表示されていない方法による使用は脱法行為である。

ANNEX 121

ここに記載する情報及び注意事項（以下「情報」という）は、上記の日付の時点で正確なものと信じ提示したものであるが、モンサント社は、情報の完全性又は正確性を断言するものではない。情報は、それを受け取る者が、それを利用する前に自己の目的に適しているかどうかを自分で判断するという条件に基づいて供給されるものである。情報の使用によって又はこれを信頼したために何らかの性質の被害が発生しても、モンサント社はいかなる場合も被害に対する責任を負わない。本文書に掲載した情報又は情報が言及した製品に関して、その市場性、特定の用途への適合性、又はその他の性質について、暗示的にも、ここに断言又は保証するものではない。

財団法人　日本中毒情報センター

散布作業中や散布後に異常を感じた場合は、直ちに医師の手当を受けて下さい。処置法などで不明なことは、医師から下記に電話してお尋ね下さい。

中毒110番	ダイヤルQ2 （3分300円）	医療機関専用 有料電話 （一件につき2,000円）
大　阪 （365日・24時間対応）	0990-50-2499	0727-26-9923
つくば （365日・9～21時対応）	0990-52-9899	0298-51-9999

メニューへ戻る

ANNEX 122

South Africa Roundup Label

[redacted]

Roundup®

Onkruiddoder deur
Herbicide by Monsanto

NOODTELEFOON/EMERGENCY TELEPHONE
(011) 790 8200 (Kantoor-ure/Office hrs)
09.1.314.694 4000
(24 uur internasionaal/24 hr international)

MONSANTO

Reg. Nr. L407 Wet 36/1947
'n Oplosbare konsentraat, nie-selektiewe, sistemiese na-opkomsonkruiddoder met min of geen grond-aktiwiteit vir die beheer van een- en meerjarige onkruide in die landbou, onbeboude en nywerheidsgebiede. ROUNDUP kan ook gebruik word as groeireguleerder vir die verhoging van sukrose in suikerriet en die vertraging van groei in onkruide.

Aktiewe bestanddeel
Glifosaat: (Glisien) 360g s.e./ℓ
(glifosaat isopropielamiensout 480 g/ℓ)
ONKRUIDWEERSTANDGROEP G

Geregistreer, vervaardig en versprei deur:
Monsanto Suid-Afrika (Edms) Bpk
Reg. No. 1968/001485/07
Posbus 69933
BRYANSTON
2021

Datum van vervaardiging
Date of Manufacture

Reg. No. L407 Act 36/1947
A soluble concentrate, non-selective, systemic post-emergence herbicide with little or no soil activity for the control of annual and perennial weeds in agricultural, non-crop and industrial areas. ROUNDUP can be used as a growth regulator to increase the sucrose content of sugar cane or reduce growth of weeds.

Active ingredient
Glyphosate (Glysine) 360g s.e./ℓ
(glyphosate isopropylamine salt 480 g/ℓ)
HERBICIDE RESISTANCE GROUP G

Registered, manufactured and distributed by:
Monsanto South Africa (Pty) Ltd.
Reg. No.1968/001485/07
P.O. Box 69933
BRYANSTON
2021
UN NUMBER 3082
Lot Nr.
Batch No.

DPM IB 120902

WAARSKUWINGS

- Giftig indien ingeneem.
- Irriterend vir die vel en oë.
- Moenie ROUNDUP-oplossings meng, berg of toedien vanuit gegalvaniseerde staal of ongevoeringde houers (behalwe vlekvrye staal) of spuittenks nie, aangesien dit chemies met die staal reageer om waterstofgas te vorm wat hoogs vlambaar is.
- Lugtoediening: Stel alle inwoners in die onmiddelike omgewing van die voorgenome bespuitingsgebied in kennis en reik die nodige waarskuwings uit.
- Stoor buite die bereik van voedsel, voer, saad, kunsmis en ander landbouchemikalieë.
- Hou buite die bereik van kinders, diere en oningeligte persone.
- Hoewel ROUNDUP op 'n verteenwoordigende reeks ekonomies belangrike plantvariëteite onder 'n groot verskeidenheid grond- en klimaatstoestande getoets is, waarborg die registrasiehouer nie dat hierdie produk

WARNINGS

- Poisonous if swallowed.
- Irritating to eyes and skin.
- Do not mix, store or apply ROUNDUP solutions in galvanized steel or unlined steel (except stainless steel) containers or spray tanks as a reaction will produce hydrogen gas which is highly combustible.
- Aerial application: Notify all inhabitants in the immediate vicinity of the area to be sprayed and issue the necessary warnings.
- Store away from food, feeds, seed, fertilizers and other agricultural chemicals.
- Keep out of reach of children, animals and uninformed persons.
- Although ROUNDUP has been tested on a representative sample of economically important plant varieties under a large variety of soil and climatic conditions, the registration holder does not warrant that this product will

onder alle omstandighede doeltreffend en veilig vir die gewasse sal wees nie. Die registrasiehouer aanvaar nie verantwoordelikheid vir, of gewasskade of ondoeltreffendheid as gevolg van die voorkoms van toestande wat nie geredelikwys voorsien kon word nie.

be effective and safe to crops under all conditions. The registration holder does not accept responsibility for either crop damage or non-performance due to the occurrence of conditions which could not reasonably have been foreseen.

- Raadpleeg u verskaffer in geval van enige onsekerheid.

- Consult your supplier in the event of any uncertainty.

VOORSORGMAATRËELS

PRECAUTIONS

- Moenie dampe of spuitnewel inasem nie.

- No not breathe in fumes or spray mist.

- In die geval van aanraking met die vel of oë moet daar dadelik met baie water gewas word. In die geval van oë, verkry mediese aandag indien nodig.

- In case of accidental contact with skin or eyes, wash immediately with plenty of water, and in the case of eyes get medical attention if necessary.

- Voorkom wegdrywing van spuitnewel en/of besoedeling van gevoelige of eetbare gewasse, weiding en enige ander gebied wat nie behandel word nie. Dit mag gewasskade veroorsaak.

- Prevent spray drift and/or contamination onto susceptible or edible crops, grazing or any other areas not under treatment as this may cause serious crop damage.

- Direkte of spuitnewelkontak van ROUNDUP met blare en/of onvolwasse bas van gewensde plante kan lei tot gelokaliseerde

- Direct or spray drift contact by ROUNDUP onto leaves and/or immature bark of desired plants can result in serious localized or

of getranslokeerde skade.

- Spoel leë houer driekeer uit met 'n volume water gelykstaande aan 'n minimum van 10% van die houer. Gooi die spoelwater by die inhoud van die spuittenk en vernietig dan die houer deur dit stukkend te steek en plat te trap. Moenie vir enige ander doel gebruik nie.

- Vermy besoedeling van voedsel, voer, drinkwater en eetgerei.

translocated damage.

- Rinse empty container three times with a volume of water equal to a minimum of 10% of that of the container. Add the rinsings to the contents of the spray tank before destroying the container by perforation and flattening and do not use for any other purpose.

- Prevent contamination of food, feed, drinking water and eating utensils.

GEBRUIKSAANWYSINGS

DIRECTIONS FOR USE

GEBRUIK ALLEENLIK SOOS AANGEDUI

USE ONLY AS DIRECTED

Algemene inligting

General information

- Die totale effek van ROUNDUP is eers vanaf twee weke na toediening sigbaar.

- Dien ROUNDUP na opkoms van die onkruid toe. Rig bespuiting op die blare en onvolwasse bas van aktiefgroeiende onkruide. Bespuit die moeilik beheerbare meerjarige onkruide in die herfs ten tye van aktiewe translokasie

- The herbicidal action is only visible from two weeks after application onwards.

- Apply ROUNDUP post-emergence to vigorously growing weeds, directed on to the foliage and immature bark. For difficult to control perennial weeds, application in autumn is recommended when weeds are actively trans-

TOEDIENINGS INSTRUKSIES

APPLICATION INFORMATION

- Maak seker dat spuittoerusting skoon en vry is van roes, stof of sediment van ander plaagdoders.
- Gebruik altyd skoon, goeie kwaliteit water. Voorkom die gebruik van water met 'n hoë kolloïedinhoud as gevolg van grond hoog in organiese materiaal of modderige water. Waar alkaliese en/of hardewater voorkom, word die byvoeging van Bladbuff 5 volgens etiket aanbeveel.
- Kalibreer alle spuite korrek onder veldtoestande.
- In situasies waar spuitnewel gevaarlik kan wees moet 'n lae druk van 100 - 200 kPa en/of laenewelspuitkoppe gebruik word.
- Moenie in windsnelhede van meer as 10km/uur spuit nie.
- Verseker 'n fyn, egalige druppelverspreiding en 'n deeglike bedekking van die teikenonkruide.

LUGTOEDIENING

- Dien 'n totale mengsel van 20-50 ℓ/ha toe en vermy spuitnewel op nie-teikenplante.

- Ensure that spray equipment is clean and free of rust, dust and sediment from other pesticides.
- Always use clean, good quality water. Avoid the use of brack or muddy water, or water with a high colloid content derived from soils high in organic matter. Where alkaline and/or hard water occurs, Bladbuff 5 should be added according to label recommendations.
- Calibrate all sprayers correctly under field conditions.
- In situations where drift may be hazardous, use low pressures of 100 to 200 kPa and or low drift nozzles when spraying.
- Do not spray when wind speed exceeds 10km/h.
- Ensure a fine, even droplet distribution and thorough coverage of the target weeds.

AERIAL APPLICATION

- Apply a total mixture rate of 20-50 ℓ/ha, avoiding drift onto non target vegetation.

TOEDIENINGS INSTRUKSIES

APPLICATION INFORMATION

- Beheer spuitnewel deur byvoeging van 'n newel-beheermiddel en/of gebruik spesiale laenewel-spuitkoppe.

- Moenie toedien as die windsnelheid 10km/uur oorskry en/of die relatiewe humiditeit laer as 40% is nie. 'n VMD van 300 tot 400 mikron word aanbeveel.

- Spuitvliegtuie moet daagliks deeglik na bespuiting gewas word, veral die landingstruktuur, om sodoende van residue wat wegvreting veroorsaak, ontslae te raak.

BEVORDERINGSMIDDELS EN BYVOEGMIDDELS

- Vir optimale resultate word 'n minimum van 1,5% ROUNDUP - oplossing per totale spuitvolume aanbeveel. Indien laer, behoort 0,5% bevorderingsmiddel (0,5 ℓ/100ℓ water) by die spuitvolume gevoeg te word.

Voorbeeld:
- 3,0ℓ ROUNDUP in 197ℓ water/ha (1,5% - oplossing) = Geen bevorderingsmiddel nodig nie.
- 1,5ℓ ROUNDUP in 198.5ℓ water/ha (0,75%-oplossing) = Voeg 1,0ℓ bevorderingsmiddel by die totale spuitvolume.

- Control drift by the addition of a drift reducing agent and/or use low drift nozzles.

- Do NOT spray when wind speed exceeds 10km/h and/or relative humidity is less than 40%. VMD should be between 300 to 400 microns.

- Thoroughly wash aircraft, especially the landing gear, after each days spraying to remove residues of the product which may result in corrosion.

SURFACTANTS/ADDITIVES

- For optimum results a minimum of 1,5% ROUNDUP solution in the total spray volume is recommended. If it is less, 0,5% surfactant (0,5ℓ/100ℓ water) should be added to the spray volume.

Example:
- 3.0ℓ ROUNDUP in 197ℓ water/ha (1,5% solution) = No surfactant is needed.
- 1.5ℓ ROUNDUP in 198.5ℓ water/ha (0,75% solution) = Add 1,0ℓ surfactant to the spray volume.

ANNEX 123

United Kingdom Glyphosate 360 Label

GLYPHOSATE 360 UK label (new format): Front label

Revised 26.9.03

- Herbicide

GLYPHOSATE 360

A foliar applied herbicide for the control of annual and perennial grassland and broad-leaved weeds before sowing or planting all crops.
For use pre-harvest in cereals and certain other crops, destruction of grassland, and in stubbles, orchards and non-crop areas.

This product is an aqueous concentrate containing 360 g/l glyphosate present as 480 g/l (41.1% w.w.) of the isopropylamine salt of glyphosate and polyoxyethylene amine surfactant

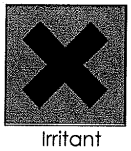
The (COSHH) Control of Substances Hazardous to Health Regulations may apply to the use of this product at work

Contents **e** up to 20 litres

MAPP Number 11726

PROTECT FROM FROST

Imported



Irritant

Dangerous for the environment

IRRITATING TO EYES.
TOXIC TO AQUATIC ORGANISMS, MAY CAUSE LONG-TERM ADVERSE EFFECTS IN THE AQUATIC ENVIRONMENT.

AVOID CONTACT WITH EYES.
IN CASE OF CONTACT WITH EYES, RINSE IMMEDIATELY WITH PLENTY OF WATER & SEEK MEDICAL ADVICE.
THIS MATERIAL AND ITS CONTAINER MUST BE DISPOSED OF IN A SAFE WAY.
USE APPROPRIATE CONTAINMENT TO AVOID ENVIRONMENTAL CONTAMINATION.

To avoid risks to man and the environment, comply with the instructions for use

Not for reformulation or repackaging.
No licence is granted under any patent.

© Monsanto 2004 (MdB)
Lot number/production date:

The Voluntary Initiative

This label has been produced according to the Crop Protection Association Voluntary Initiative (VI) guidance.

ANNEX 124

United Kingdom Roundup Ultra ST Label

ROUNDUP ULTRA ST: UK label: front panel

Revised Dec 04

H - Herbicide

ROUNDUP® ULTRA ST™

A foliar applied translocated herbicide for the control of broad-leaved and grass weeds, especially common couch, for use pre-emergence of cereals and certain other crops, for use in stubbles, set-aside or in cultivated land, in cereals, peas harvested dry, field beans, linseed and oilseed rape pre-harvest, in orchards, for the destruction of grassland prior to re-cropping and for the pre-harvest desiccation of oilseed rape and linseed.

This product is a soluble concentrate containing 450 g/l glyphosate, present as 600 g/l (51.4% ww) of the isopropylamine salt of glyphosate.

The (COSHH) Control of Substances Hazardous to Health Regulations may apply to the use of this product at work

Contents ℮ 20 litres

MAPP Number 10199

PROTECT FROM FROST

Imported

© Monsanto 2004 (MdB)
Not for reformulation or repackaging.
No licence is granted under any patent.

Lot number/production date:

The Voluntary Initiative

This label has been produced according to the Crop Protection Association Voluntary Initiative (VI) guidance.

ANNEX 124

MONSANTO UK LIMITED,
The Maris Centre, Hauxton Road, Trumpington, Cambridge CB2 2LQ
Tel: (01223) 849200
Tel: (01223) 849540- Technical Enquiries
E-mail: technical.helpline.uk@monsanto.com
Website: www.monsanto-ag.co.uk

In case of emergency day or night, telephone National Chemical Emergency Centre: (01865) 407333

To avoid risks to man and the environment, comply with the instructions for use

COMPLIANCE WITH THE FOLLOWING CONDITIONS OF USE AND ALL SAFETY PRECAUTIONS MARKED* IS A LEGAL REQUIREMENT

FOR USE ONLY AS AN AGRICULTURAL/HORTICULTURAL HERBICIDE

Crops/situations:
Wheat, barley, oats, durum wheat;
Oilseed rape, linseed;
Combining pea, field bean;
All edible crops (stubble), all non-edible crops (stubble);
Wheat, barley, oats, durum wheat, oilseed rape, combining pea, field bean, mustard, linseed, sugar beet, swede, turnip, onion, leek (pre-emergence);
Rotational grass, permanent grassland;
Green cover on land temporarily removed from production;
Apple, pear;
Plum, cherry, damson;

Maximum individual dose: }
Maximum number of treatments: } Full details are given in Statutory Area
Latest time of application: } on the attached leaflet
Other specific restrictions: } (Crop Specific Information - marked #)

READ ALL OTHER SAFETY PRECAUTIONS AND DIRECTIONS FOR USE BEFORE USE

Crop specific information

#

COMPLIANCE WITH THE FOLLOWING CONDITIONS OF USE AND ALL SAFETY PRECAUTIONS MARKED* IS A LEGAL REQUIREMENT

	Maximum individual dose (litres product/ hectare):	Maximum total dose (litres of product/hectare/ crop/annum):	Latest time of application:
Winter wheat, winter barley, winter oats, spring wheat, spring barley, spring oats, durum wheat, combining peas, field beans	3.2	3.2	7 days before harvest
Oilseed rape and linseed	3.2	3.2	14 days before harvest
Stubbles (of all crops)	3.2 or 1.2	3.2 or 1.2	5 days before drilling 2 days before drilling
Post planting and pre-emergence of listed cereals, oilseed rape, combining peas, field beans, mustard, linseed, sugar beet, swedes, turnips, onions and leeks	1.2	1.2	Pre-emergence
Grassland	4.8	4.8	5 days before harvest (cutting), grazing or drilling.
Green cover on land temporarily removed from production	4.8	See 'Other Specific Restrictions'	24 hours before cultivating
Apple and pear orchards	4.0	4.0	After harvest (post leaf fall) but before green cluster stage.
Cherry, plum and damson orchards	4.0	4.0	After harvest (post leaf fall) but before white bud stage

Other Specific Restrictions:

Weed wipers may be used in any recommended crop where the wiper or chemical does not touch the growing crop.

When using weed wipers, the maximum concentrations used must not exceed the following:

Weedwiper Mini	2:5 dilution with water
Other Wipers	4:5 dilution with water

The maximum total dose applied to green cover on land temporarily removed from production must not exceed 4.8 litres of product per hectare per year.

READ ALL OTHER SAFETY PRECAUTIONS AND DIRECTIONS FOR USE BEFORE USE

ANNEX 125

United States Roundup Export Label, United States Pesticide Product Label System, Registration No. 524-308 (9 July 1997)

ACCEPTED
JUL 8 1997
Under the Federal Insecticide, Fungicide, and Rodenticide Act, as amended, for the pesticide registered under EPA Reg. No. 524-308

EXPORT

Roundup®

Herbicide by Monsanto

FOR EXPORT ONLY

Not Registered for Use in the United States of America

PRECAUTIONARY STATEMENTS

Hazards to Humans and Domestic Animals

Keep out of reach of children.

DANGER!

CAUSES IRREVERSIBLE EYE DAMAGE.

HARMFUL IF SWALLOWED OR INHALED.

MAY CAUSE SKIN IRRITATION.

Do not get in eyes, on skin or on clothing.

Wear goggles or face shield.

Avoid breathing vapor or spray mist.

Wash thoroughly with soap and water after handling.

Remove contaminated clothing and wash before reuse.

FIRST AID: IF IN EYES, immediately flush with plenty of water for at least 15 minutes. Get medical attention.

IF ON SKIN, immediately flush with plenty of water. Remove contaminated clothing. Wash clothing before reuse.

IF SWALLOWED, this product will cause gastrointestinal tract irritation. Immediately dilute by swallowing water or milk. Get medical attention.

NOTE TO PHYSICIAN: Probable mucosal damage may contraindicate the use of gastric lavage.

IF INHALED, remove individual to fresh air. Get medical attention if breathing difficulty develops.

In case of an emergency involving this product, Call Collect, day or night, (314) 694-4000.

Environmental Hazards

Do not apply directly to water, to areas where surface water is present or to intertidal areas below the mean high water mark. Do not contaminate water when disposing of equipment washwaters.

Physical or Chemical Hazards

Spray solutions of this product should be mixed, stored and applied using only stainless steel, aluminum, fiber glass, plastic or plastic-lined steel containers.

DO NOT MIX, STORE OR APPLY THIS PRODUCT OR SPRAY SOLUTIONS OF THIS PRODUCT IN GALVANIZED STEEL OR UNLINED STEEL (EXCEPT STAINLESS STEEL) CONTAINERS OR SPRAY TANKS. This product or spray solutions of this product react with such containers and tanks to produce hydrogen gas which may form a highly combustible gas mixture. This gas mixture could flash or explode, causing serious personal injury, if ignited by open flame, spark, welder's torch, lighted cigarette or other ignition source.

DIRECTIONS FOR USE

Storage and Disposal

Do not contaminate water, foodstuffs, feed or seed by storage or disposal.

DISPOSAL:

Wastes resulting from the use of this product that cannot be used or chemically reprocessed should be disposed of in a landfill approved for pesticide disposal or in accordance with applicable local procedures.

Emptied container retains vapor and product residue. Observe all labeled safeguards until container is destroyed.

Do not reuse container. Triple rinse container, then puncture and dispose of in a sanitary landfill, or by other procedures approved by local authorities. Plastic may be burned or incinerated if permissible under local rules. If burned, stay out of smoke.

FOR REPACKAGING ONLY

ACTIVE INGREDIENT:	
*Glyphosate, N-(phosphonomethyl) glycine, in the form of its isopropylamine salt	41.0%
INERT INGREDIENTS:	59.0%
	100.0%

*Contains 480 grams per litre or 4 pounds per U.S. gallon of the active ingredient glyphosate in the form of its isopropylamine salt. Equivalent to 356 grams per litre or 3 pounds per U.S. gallon of the acid, glyphosate.

Roundup® herbicide is protected by U.S. Patent No. 4,405,531. Other patents are pending. No license granted under any non-U.S. patents).

®Registered trademark of Monsanto Company

© MONSANTO COMPANY 1993

Monsanto®

In case of an emergency involving this product, Call Collect, day or night, (314) 694-4000

LOT NO. _____ PACKER _____ NET 54 gal

EPA Est. 524-LA-1

MONSANTO COMPANY • AGRICULTURAL PRODUCTS • ST. LOUIS, MISSOURI 63167 U.S.A.

897.10-006.04/53L

PH 25 524-308 7-9-97 1 of 35

Clean sprayer and parts immediately after using this product by thoroughly flushing with water.

ADDITIVES

SURFACTANTS

Nonionic surfactants which are labeled for use with herbicides may be used. Do not reduce rates of this product when adding surfactant. When adding additional surfactant use 0.5 percent surfactant concentration (2 quarts per 100 gallons of spray solution) when using surfactants which contain at least 70 percent active ingredient or a 1 percent surfactant concentration (4 quarts per 100 gallons of spray solution) for those surfactants containing less than 70 percent active ingredient. Read and carefully observe surfactant cautionary statements and other information appearing on the surfactant label.

AMMONIUM SULFATE

The addition of 1 to 2 percent dry ammonium sulfate by weight or 8.5 to 17 pounds per 100 gallons of water may increase the performance of this product, and this product plus 2,4-D, Banvel™ or residual herbicide tank mixtures on annual and perennial weeds. The improvement in performance may be apparent where environmental stress is a concern. Low quality ammonium sulfate may contain material that will not readily dissolve which could result in nozzle tip plugging. To determine quality, perform a jar test by adding 1/3 cup of ammonium sulfate to 1 gallon of water and agitate for 1 minute. If undissolved sediment is observed, predissolve the ammonium sulfate in water and filter prior to addition to the spray tank. If ammonium sulfate is added directly to the spray tank, add slowly with agitation. Adding too quickly may clog outlet line. Ensure that ammonium sulfate is completely dissolved in the spray tank before adding herbicides or surfactant. Thoroughly rinse the spray system with clean water after use to reduce corrosion.

NOTE: The use of ammonium sulfate as an additive does not preclude the need for additional surfactant. Do not use herbicide rates lower than recommended in this label.

COLORANTS OR DYES

Agriculturally approved colorants or marking dyes may be added to this product. Colorants or dyes used in spray solutions of this product may reduce performance, especially at lower rates or dilutions. Use colorants or dyes according to the manufacturer's recommendations.

APPLICATION EQUIPMENT AND TECHNIQUES

Do not apply this product through any type of irrigation system.

This product may be applied with the following application equipment:

Aerial—Fixed Wing and Helicopter

Broadcast Spray

Controlled Droplet Applicator (CDA)—Hand-held or boom-mounted applicators which produce a spray consisting of a narrow range of droplet sizes.

Hand-Held and High-Volume Spray Equipment—Knapsack and backpack sprayers, pump-up pressure sprayers, handguns, handwands, lances and other hand-held spray equipment used to direct the spray onto weed foliage and vehicle-mounted high-volume spray equipment for spray-to-wet applications.

Selective equipment—Recirculating sprayers, shielded sprayers and wiper applicators.

See the appropriate part of this section for specific rates of application and instructions.

■ AERIAL EQUIPMENT ■

Use the recommended rates of this herbicide in 3 to 15 gallons of water per acre unless otherwise specified on this label. See the "Weeds Controlled" section of this label for specific rates. Unless otherwise specified, do not exceed one quart per acre. **(Aerial applications of this product may be made in annual cropping conventional tillage systems, fallow and reduced tillage systems, and preharvest. Refer to the individual use area sections of this label for recommended volumes and application rates.)**

Avoid direct application to any body of water.

AVOID DRIFT—DO NOT APPLY DURING INVERSION CONDITIONS, WHEN WINDS ARE GUSTY, OR UNDER ANY OTHER CONDITION WHICH FAVORS DRIFT. DRIFT MAY CAUSE DAMAGE TO ANY VEGETATION CONTACTED TO WHICH TREATMENT IS NOT INTENDED. TO PREVENT INJURY TO ADJACENT DESIRABLE VEGETATION, APPROPRIATE BUFFER ZONES MUST BE MAINTAINED.

Coarse sprays are less likely to drift; therefore, do not use nozzles or nozzle configurations which dispense spray as fine spray droplets. Do not angle nozzles forward into the airstream and do not increase spray volume by increasing nozzle pressure.

Drift control additives may be used. When a drift control additive is used, read and carefully observe the cautionary statements and all other information appearing on the additive label.

Ensure uniform application—To avoid streaked, uneven or overlapped application, use appropriate marking devices.

Thoroughly wash aircraft, especially landing gear, after each day of spraying to remove residues of this product accumulated during spraying or from spills. PROLONGED EXPOSURE OF THIS PRODUCT TO UNCOATED STEEL SURFACES MAY RESULT IN CORROSION AND POSSIBLE FAILURE OF THE PART. LANDING GEAR ARE MOST SUSCEPTIBLE. The maintenance of an organic coating (paint) which meets aerospace specification MIL-C-38413 may prevent corrosion.

■ BROADCAST EQUIPMENT ■

For control of annual or perennial weeds listed on this label using broadcast equipment—Use the recommended rates of this product in 3 to 40 gallons of water per acre as a broadcast spray unless otherwise specified on this label. See the "Weeds Controlled" section of this label for specific rates. As density of weeds increases, spray volume should be increased within the recommended range to ensure complete coverage. Carefully select proper nozzle to avoid spraying a fine mist. For best results with ground application equipment, use flat fan nozzles. Check for even distribution of spray droplets.

■ CONTROLLED DROPLET APPLICATION (CDA) ■

The rate of this product applied per acre by vehicle-mounted CDA equipment must not be less than the amount recommended in this label when applied by conventional broadcast equipment. For vehicle-mounted CDA equipment, apply 3 to 15 gallons of water per acre.

For the control of labeled annual weeds with hand-held CDA units, apply a 20 percent solution of this product at a flow rate of 2 fluid ounces per minute and a walking speed of 1.5 MPH (1 quart per acre). For the control of labeled perennial weeds, apply a 20 to 40 percent solution of this product at a flow rate of 2 fluid

ANNEX 126

United States Fuete SL Label, United States Pesticide Product Label System, Registration No. 524-308 (19 Feb. 2002)

2 7 12

Fuete SL

Herbicide

Complete Directions for Use

EPA Reg. No. 524-308

Herbicide for ground and aerial application to remove undesirable vegetation in non-agricultural sites

AVOID CONTACT OF HERBICIDE WITH FOLIAGE, GREEN STEMS, EXPOSED NON-WOODY ROOTS, OR FRUIT OF CROPS, DESIRABLE PLANTS AND TREES, BECAUSE SEVERE INJURY OR DESTRUCTION MAY RESULT.

Read the entire label before using this product.

Use only according to label instructions.

Read the "LIMIT OF WARRANTY AND LIABILITY" statement at the end of the label before buying or using. If terms are not acceptable, return at once unopened.

THIS IS AN END-USE PRODUCT. MONSANTO DOES NOT INTEND AND HAS NOT REGISTERED IT FOR REFORMULATION OR REPACKAGING.

ACTIVE INGREDIENT:

*Glyphosate, N-(phosphonomethyl) glycine, in the form of its isopropylamine salt	41.0%
OTHER INGREDIENTS:	59.0%
	100.0%

*Contains 480 grams per litre or 4 pounds per U.S. gallon of the active ingredient glyphosate, in the form of its isopropylamine salt. Equivalent to 356 grams per litre or 3 pounds per U.S. gallon of the acid, glyphosate.

ACCEPTED
with COMMENTS
In EPA Letter Dated
2/19/2002
Under the Federal Insecticide, Fungicide, and Rodenticide Act as amended, for the pesticide registered under EPA Reg. No.
524-308

IMPORTANT PHONE NUMBERS

1. FOR PRODUCT INFORMATION OR ASSISTANCE IN USING THIS PRODUCT, CALL TOLL-FREE,
   1-800-332-3111

2. IN CASE OF AN EMERGENCY INVOLVING THIS HERBICIDE PRODUCT, OR FOR MEDICAL ASSISTANCE, CALL COLLECT, DAY OR NIGHT,
   (314)-694-4000

PRECAUTIONARY STATEMENTS

Hazards to Humans and Domestic Animals

Keep out of reach of children.

DANGER! PELIGRO!

Si usted no entiende la etiqueta, busque a alguien para que se la explique a usted en detalle. (If you do not understand the label, find someone to explain it to you in detail.)

CAUSES IRREVERSIBLE EYE DAMAGE.
HARMFUL IF SWALLOWED OR INHALED.
MAY CAUSE SKIN IRRITATION.

Do not get in eyes, on skin, or on clothing. Avoid breathing vapor or spray mist.

FIRST AID: Call a poison control center or doctor for treatment advice.	
IF IN EYES	• Hold eye open and rinse slowly and gently with water for 15 - 20 minutes. • Remove contact lenses if present after the first 5 minutes then continue rinsing eye.

3 7 12

IF ON SKIN	• Take off contaminated clothing. • Rinse skin immediately with plenty of water for 15 - 20 minutes.
IF INHALED	• Move person to fresh air • If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably mouth-to-mouth, if possible.
IF SWALLOWED	• Have a person sip a glass of water if able to swallow. • Do not induce vomiting unless told to do so by the poison control center or doctor. • Do not give anything by mouth to an unconscious person.
NOTE TO PHYSICIAN	• Probable mucosal damage may contraindicate the use of gastric lavage.

- Have the product container or label with you when calling a poison control center or doctor, or going for treatment.
- You may also contact **(314) 694-4000**, collect day or night, for emergency medical treatment information.
- This product is identified as **Fuete SL Herbicide, EPA Registration No. 524-308.**

Personal Protective Equipment (PPE)

Applicators and other handlers must wear: long-sleeved shirt and long pants, chemical resistant gloves, shoes plus socks, and protective eyewear. Discard clothing and other absorbent materials that have been drenched or heavily contaminated with this product's concentrate. Do not reuse them. Follow manufacturer's instructions for cleaning/maintaining PPE. If no such instructions for washables, use detergent and hot water. Keep and wash PPE separately from other laundry.

User Safety Recommendations:

Users should:

- Wash hands before eating, drinking, chewing gum, using tobacco, or using the toilet.
- Remove clothing immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing.

Environmental Hazards

Do not apply directly to water, to areas where surface water is present or to intertidal areas below the mean high water mark. Do not contaminate water when cleaning equipment or disposing of equipment washwaters.

Physical or Chemical Hazards

Spray solutions of this product should be mixed, stored and applied using only stainless steel, aluminum, fiberglass, plastic or plastic-lined steel containers.

DO NOT MIX, STORE OR APPLY THIS PRODUCT OR SPRAY SOLUTIONS OF THIS PRODUCT IN GALVANIZED STEEL OR UNLINED STEEL (EXCEPT STAINLESS STEEL) CONTAINERS OR SPRAY TANKS. This product or spray solutions of this product react with such containers and tanks to produce hydrogen gas which may form a highly combustible gas mixture. This gas mixture could flash or explode, causing serious personal injury, if ignited by open flame, spark, welder's torch, lighted cigarette or other ignition source.

DIRECTIONS FOR USE

APPLICATIONS TO REMOVE UNDESIRABLE VEGETATION IN NON-AGRICULTURAL SITES

It is a violation of Federal law to use this product in any manner inconsistent with its labeling. For any requirements specific to your State or Tribe, consult the agency responsible for pesticide regulations.

Note: This product is for use on plants in non-crop and non-timber areas only. Not for use on crops, timber, or other plants being grown

4 8 12

for sale or other commercial use, or for commercial seed production, or for research purposes.

Keep people and pets off treated areas until spray solution has dried to prevent transfer of this product onto desirable vegetation.

STORAGE AND DISPOSAL

Do not contaminate water, foodstuffs, feed or seed by storage or disposal.

Keep container closed to prevent spills and contamination.

Wastes of this product may cause irreversible eye damage and may be dangerous. Wastes resulting from the use of this product that cannot be used or chemically reprocessed should be disposed of in a landfill approved for pesticide disposal or in accordance with applicable Federal, state, or local procedures.

Emptied container retains vapor and product residue. Observe all labeled safeguards until container is cleaned, reconditioned, or destroyed.

Do not reuse container. Triple rinse container, then puncture and dispose of in a sanitary landfill or by incineration, or, if allowed by state and local authorities, by burning. If burned, stay out of smoke.

GENERAL INFORMATION

(How This Product Works)

Product Description: This product is a postemergent, systemic herbicide with no soil residual activity. It is generally non-selective and gives broad-spectrum control of many annual weeds, perennial weeds, woody brush and trees. It is formulated as a water-soluble liquid. It may be applied through most standard industrial or field-type sprayers after dilution and thorough mixing with water or other carriers according to label instructions.

Annual Maximum Use Rate: The combined total of all treatments must not exceed 10.6 quarts of this product per acre per year. The maximum use rates stated throughout this product's labeling apply to this product combined with the use of all other herbicides containing glyphosate or sulfosate as the active ingredient, whether applied as mixtures or separately. Calculate the application rates and ensure that the total use of this and other glyphosate or sulfosate containing products does not exceed stated maximum use rate.

MIXING

Clean sprayer parts immediately after using this product by thoroughly flushing with water.

NOTE: REDUCED RESULTS MAY OCCUR IF WATER CONTAINING SOIL IS USED, SUCH AS VISIBLY MUDDY WATER OR WATER FROM PONDS AND DITCHES THAT IS NOT CLEAR.

Mixing with Water

This product mixes readily with water. Mix spray solutions of this product as follows: Fill the mixing or spray tank with the required amount of water. Add the recommended amount of this product and any spray additives near the end of the filling process and mix well. Use caution to avoid siphoning back into the carrier source. Use approved anti-back-siphoning devices where required by state or local regulations. During mixing and application, foaming of the spray solution may occur. To prevent or minimize foam, avoid the use of mechanical agitators, terminate by-pass and return lines at the bottom of the tank and, if needed, use an approved antifoam or defoaming agent.

Surfactants

Nonionic surfactants that are specified for use with herbicides may be used to improve wetting of foliage. The addition of surfactants may improve the consistency of weed control, but application rates of this product should not be reduced when added surfactants are used. Read and carefully observe surfactant rates, cautionary statements, and other information appearing on the surfactant label.

ANNEX 127

United States Roundup Original Label

This sample label is current as of 11/20/2002. The product descriptions and recommendations provided in this sample label are for background information only. Always refer to the label on the product before using Monsanto or any other agrichemical product.

21154B4-1/CG

Roundup ORIGINAL®

HERBICIDE

Complete Directions for Use

EPA Reg. No. 524-445

AVOID CONTACT OF HERBICIDE WITH FOLIAGE, GREEN STEMS, EXPOSED NON-WOODY ROOTS OR FRUIT OF CROPS (EXCEPT AS SPECIFIED FOR INDIVIDUAL ROUNDUP READY® CROPS), DESIRABLE PLANTS AND TREES, BECAUSE SEVERE INJURY OR DESTRUCTION MAY RESULT.

2004-1

Not all products recommended on this label are registered for use in California. Check the registration status of each product in California before using.

Read the entire label before using this product.

Use only according to label instructions.

It is a violation of Federal law to use this product in any manner inconsistent with its labeling

Read the "LIMIT OF WARRANTY AND LIABILITY" statement at the end of the label before buying or using. If terms are not acceptable, return at once unopened.

THIS IS AN END-USE PRODUCT. THIS COMPANY DOES NOT INTEND AND HAS NOT REGISTERED IT FOR REFORMULATION. SEE INDIVIDUAL CONTAINER LABEL FOR REPACKAGING LIMITATIONS.

1.0 INGREDIENTS

ACTIVE INGREDIENT:	
*Glyphosate, N-(phosphonomethyl)glycine, in the form of its isopropylamine salt	41.0%
OTHER INGREDIENTS:	59.0%
	100.0%

*Contains 480 grams per litre or 4 pounds per U.S. gallon of the active ingredient glyphosate, in the form of its isopropylamine salt. Equivalent to 356 grams per litre or 3 pounds per U.S. gallon of the acid, glyphosate.

No license granted under any non-U.S. patent(s).

2.0 IMPORTANT PHONE NUMBERS

1. FOR PRODUCT INFORMATION OR ASSISTANCE IN USING THIS PRODUCT, CALL TOLL-FREE,
1-800-332-3111.

2. IN CASE OF AN EMERGENCY INVOLVING THIS HERBICIDE PRODUCT, OR FOR MEDICAL ASSISTANCE, CALL COLLECT, DAY OR NIGHT,
(314)-694-4000.

3.0 PRECAUTIONARY STATEMENTS

3.1 Hazards to Humans and Domestic Animals

Keep out of reach of children.

WARNING! AVISO!

Si usted no entiende la etiqueta, busque a alguien para que se la explique a usted en detalle. (If you do not understand the label, find someone to explain it to you in detail.)

CAUSES SUBSTANTIAL BUT TEMPORARY EYE INJURY.

HARMFUL IF SWALLOWED OR INHALED.

Do not get in eyes or on clothing.

Avoid breathing vapor or spray mist.

FIRST AID:	Call a poison control center or doctor for treatment advice.
IF IN EYES	• Hold eye open and rinse slowly and gently with water for 15 - 20 minutes. • Remove contact lenses if present after the first 5 minutes then continue rinsing eye.
IF INHALED	• Remove individual to fresh air. If not breathing, give artificial respiration, preferably mouth-to mouth. Get medical attention.
IF SWALLOWED	• This product will cause gastrointestinal tract irritation. Immediately dilute by swallowing water or milk. Get medical attention. NEVER GIVE ANYTHING BY MOUTH TO AN UNCONSCIOUS PERSON.

- Have the product container or label with you when calling a poison control center or doctor, or going for treatment.
- This product is identified as **Roundup Original herbicide, EPA Registration No. 524-445**.
- You may also contact **(314) 694-4000**, collect day or night, for emergency medical treatment information.

DOMESTIC ANIMALS: This product is considered to be relatively nontoxic to dogs and other domestic animals; however, ingestion of this product or large amounts of freshly sprayed vegetation may result in temporary gastrointestinal irritation (vomiting, diarrhea, colic, etc.). If such symptoms are observed, provide the animal with plenty of fluids to prevent dehydration. Call a veterinarian if symptoms persist for more than 24 hours.

Personal Protective Equipment (PPE)

Applicators and other handlers must wear: long-sleeved shirt and long pants, shoes plus socks, and protective eyewear.

Discard clothing and other absorbent materials that have been drenched or heavily contaminated with this product's concentrate. Do not reuse them. Follow manufacturer's instructions for cleaning/maintaining PPE. If no such instructions for washables, use detergent and hot water. Keep and wash PPE separately from other laundry.

When handlers use closed systems, enclosed cabs, or aircraft in a manner that meets the requirements listed in Worker Protection Standard (WPS) for agricultural pesticides [40 CFR 170.240 (d) (4-6)], the handler PPE requirements may be reduced or modified as specified in the WPS.

User Safety Recommendations

Users should:

- Wash hands before eating, drinking, chewing gum, using tobacco, or using the toilet.
- Remove clothing immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing.

3.2 Environmental Hazards

Do not apply directly to water, to areas where surface water is present or to intertidal areas below the mean high water mark. Do not contaminate water when cleaning equipment or disposing of equipment washwaters.

3.3 Physical or Chemical Hazards

Spray solutions of this product should be mixed, stored and applied using only stainless steel, aluminum, fiberglass, plastic or plastic-lined steel containers.

DO NOT MIX, STORE OR APPLY THIS PRODUCT OR SPRAY SOLUTIONS OF THIS PRODUCT IN GALVANIZED STEEL OR UNLINED STEEL (EXCEPT STAINLESS STEEL) CONTAINERS OR SPRAY TANKS. This product or spray solutions of this product react with such containers and tanks to produce hydrogen gas which may form a highly combustible gas mixture. This gas mixture could flash or explode, causing serious personal injury, if ignited by open flame, spark, welder's torch, lighted cigarette or other ignition source.

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in any manner inconsistent with its labeling. This product can only be used in accordance with the Directions for Use on this label or in separately published Supplemental Labeling.

Do not apply this product in a way that will contact workers or other persons, either directly or through drift. Only protected handlers may be in the area during application. For any requirements specific to your State or Tribe, consult the agency responsible for pesticide regulations.

6.3 Mixing for Hand-Held Sprayers

Prepare the desired volume of spray solution by mixing the amount of this product in water as shown in the following table:

Spray Solution

Desired Volume	Amount of Roundup Original 0.5%	1%	1.5%	2%	5%	10%
1 gal	0.7 oz	1.3 oz	2 oz	2.7 oz	6.5 oz	13 oz
25 gal	1 pt	1 qt	1.5 qt	2 qt	5 qt	10 qt
100 gal	2 qt	1 gal	1.5 gal	2 gal	5 gal	10 gal

2 tablespoons = 1 fluid ounce

For use in knapsack sprayers, it is suggested that the recommended amount of this product be mixed with water in a larger container. Fill sprayer with the mixed solution.

6.4 Surfactants

Nonionic surfactants (NIS) or wetting agents that are labeled for use with herbicides may be added to the spray solution. Do not reduce rates of this herbicide when adding surfactants. Read and carefully observe cautionary statements and other information appearing on the additives label.

When adding additional surfactant, use 0.5 percent surfactant concentration (2 quarts per 100 gallons of spray solution) when using surfactants that contain at least 70 percent active surfactant, or a 1 percent surfactant concentration (4 quarts per 100 gallons of spray solution) for those surfactants containing less than 70 percent active surfactant.

6.5 Ammonium Sulfate

The addition of 1 to 2 percent dry ammonium sulfate by weight or 8.5 to 17 pounds per 100 gallons of water may increase the performance of this product, particularly under hard water conditions, drought conditions or when tank mixed with certain residual herbicides, on annual and perennial weeds. The equivalent rate of ammonium sulfate in a liquid formulation may also be used. Ensure that dry ammonium sulfate is completely dissolved in the spray tank before adding herbicides or surfactants. Thoroughly rinse the spray system with clean water after use to reduce corrosion.

NOTE: When using ammonium sulfate, apply this product at rates recommended in this label. Lower rates will result in reduced performance. The use of ammonium sulfate as an additive does not preclude the need for additional surfactant.

6.6 Colorants or Dyes

Agriculturally approved colorants or marking dyes may be added to this product. Colorants or dyes used in spray solutions of this product may reduce performance, especially at lower rates or dilutions. Use colorants or dyes according to the manufacturer's recommendations.

6.7 Drift Reduction Additives

Drift reduction additives may be used with all equipment types, except wiper applicators, sponge bars and Controlled Droplet Applicator (CDA) equipment. When a drift reduction additive is used, read and carefully observe the cautionary statements and all other information appearing on the additive label. The use of drift reduction additives can affect spray coverage which may result in reduced performance.

7.0 APPLICATION EQUIPMENT AND TECHNIQUES

Do not apply this product through any type of irrigation system.

This product may be applied with the following application equipment:

Aerial—Fixed Wing and Helicopter

Ground Broadcast Spray—Boom or boomless systems, pull-type sprayer, floaters, pick-up sprayers, spray coupes and other ground broadcast equipment.

Hand-Held or High-Volume Spray Equipment—Knapsack and backpack sprayers, pump-up pressure sprayers, handguns, handwands, mistblowers*, lances and other hand-held and motorized spray equipment used to direct the spray onto weed foliage.

*This product is not registered in California or Arizona for use in mistblowers.

Selective Equipment—Recirculating sprayers, shielded and hooded sprayers, wiper applicators and sponge bars.

Injection Systems—Aerial or ground injection sprayers.

Controlled Droplet Applicator (CDA)—Hand-held or boom-mounted applicators which produce a spray consisting of a narrow range of droplet sizes.

APPLY THESE SPRAY SOLUTIONS IN PROPERLY MAINTAINED AND CALIBRATED EQUIPMENT CAPABLE OF DELIVERING DESIRED VOLUMES.

SPRAY DRIFT MANAGEMENT

AVOID DRIFT. EXTREME CARE MUST BE USED WHEN APPLYING THIS PRODUCT TO PREVENT INJURY TO DESIRABLE PLANTS AND CROPS.

Do not allow the herbicide solution to mist, drip, drift or splash onto desirable vegetation since minute quantities of this product can cause severe damage or destruction to the crop, plants or other areas on which treatment was not intended.

Avoiding spray drift at the application site is the responsibility of the applicator. The interaction of many equipment and weather-related factors determine the potential for spray drift. The applicator and the grower is responsible for considering all these factors when making decisions.

7.1 Aerial Equipment

DO NOT APPLY THIS PRODUCT USING AERIAL SPRAY EQUIPMENT EXCEPT UNDER CONDITIONS AS SPECIFIED WITHIN THIS LABEL.

Use the recommended rates of this herbicide in 3 to 15 gallons of water per acre unless otherwise specified on this label. Unless otherwise specified, do not exceed 1 quart per acre. Refer to the individual use area sections of this label for recommended volumes, application rates, and further instructions.

FOR AERIAL APPLICATION IN CALIFORNIA OR SPECIFIC COUNTIES THEREIN, OR ARKANSAS, REFER TO THE FEDERAL SUPPLEMENTAL LABEL FOR AERIAL APPLICATIONS IN THAT STATE OR COUNTY FOR SPECIFIC INSTRUCTIONS, RESTRICTIONS AND REQUIREMENTS

This product plus dicamba tank mixtures may not be applied by air in California.

Ensure uniform application—To avoid streaked, uneven or overlapped application, use appropriate marking devices.

AERIAL SPRAY DRIFT MANAGEMENT

The following drift management requirements must be followed to avoid off-target drift movement from aerial applications to agricultural field crops.

1. The distance of the outermost nozzles on the boom must not exceed 3/4 the length of the wingspan or rotor.
2. Nozzles must always point backward, parallel with the air stream and never be pointed downwards more than 45 degrees. Where states have more stringent regulations, they should be observed.

Importance of Droplet Size

The most effective way to reduce drift potential is to apply large droplets. The best drift management strategy is to apply the largest droplets that provide sufficient coverage and control. Applying larger droplets reduces drift potential, but will not prevent drift if applications are made improperly, or under unfavorable environmental conditions (see the **"Wind", "Temperature and Humidity"**, and **"Temperature Inversions"** sections of this label).

Controlling Droplet Size

- **Volume:** Use high-flow-rate nozzles to apply the highest practical spray volume. Nozzles with the higher rated flows produce larger droplets.
- **Pressure:** Use the lower spray pressures recommended for the nozzle. Higher pressure reduces droplet size and does not improve canopy penetration. When higher flow rates are needed, use higher-flow-rate nozzles instead of increasing pressure.
- **Number of nozzles:** Use the minimum number of nozzles that provide uniform coverage.
- **Nozzle orientation:** Orienting nozzles so that the spray is released backwards, parallel to the airstream, will produce larger droplets than other orientations. Significant deflection from the horizontal will reduce droplet size and increase drift potential.
- **Nozzle type:** Use a nozzle type that is designed for the intended application. With most nozzle types, narrower spray angles produce larger droplets. Consider using low-drift nozzles. Solid stream nozzles oriented straight back produce larger droplets than other nozzle types.
- **Boom length:** For some use patterns, reducing the effective boom length to less than 3/4 of the wingspan or rotor length may further reduce drift without reducing swath width.
- **Application height:** Applications should not be made at a height greater than 10 feet above the top of the largest plants unless a greater height is required for aircraft safety. Making applications at the lowest height that is safe reduces the exposure of the droplets to evaporation and wind.

Swath Adjustment

When applications are made with a crosswind, the swath will be displaced downwind. Therefore, on the up and downwind edges of the field, the applicator must compensate for this displacement by adjusting the path of the aircraft upwind. Swath adjustment distance should increase, with increasing drift potential (higher wind, smaller droplets, etc.).

Wind

Drift potential is lowest between wind speeds of 2 to 10 miles per hour. However, many factors, including droplet size and equipment type determine drift potential at any given speed. Application should be avoided below 2 miles per hour due to variable wind direction and high inversion potential. **NOTE:** Local terrain can influence wind patterns. Every applicator should be familiar with local wind patterns and how they affect drift.

Temperature and Humidity

When making applications in low relative humidity, set up equipment to produce larger droplets to compensate for evaporation. Droplet evaporation is most severe when conditions are both hot and dry.

Temperature Inversions

Applications should not occur during a temperature inversion because drift potential is high. Temperature inversions restrict vertical air mixing, which causes small suspended droplets to remain in a concentrated cloud. This cloud can move in unpredictable directions due to the light variable winds common during inversions. Temperature inversions

are characterized by increasing temperatures with altitude and are common on nights with limited cloud cover and light to no wind. They begin to form as the sun sets and often continue into the morning. Their presence can be indicated by ground fog; however, if fog is not present, inversions can also be identified by the movement of smoke from a ground source or an aircraft smoke generator. Smoke that layers and moves laterally in a concentrated cloud (under low wind conditions) indicates an inversion, while smoke that moves upward and rapidly dissipates indicates good vertical air mixing.

Sensitive Areas

The product should only be applied when the potential for drift to adjacent sensitive areas (e.g., residential areas, bodies of water, known habitat for threatened or endangered species, non-target crops) is minimal (e.g., when wind is blowing away from the sensitive areas).

Avoid direct application to any body of water.

Aircraft Maintenance

Thoroughly wash aircraft, especially landing gear, after each day of spraying to remove residues of this product accumulated during spraying or from spills. PROLONGED EXPOSURE OF THIS PRODUCT TO UNCOATED STEEL SURFACES MAY RESULT IN CORROSION AND POSSIBLE FAILURE OF THE PART. LANDING GEAR IS MOST SUSCEPTIBLE. The maintenance of an organic coating (paint), which meets aerospace specification MIL-C-38413, may prevent corrosion.

7.2 Ground Broadcast Equipment

Use the recommended rates of this product in 3 to 40 gallons of water per acre as a broadcast spray unless otherwise specified. As density of weeds increases, spray volume should be increased within the recommended range to ensure complete coverage. Carefully select proper nozzles to avoid spraying a fine mist. For best results with ground application equipment, use flat spray nozzles. Check for even distribution of spray droplets.

7.3 Hand-Held or High-Volume Equipment

Apply to foliage of vegetation to be controlled. For applications made on a spray-to-wet basis, spray coverage should be uniform and complete. Do not spray to the point of runoff. Use coarse sprays only. For recommended rates and timing, refer to the "ANNUAL WEEDS—Hand-Held or High-Volume Equipment" section of this product label.

7.4 Selective Equipment

This product may be applied through recirculating spray systems, shielded applicators, hooded sprayers, wiper applicators or sponge bars, after dilution and thorough mixing with water, to listed weeds growing in any non-crop site specified on this label.

In cropping systems, hooded sprayers, shielded sprayers, and wipers may be used in row middles (in between rows of crop plants) where any dripping or leaking will not contact crop foliage, when listed under "TYPES OF APPLICATION" in the crop sections of this product's labeling. Such equipment must be capable of preventing all crop contact with herbicide solutions and operated without leakage of spray mists or dripping onto crop. Wipers over-the-top of crops may be used only when specifically recommended in this product's labeling.

AVOID CONTACT OF HERBICIDE WITH DESIRABLE VEGETATION.

Contact of the herbicide solution with desirable vegetation may result in damage or destruction. Applicators used above desirable vegetation should be adjusted so that the lowest spray stream or wiper contact point is at least 2 inches above the desirable vegetation. Droplets, mist, foam or splatter of the herbicide solution settling on desirable vegetation may result in discoloration, stunting or destruction.

Applications made above the crops should be made when the weeds are a minimum of 6 inches above the desirable vegetation. Better results may be obtained when more of the weed is exposed to the herbicide solution. Weeds not contacted by the herbicide solution will not be affected. This may occur in dense clumps, severe infestations or when the height of the weeds varies so that not all weeds are contacted. In these instances, repeat treatment may be necessary.

Recirculating Spray System

A recirculating spray system directs the spray solution onto weeds growing above desirable vegetation, while spray solution not intercepted by weeds is collected and returned to the spray tank for reuse.

Shielded and Hooded Applicators

When applied under the conditions described in the following paragraphs for shielded and hooded applications, this product at recommended rates will control those weeds listed in the "ANNUAL WEEDS RATE TABLE" and "PERENNIAL WEEDS RATE TABLE" sections of this label. A hooded sprayer is a type of shielded applicator where the spray pattern is fully enclosed including top, sides, front and back, thereby shielding the crop from the spray solution. Keep shields on these sprayers adjusted to protect desirable vegetation. When applying to crops grown on raised beds, ensure that the hood is designed to completely enclose the spray solution. If necessary, extend the front and rear flaps of the hoods to reach the ground in deep furrows. EXTREME CARE MUST BE EXERCISED TO AVOID CONTACT OF HERBICIDE WITH DESIRABLE VEGETATION.

This equipment must be set up and operated in a manner that avoids bouncing or raising the hoods off the ground in any way. If the hoods are raised, spray particles may escape and come into contact with the crop, causing damage or destruction of the crop. Avoid operation on rough or sloping ground where the spray hoods might be raised off the ground.

Use hoods designed to minimize excessive dripping or run-off down the insides of the hoods. A single, low pressure/ low drift flat-fan nozzle with an 80 to 95 degree spray angle positioned at the top center of the hood is recommended. Spray volume should be 20 to 30 gallons per acre.

These procedures will reduce the potential for crop injury:

- The spray hoods must be operated on the ground or skimming across the ground.
- Leave at least an 8-inch untreated strip over the drill row. For example, if the crop row width is 38 inches, the maximum width of the spray hood should be 30 inches.
- Maximum tractor speed: 5 miles per hour to avoid bouncing of the spray hoods.
- Maximum wind speed: 10 miles per hour.
- Use low-drift nozzles that provide uniform coverage within the treated area.

Crop injury may occur when the foliage of treated weeds comes into direct contact with leaves of the crop. Do not apply this product when the leaves of the crop are growing in direct contact with weeds to be treated. Droplets, mist, foam or splatter of the herbicide solution may contact the crop and cause discoloration, stunting or destruction.

Wiper Applicators

When applied under the conditions described in the following paragraphs, this product CONTROLS many weeds, including volunteer corn, Texas panicum, common rye, shattercane, sicklepod, spanishneedles and bristly starbur; and SUPPRESSES many weeds including Florida beggarweed, Bermudagrass, hemp dogbane, dogfennel, guineagrass, johnsongrass, milkweed, silverleaf nightshade, redroot pigweed, giant ragweed, smutgrass, sunflower, Canada thistle, musk thistle, vaseygrass, velvetleaf.

Wiper applicators are devices that physically wipe appropriate amounts of this product directly onto the weed.

Equipment must be designed, maintained and operated to prevent the herbicide solution from contacting desirable vegetation. Operate this equipment at ground speeds no greater than 5 miles per hour. Performance may be improved by reducing speed in areas of heavy weed infestations to ensure adequate wiper saturation. Better results may be obtained if two applications are made in opposite directions.

Avoid leakage or dripping onto desirable vegetation. Adjust height of applicator to ensure adequate contact with weeds. Keep wiping surfaces clean. Be aware that, on sloping ground, the herbicide solution may migrate, causing dripping on the lower end and drying of the wicks on the upper end of a wiper applicator.

Do not use wiper equipment when weeds are wet.

Mix only the amount of solution to be used during a 1-day period, as reduced activity may result from use of leftover solutions. Clean wiper parts immediately after using this product by thoroughly flushing with water.

Do not add surfactant to the herbicide solution.

For Rope or Sponge Wick Applicators—Solutions ranging from 33 to 75 percent of this product in water may be used. Apply this solution to weeds listed in this section.

For Panel Applicators—Solutions ranging from 33 to 100 percent of this product in water may be used in panel wiper applicators.

7.5 Injection Systems

This product may be used in aerial or ground injection spray systems. It may be used as a liquid concentrate or diluted prior to injecting into the spray stream. Do not mix this product with the concentrate of other products when using injection systems.

7.6 CDA Equipment

The rate of this product applied per acre by vehicle-mounted CDA equipment must not be less than the amount recommended in this label when applied by conventional broadcast equipment. For vehicle-mounted CDA equipment, apply 2 to 15 gallons of water per acre.

For the control of annual weeds with hand-held CDA units, apply a 20 percent solution of this product at a flow rate of 2 fluid ounces per minute and a walking speed of 1.5 miles per hour (1 quart per acre). For the control of perennial weeds, apply a 20 to 40 percent solution of this product at a flow rate of 2 fluid ounces per minute and a walking speed of 0.75 miles per hour (2 to 4 quarts per acre).

Controlled droplet application equipment produces a spray pattern that is not easily visible. Extreme care must be exercised to avoid spray or drift contacting the foliage or any other green tissue of desirable vegetation, as damage or destruction may result.

8.0 ANNUAL AND PERENNIAL CROPS (Alphabetical)

NOTE: THIS SECTION GIVES GENERAL DIRECTIONS THAT APPLY TO ALL LISTED CROPS WITHIN SECTION 8 GROUPED ALPHABETICALLY BELOW. SEE THE INDIVIDUAL CROP CATEGORIES FOR SPECIFIC INSTRUCTIONS, PREHARVEST INTERVALS, AND ADDITIONAL PRECAUTIONS AND RESTRICTIONS.

See the "ROUNDUP READY CROPS" section of this label or separately published Supplemental Labeling for instructions for treating Roundup Ready crops.

TYPES OF APPLICATIONS: Chemical Fallow, Preplant Fallow Beds, Preplant, Preemergence, At-Planting, Hooded Sprayers in Row-Middles, Shielded Sprayers in Row-

10.4 Pastures

LABELED CROPS: Any grass (*Gramineae* family) except Corn, Sorghum, Sugarcane and those listed in this product's label booklet under "Cereal and Grain Crops". Grasses that may be treated include Bahiagrass, Bermudagrass, Bluegrass, Brome, Fescue, Guineagrass, Kikuyugrass, Orchardgrass, Pangola grass, Ryegrass, Timothy, Wheatgrass.

TYPES OF APPLICATIONS: Preplant, Preemergence, Spot Treatment, Over-the-Top Wiper Applications, Pasture Renovation, Postemergent Weed Control (Broadcast Treatments).

Preplant, Preemergence, Pasture Renovation

USE INSTRUCTIONS: This product may be applied prior to planting or emergence of forage grasses. In addition, this product may be used to control perennial pasture species listed on this label prior to replanting.

PRECAUTIONS, RESTRICTIONS: If application rates total 3 quarts per acre or less, no waiting period between treatment and feeding or livestock grazing is required. If the rate is greater than 3 quarts per acre, remove domestic livestock before application and wait 8 weeks after application before grazing or harvesting. Crops listed for treatment in this label booklet may be planted into the treated area at any time; for other crops, wait 30 days between application and planting.

Spot Treatment, Over-the-Top Wiper Applications

USE INSTRUCTIONS: This product may be applied as a spot treatment or with wiper applicators in pastures. Applications may be made in the same area at 30-day intervals.

PRECAUTIONS, RESTRICTIONS: For spot treatments or wiper application methods using rates of 3 quarts per acre or less, the entire field or any portion of it may be treated. When spot treatments or wiper application are made using rates above 3 quarts per acre, no more than 10 percent of the total pasture may be treated at any one time. To achieve maximum performance, remove domestic livestock before application and wait 7 days after application before grazing livestock or harvesting.

Postemergent Weed Control (Broadcast Treatments)

USE INSTRUCTIONS: This product may be used to suppress competitive growth and seed production of annual weeds and undesirable vegetation in pastures. For selective applications with broadcast spray equipment, apply 12 to 16 fluid ounces of this product per acre in early spring before desirable perennial grasses break dormancy and initiate green growth. Late fall applications can be made after desirable perennial grasses have reached dormancy.

PRECAUTIONS, RESTRICTIONS: Some stunting of perennial grasses will occur if broadcast applications are made when plants are not dormant. No waiting period is required between application and grazing or harvesting for feed. Use of higher application rates will cause stand reductions. Do not apply more than 3 quarts per acre per year onto pasture grasses except for renovation uses (see instructions above). If replanting is needed due to severe stand reduction, applications must be made at least 30 days prior to planting any crop not listed for treatment in this product's label booklet.

10.5 Rangelands

TYPES OF APPLICATIONS: Postemergence.

This product will control or suppress many annual weeds growing in perennial cool and warm-season grass rangelands.

Preventing viable seed production is key to the successful control and invasion of annual grassy weeds in rangelands. Follow-up applications in sequential years should eliminate most of the viable seeds.

Grazing of treated areas should be delayed to encourage growth of desirable perennials. Allowing desirable perennials to flower and reseed in the treated area will encourage successful transition.

USE INSTRUCTIONS: Apply 12 to 16 fluid ounces of this product per acre to control or suppress many weeds, including downy brome, cheatgrass, cereal rye and jointed goatgrass in rangelands. Apply when most brome plants are in early flower and before the plants, including seedheads, turn color. Allowing for secondary weed flushes to occur in the spring following rain events further depletes the seed reserve and encourages perennial grass conversion on weedy sites. Fall applications are possible, and recommended, where spring moisture is usually limited and fall germination allows for good weed growth.

For medusahead, apply 16 fluid ounces of this product per acre at the 3-leaf stage. Delaying applications beyond this stage will result in reduced or unacceptable control. Controlled burning may be useful in eliminating the thatch layer produced by slow decaying culms prior to application. Allow new growth to occur before spraying after a burn. Repeat applications in subsequent years may be necessary to eliminate the seedbank before reestablishing desirable perennial grasses in medusahead-dominated rangelands.

PRECAUTIONS, RESTRICTIONS: Slight discoloration of the desirable grasses may occur, but they will regreen and regrow under moist soil conditions as effects of this product wear off. Do not use ammonium sulfate when spraying rangeland grasses with this product. No waiting period between treatment and feeding of livestock grazing is required. Do not apply more than 3 quarts per acre per year.

11.0 ROUNDUP READY CROPS

The following instructions or those separately published on Supplemental labeling include all applications which can be made onto the specified Roundup Ready crops during the complete cropping season. Do NOT combine these instructions with other recommendations made for crop varieties that do not contain the Roundup Ready gene, in the "ANNUAL AND PERENNIAL CROPS (Alphabetical)" section of this label.

THIS COMPANY RECOMMENDS USE OF THIS PRODUCT FOR POSTEMERGENCE APPLICATION ONLY ON CROP VARIETIES DESIGNATED AS CONTAINING THE ROUNDUP READY GENE.

Applying this product to crop varieties that are not designated as Roundup Ready will result in severe crop injury and yield loss. Avoid contact with foliage, green stems, or fruit of crops, or any desirable plants that do not contain the Roundup Ready gene, since severe injury or destruction will result.

The Roundup Ready designation indicates that the crop variety contains a patented gene that provides tolerance to this product. Information on Roundup Ready crop varieties may be obtained from your seed supplier , Roundup Ready crop varieties must be purchased from an authorized licensed seed supplier.

NOTE: Roundup Ready seed, and the method of selectively controlling weeds using glyphosate on a Roundup Ready crop, are protected under several U.S. Patents, including 5,352,605 and 5,633,435. A license to use Roundup Ready seed must be obtained prior to use. Monsanto retains ownership of the gene and process technologies, and the Purchaser of the seed receives the right to use the licensed genes and technologies subject to the limited use license conditions. Seed containing the Roundup Ready trait cannot be used for research and demonstration, reverse engineering or in connection with herbicide registration. Progeny seed containing the Roundup Ready trait cannot be saved for replanting or transferred to others for replanting. Contact your Authorized Retailer for information on obtaining a limited use license.

For ground applications with broadcast equipment, apply this product in 5 to 20 gallons of spray solution per acre. Carefully select proper nozzle and spray pressure to avoid spraying a fine mist. For best results with ground application equipment use flat spray nozzles. Check for even distribution of spray droplets.

For aerial applications apply this product in 3 to 15 gallons of water per acre. See the "APPLICATION EQUIPMENT AND TECHNIQUES" section of this label for procedures to avoid spray drift that may cause injury to any vegetation not intended for treatment. Use of appropriate buffer zones will help prevent injury to adjacent vegetation.

ATTENTION: AVOID DRIFT. EXTREME CARE MUST BE USED WHEN APPLYING THIS PRODUCT TO PREVENT INJURY TO DESIRABLE PLANTS AND CROPS WHICH DO NOT CONTAIN THE ROUNDUP READY GENE.

See the "MIXING" and "APPLICATION EQUIPMENT AND TECHNIQUES" sections of this label for additional directions and restrictions on the application of this product.

Tank mixtures with other herbicides, insecticides, fungicides, micronutrients or foliar fertilizers may result in reduced weed control or crop injury and are NOT recommended for over-the-top applications of this product unless otherwise noted in this product label, supplemental labeling or fact sheets published separately.

Unless otherwise directed, nonionic surfactant may be added to the spray solution for applications to Roundup Ready crops. The addition of certain surfactants to this product may result in some crop response including leaf necrosis, leaf chlorosis or leaf speckling due to the surfactant added to the spray mixture. Read and carefully observe cautionary statements and other information appearing on the surfactant label.

Ammonium sulfate may be mixed with this product for applications to Roundup Ready crops. Refer to the "MIXING" section for use instructions for ammonium sulfate.

Sprayer Preparation: It is important that sprayer and mixing equipment be clean and free of pesticide residue before making applications of this product. Follow the cleaning procedures specified on the label of the product(s) previously used. THOROUGHLY CLEAN THE SPRAY TANK AND ALL LINES AND FILTERS TO ELIMINATE POTENTIAL CONTAMINATION FROM OTHER HERBICIDES PRIOR TO MIXING AND APPLYING THIS PRODUCT.

NOTE: The following recommendations are based on a clean start at planting by using a burndown application or tillage to control existing weeds before crop emergence. In no-till and stale seedbed systems, a preplant burn-down treatment of this product is recommended to control existing weeds prior to crop emergence. Some weeds, such as black nightshade, broadleaf signalgrass, sicklepod, Texas panicum, sandbur, annual morningglory, woolly cupgrass, shattercane, wild proso millet, burcucumber, and giant ragweed with multiple germination times or suppressed (stunted) weeds may require a second application of this product for complete control. The second application should be made after some regrowth has occurred and at least 10 days after a previous application of this product.

11.1 Canola with the Roundup Ready Gene

TYPES OF APPLICATIONS: Preplant, At-Planting, Preemergence, Postemergence

DO NOT USE THIS PRODUCT ON CANOLA WITH THE ROUNDUP READY GENE PLANTED IN THE FOLLOWING STATES: ALABAMA, DELAWARE, FLORIDA, GEORGIA, KENTUCKY, MARYLAND, NEW JERSEY, NORTH CAROLINA, SOUTH CAROLINA, TENNESSEE, VIRGINIA AND WEST VIRGINIA.

Maximum Allowable Combined Application Quantities Per Season	
Preplant, At-Planting, Preemergence applications	2 quarts per acre
Total in-crop applications from emergence to 6-leaf stage	1 quart per acre

ANNEX 128

United States Roundup Pro Label

ATTENTION:
This specimen label is provided for general information only.

- This pesticide product may not yet be available or approved for sale or use in your area.
- It is your responsibility to follow all federal, state and local laws and regulations regarding the use of pesticides.
- Before using any pesticide, be sure the intended use is approved in your state or locality.
- Your state or locality may require additional precautions and instructions for use of this product that are not included here.
- Monsanto does not guarantee the completeness or accuracy of this specimen label. The information found in this label may differ from the information found on the product label. You must have the EPA approved labeling with you at the time of use and must read and follow all label directions.
- You should not base any use of a similar product on the precautions, instructions for use or other information you find here.
- Always follow the precautions and instructions for use on the label of the pesticide you are using.

21136F2-48

Roundup PRO® Herbicide

GROUP	9	HERBICIDE

The complete broad-spectrum postemergence professional herbicide for industrial, turf and ornamental weed control.

Complete Directions for Use

AVOID CONTACT OF HERBICIDE WITH FOLIAGE, GREEN STEMS, EXPOSED NON-WOODY ROOTS OR FRUIT OF CROPS, DESIRABLE PLANTS AND TREES, BECAUSE SEVERE INJURY OR DESTRUCTION IS LIKELY TO RESULT.

EPA Reg. No. 524-475 2007-1

Read the entire label before using this product.

Use only according to label instructions.

Not all products recommended on this label are registered for use in California. Check the registration status of each product in California before using .

Read the **LIMIT OF WARRANTY AND LIABILITY** statement at the end of the label before buying or using. If terms are not acceptable, return at once unopened.

THIS IS AN END-USE PRODUCT. MONSANTO DOES NOT INTEND AND HAS NOT REGISTERED IT FOR REFORMULATION. SEE INDIVIDUAL CONTAINER LABEL FOR REPACKAGING LIMITATIONS.

1.0 INGREDIENTS

ACTIVE INGREDIENT:	
*Glyphosate, N-(phosphonomethyl)glycine, in the form of its isopropylamine salt	41.0%
OTHER INGREDIENTS (including surfactant):	59.0%
	100.0%

*Contains 480 grams per liter or 4 pounds per U.S. gallon of the active ingredient glyphosate, in the form of its isopropylamine salt. Equivalent to 356 grams per liter or 3 pounds per U.S. gallon of the acid, glyphosate.

This product is protected by U.S. Patent Nos. 5,683,958; 5,703,015; 6,063,733; 6,121,199; 6,121,200. No license granted under any non-U.S. patent(s).

2.0 IMPORTANT PHONE NUMBERS

1. FOR PRODUCT INFORMATION OR ASSISTANCE IN USING THIS PRODUCT, CALL TOLL-FREE,
   1-800-332-3111.
2. IN CASE OF AN EMERGENCY INVOLVING THIS PRODUCT, OR FOR MEDICAL ASSISTANCE, CALL COLLECT, DAY OR NIGHT,
   (314)-694-4000.

3.0 PRECAUTIONARY STATEMENTS

3.1 Hazards to Humans and Domestic Animals

Keep out of reach of children.

CAUTION!

CAUSES EYE IRRITATION.

Avoid contact with eyes or clothing.

FIRST AID: Call a poison control center or doctor for treatment advice.	
IF IN EYES	• Hold eye open and rinse slowly and gently with water for 15 - 20 minutes. • Remove contact lenses if present after the first 5 minutes then continue rinsing eye.

- Have the product container or label with you when calling a poison control center or doctor, or going for treatment.
- You may also contact **(314) 694-4000,** collect day or night, for emergency medical treatment information.
- This product is identified as **Roundup PRO® herbicide, EPA Registration No. 524-475.**

DOMESTIC ANIMALS: This product is considered to be relatively nontoxic to dogs and other domestic animals; however, ingestion of this product or large amounts of freshly sprayed vegetation may result in temporary gastrointestinal irritation (vomiting, diarrhea, colic, etc.). If such symptoms are observed, provide the animal with plenty of fluids to prevent dehydration. Call a veterinarian if symptoms persist for more than 24 hours.

Personal Protective Equipment (PPE)

Applicators and other handlers must wear: long-sleeved shirt and long pants, shoes plus socks. Follow manufacturer's instructions for cleaning/maintaining Personal Protective Equipment (PPE). If there are no such instructions for washables, use detergent and hot water. Keep and wash PPE separately from other laundry.

Discard clothing and other absorbent materials that have been drenched or heavily contaminated with this product's concentrate. Do not reuse them.

When handlers use closed systems, enclosed cabs or aircraft in a manner that meets the requirements listed in Worker Protection Standard (WPS) for agricultural pesticides [40 CFR 170.240 (d) (4-6)], the handler PPE requirements may be reduced or modified as specified in the WPS.

IMPORTANT: When reduced PPE is worn because a closed system is being used, handlers must be provided all PPE specified above for "applicators and other handlers" and have such PPE immediately available for use in an emergency, such as spill or equipment breakdown.

User Safety Recommendations

Users should:

- Wash hands before eating, drinking, chewing gum, using tobacco, or using the toilet.
- Remove clothing immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing.

3.2 Environmental Hazards

Do not apply directly to water, to areas where surface water is present or to intertidal areas below the mean high water mark. Do not contaminate water when cleaning equipment or disposing of equipment washwaters.

3.3 Physical or Chemical Hazards

Spray solutions of this product should be mixed, stored and applied using only stainless steel, aluminum, fiberglass, plastic or plastic-lined steel containers.

DO NOT MIX, STORE OR APPLY THIS PRODUCT OR SPRAY SOLUTIONS OF THIS PRODUCT IN GALVANIZED STEEL OR UNLINED STEEL (EXCEPT STAINLESS STEEL) CONTAINERS OR SPRAY TANKS. This product or spray solutions of this product react with such containers and tanks to produce hydrogen gas which may form a highly combustible gas mixture. This gas mixture could flash or explode, causing serious personal injury, if ignited by open flame, spark, welder's torch, lighted cigarette or other ignition source.

DIRECTIONS FOR USE

It is a violation of Federal law to use this product in any manner inconsistent with its labeling. This product can only be used in accordance with the Directions for Use on this label or in separately published Monsanto Supplemental Labeling. Supplemental labeling may be found on the www.cdms.net or www.greenbook.net websites or obtained by contacting your Authorized Monsanto Retailer or Monsanto Company representative.

Do not apply this product in a way that will contact workers or other persons, either directly or through drift. Only protected handlers may be in the area during application. For any requirements specific to your State or Tribe, consult the agency responsible for pesticide regulations.

Agricultural Use Requirements

Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR part 170. This Standard contains requirements for the protection of agricultural workers on farms, forests, nurseries, and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification, and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this label about Personal Protective Equipment (PPE) and restricted entry interval. The requirements in this box only apply to uses of this product that are covered by the Worker Protection Standard.

Do not enter or allow worker entry into treated areas during the restricted entry interval (REI) of 4 hours.

PPE required for early entry to treated areas that is permitted under the Worker Protection Standard and that involves contact with anything that has been treated, such as plants, soil, or water, is: coveralls, chemical resistant gloves greater than 14 mils in thickness composed of materials such as butyl rubber, natural rubber, neoprene rubber, or nitrile rubber, shoes plus socks.

Non-Agricultural Use Requirements

The requirements in this box apply to uses of this product that are NOT within the scope of the Worker Protection Standard (40 CFR Part 170) for agricultural pesticides. The WPS applies when this product is used to produce agricultural plants on farms, forests, nurseries or greenhouses.

Keep people and pets off treated areas until spray solution has dried.

4.0 STORAGE AND DISPOSAL

PESTICIDE STORAGE: Do not contaminate water, foodstuffs, feed or seed by storage or disposal. Keep container closed to prevent spills and contamination.

PESTICIDE DISPOSAL: Wastes resulting from the use of this product that cannot be used or chemically reprocessed should be disposed of in a landfill approved for pesticide disposal or in accordance with applicable Federal, state, or local procedures.

CONTAINER DISPOSAL: Emptied container retains vapor and product residue. Observe all labeled safeguards until container is cleaned, reconditioned, or destroyed.

FOR PLASTIC 1-WAY CONTAINERS & BOTTLES:
Do not reuse container. Triple rinse container, then puncture and dispose of in a sanitary landfill, or by incineration, or, if allowed by state and local authorities, by burning. If burned, stay out of smoke.

FOR ONE-WAY DRUMS:
Do not reuse container. Return container per the Monsanto container return program. If not returned, triple rinse container, then puncture and dispose of in a sanitary landfill, or by incineration, or, if allowed by state and local authorities, by burning. If burned, stay out of smoke.

FOR REFILLABLE PORTABLE (MINI-BULK) CONTAINERS:
This container must only be refilled with pesticide product. **Do not reuse this container for any other purpose.**

Final disposal must be in compliance with state and local regulations. If not refilled, returned, or recycled, triple rinse or pressure rinse, puncture and dispose of in a sanitary landfill, or by incineration, or, if allowed by state and local authorities, by burning. If burned, stay out of smoke.

Do not transport this container if it is damaged or leaking. If the container is damaged, leaking or obsolete or to obtain information about recycling portable refillable containers, contact Monsanto Company at 1-800-ROUNDUP (1-800-768-6387).

Users: When the container is empty, replace the cap and seal all openings that have been made during usage, and return the container to the point of purchase, or to an alternate location designated by the manufacturer at the time of purchase of this product. If not returned, triple rinse or pressure rinse the empty container and offer it for recycling if available.

Refillers: Do not reuse this mini-bulk container except for refill in accordance with a valid Monsanto Repackaging or Toll Repackaging Agreement. Prior to refilling, inspect carefully for damage such as cracks, punctures, abrasions, worn-out threads and closure devices. Check for leaks after refilling and before transporting.

FOR REFILLABLE STATIONARY BULK CONTAINERS:
This container must only be refilled with pesticide product. **Do not reuse this container for any other purpose.**

Prior to refilling, inspect carefully for damage such as cracks, punctures, abrasions, worn-out threads and closure devices.

Final disposal must be in compliance with state and local regulations. If not refilled, triple rinse or pressure rinse container and offer for recycling or reconditioning if possible. If burned, stay out of smoke.

5.0 GENERAL INFORMATION
(How This Product Works)

Product Description: This product is a postemergence, systemic herbicide with no soil residual activity. It gives broad-spectrum control of many annual weeds, perennial weeds, woody brush and trees. It is formulated as a water-soluble liquid containing surfactant and no additional surfactant is needed or recommended.

Time to Symptoms: This product moves through the plant from the point of foliage contact to and into the root system. Visible effects are a gradual wilting and yellowing of the plant, which advances to complete browning of aboveground growth and deterioration of underground plant parts. Effects are visible on most annual weeds within 2 to 4 days, but on most perennial weeds, effects may not be visible for 7 days or more. Extremely cool or cloudy weather following treatment may slow activity of this product and delay development of visual symptoms.

Mode of Action in Plants: The active ingredient in this product inhibits an enzyme found only in plants and microorganisms that is essential to the formation of specific amino acids.

Cultural Considerations: Reduced control may result when applications are made to annual or perennial weeds that have been mowed, grazed or cut, and have not been allowed to regrow to the recommended stage for treatment.

Rainfastness: Heavy rainfall soon after application may wash this product off of the foliage and a repeat application may be required for adequate control.

No Soil Activity: Weeds must be emerged at the time of application to be controlled by this product. Weeds germinating from seed after application will not be controlled. Unemerged plants arising from unattached underground rhizomes or rootstocks of perennials will not be affected by this herbicide and will continue to grow.

Tank Mixing: This product does not provide residual weed control. For subsequent residual weed control, follow a label-approved herbicide program. Read and carefully observe the cautionary statements and all other information appearing on the labels of all herbicides used. Use according to the most restrictive precautionary statements for each product in the mixture.

When this label recommends a tank mixture with a single generic active ingredient such as diuron, 2,4-D or dicamba, the user is responsible for ensuring that the mixture product's label allows the specific application.

Buyer and all users are responsible for all loss or damage in connection with the use or handling of mixtures of this product with herbicides or other materials that are not expressly recommended in this label. Mixing this product with herbicides or other materials not recommended on this label may result in reduced performance.

Annual Maximum Use Rate: The combined total of all treatments must not exceed 10.6 quarts of this product per acre per year. The maximum use rates stated throughout this product's labeling apply to this product combined with the use of all other herbicides containing glyphosate as the active ingredient, whether applied as mixtures or separately. Calculate the application rates and ensure that the total use of this and other glyphosate containing products does not exceed stated maximum use rates.

ATTENTION

AVOID CONTACT OF HERBICIDE WITH FOLIAGE, GREEN STEMS, EXPOSED NON-WOODY ROOTS OR FRUIT OF CROPS, DESIRABLE PLANTS AND TREES, BECAUSE SEVERE INJURY OR DESTRUCTION MAY RESULT.

AVOID DRIFT. EXTREME CARE MUST BE USED WHEN APPLYING THIS PRODUCT TO PREVENT INJURY TO DESIRABLE PLANTS AND CROPS.

Do not allow the herbicide solution to mist, drip, drift or splash onto desirable vegetation since minute quantities of this product can cause severe damage or destruction to the crop, plants or other areas on which treatment was not intended. The likelihood of injury occurring from the use of this product increases when winds are gusty, as wind velocity increases, when wind direction is constantly changing or when there are other meteorological conditions that favor spray drift. When spraying, avoid combinations of pressure and nozzle type that will result in splatter or fine particles (mist) that are likely to drift. AVOID APPLYING AT EXCESSIVE SPEED OR PRESSURE.

NOTE: Use of this product in any manner not consistent with this label may result in injury to persons, animals or crops, or have other unintended consequences.

5.1 Weed Resistance Management

GROUP	9	HERBICIDE

Glyphosate, the active ingredient in this product, is a Group 9 herbicide based on the mode of action classification system of the Weed Science Society of America. Any weed population may contain plants naturally resistant to Group 9 herbicides. Weed species resistant to Group 9 herbicides may be effectively managed utilizing another herbicide from a different Group or using other cultural or mechanical practices.

To minimize the occurrence of glyphosate-resistant biotypes observe the following general weed management recommendations:

- Scout your application site before and after herbicide applications.
- Control weeds early when they are relatively small.
- Incorporate other herbicides and cultural or mechanical practices as part of your weed control system where appropriate.
- Utilize the recommended label rate for the most difficult weed in the site. Avoid tank-mixtures with other herbicides that reduce this product's efficacy (through antagonism) or tank mixture recommendations which encourage rates of this product below the label recommendations.
- Control weed escapes and prevent weeds from setting seeds.
- Clean equipment before moving from site to site to minimize spread of weed seed.
- Use new commercial seed as free of weed seed as possible.
- Report any incidence of repeated non-performance of this product on a particular weed to your Monsanto representative, local retailer, or county extension agent.

5.2 Management Recommendations for Glyphosate Resistant Weed Biotypes

NOTE: Appropriate testing is critical in order to confirm weed resistance to glyphosate. Contact your Monsanto representative to determine if resistance has been confirmed to any particular weed biotype in your area. Control recommendations for biotypes confirmed as resistant to glyphosate are made available on separately published supplemental labeling or fact sheets for this product and may be obtained from your local retailer or Monsanto representative.

Follow good weed management practices to avoid the spread of confirmed resistant biotypes.

- If a naturally occurring resistant biotype is present at your site, this product may be tank-mixed or applied sequentially with an appropriately la beled herbicide with a different mode of action to achieve control.
- Cultural and mechanical control practices may also be used as appropriate.
- Scout treated sites after herbicide applications and control escapes of resistant biotypes before they set seed.
- Thoroughly clean equipment before leaving sites known to contain resistant biotypes.

6.0 MIXING

Clean sprayer parts immediately after using this product by thoroughly flushing with water.

NOTE: REDUCED RESULTS MAY OCCUR IF WATER CONTAINING SOIL IS USED, SUCH AS VISIBLY MUDDY WATER OR WATER FROM PONDS AND DITCHES THAT IS NOT CLEAR.

6.1 Mixing with Water

This product mixes readily with water. Mix spray solutions of this product as follows: Begin filling the mixing tank or spray tank with the required amount of clean water. Add the recommended amount of this product near the end of the filling process and mix well. Use caution to avoid siphoning back into the carrier source. Use approved anti-back-siphoning devices where required by state or local regulations. During mixing and application, foaming of the spray solution may occur. To prevent or minimize foam, avoid the use of mechanical agitators, terminate by-pass and return lines at the bottom of the tank and, if needed, use an approved anti-foam or defoaming agent.

6.2 Tank Mixing Procedure

When tank mixing, read and carefully observe label directions, cautionary statements and all information on the labels of all products used. Add the tank-mix product to the tank as directed by the label. Maintain agitation and add the recommended amount of this product.

Maintain good agitation at all times until the contents of the tank are sprayed. If the spray mixture is allowed to settle, thorough agitation may be required to resuspend the mixture before spraying is resumed.

Keep by-pass line on or near the bottom of the tank to minimize foaming. Screen size in nozzle or line strainers should be no finer than 50-mesh.

Always predetermine the compatibility of labeled tank mixtures of this product with water carrier by mixing small proportional quantities in advance. Ensure that the specific tank mixture product is registered for application at the desired site.

Refer to the **Tank Mixing** section for additional precautions.

6.3 Mixing for Hand-Held Sprayers

Prepare the desired volume of spray solution by mixing the amount of this product as indicated in the following table with water:

Spray Solution

Desired Volume	Amount of Roundup PRO herbicide					
	1/2 %	1%	1 1/2 %	2%	5%	10%
1 gal	2/3 oz	1 1/3 oz	2 oz	2 2/3 oz	6 1/2 oz	13 oz
25 gal	1 pt	1 qt	1 1/2 qt	2 qt	5 qt	10 qt
100 gal	2 qt	1 gal	1 1/2 gal	2 gal	5 gal	10 gal
2 tablespoons = 1 fluid ounce						

For use in backpack, knapsack or pump-up sprayers, it is recommended that the appropriate amount of this product be mixed with water in a larger container and then filling the sprayer with the mixed solution.

6.4 Colorants or Dyes

Colorants or marking dyes may be added to spray solutions of this product; however they may reduce product performance at lower rates or dilution. Use colorants or dyes according to the manufacturer's recommendations.

7.0 APPLICATION EQUIPMENT AND TECHNIQUES

Do not apply this product through any type of irrigation system.

APPLY THESE SPRAY SOLUTIONS IN PROPERLY MAINTAINED AND CALIBRATED EQUIPMENT CAPABLE OF DELIVERING DESIRED VOLUMES.

7.1 Aerial Equipment

DO NOT APPLY THIS PRODUCT USING AERIAL SPRAY EQUIPMENT EXCEPT UNDER CONDITIONS SPECIFIED IN THIS LABEL or in separately published Monsanto Supplemental Labeling.

Use the recommended rates of this herbicide in 3 to 25 gallons of water per acre. When used according to label directions, this product will give control or partial control of herbaceous weeds, woody brush and trees listed in the **WEEDS CONTROLLED** section of this label.

Coarse sprays are less likely to drift; therefore, do not use nozzles or nozzle configurations that dispense spray as fine spray droplets. Do not angle nozzles forward into the airstream and do not increase spray volume by increasing nozzle pressure. Drift control additives may be used. When a drift control additive is used, read and carefully observe the cautionary statements and all other information appearing on the additive label.

FOR AERIAL APPLICATION IN CALIFORNIA OR ARKANSAS, REFER TO THE FEDERAL SUPPLEMENTAL LABEL FOR AERIAL APPLICATIONS IN THAT STATE FOR SPECIFIC INSTRUCTIONS, RESTRICTIONS AND REQUIREMENTS.

Avoid direct application to any body of water.

Ensure uniform application. To avoid streaked, uneven or overlapped application, use appropriate marking devices.

Aircraft Maintenance: PROLONGED EXPOSURE OF THIS PRODUCT TO UNCOATED STEEL SURFACES MAY RESULT IN CORROSION AND POSSIBLE FAILURE OF THE PART. The maintenance of an organic coating (paint) which meets aerospace specification MIL-C-38413 may prevent corrosion. To prevent corrosion of exposed parts, thoroughly wash aircraft after each day of spraying to remove residues of this product accumulated during spraying or from spills. Landing gear is most susceptible.

SPRAY DRIFT MANAGEMENT

AVOID DRIFT. EXTREME CARE MUST BE USED WHEN APPLYING THIS PRODUCT TO PREVENT INJURY TO DESIRABLE PLANTS AND CROPS.

Do not allow the herbicide solution to mist, drip, drift or splash onto desirable vegetation since minute quantities of this product can cause severe damage or destruction to the crop, plants or other areas on which treatment was not intended.

Avoiding spray drift at the application site is the responsibility of the applicator. The interaction of many equipment- and weather-related factors determines the potential for spray drift. The applicator and the grower are/is responsible for considering all these factors when making decisions.

AERIAL SPRAY DRIFT MANAGEMENT

The following drift management requirements must be followed to avoid off-target drift movement from aerial applications to agricultural field crops.

1. The distance of the outermost nozzles on the boom must not exceed 3/4 the length of the wingspan or rotor.
2. Nozzles must always point backward parallel with the airstream and never be pointed downwards more than 45 degrees. Where states have more stringent regulations, they should be observed.

Importance of droplet size

The most effective way to reduce drift potential is to apply large droplets. The best drift management strategy is to apply the largest droplets that provide sufficient coverage and control. Applying larger droplets reduces drift potential, but will not prevent drift if applications are made improperly, or under unfavorable environmental conditions (see the **Wind**, **Temperature and Humidity**, and **Temperature Inversion** sections of this label).

Controlling droplet size

- **Volume:** Use high flow rate nozzles to apply the highest practical spray volume. Nozzles with the higher rated flows produce larger droplets.
- **Pressure:** Use the lower spray pressures recommended for the nozzle. Higher pressure reduces droplet size and does not improve canopy penetration. When higher flow rates are needed, use higher flow rate nozzles instead of increasing pressure.
- **Number of nozzles:** Use the minimum number of nozzles that provide uniform coverage.
- **Nozzle orientation:** Orienting nozzles so that the spray is released backwards, parallel to the airstream, will produce larger droplets than other orientations. Significant deflection from the horizontal will reduce droplet size and increase drift potential.
- **Nozzle type:** Use a nozzle type that is designed for the intended application. With most nozzle types, narrower spray angles produce larger droplets. Consider using low-drift nozzles. Solid stream nozzles oriented straight back produce larger droplets than other nozzle types.
- **Boom length**: For some use patterns, reducing the effective boom length to less than 3/4 of the wingspan or rotor length may further reduce drift without reducing swath width.
- **Application height:** Applications should not be made at a height greater than 10 feet above the top of the largest plants unless a greater height is required for aircraft safety. Making applications at the lowest height that is safe reduces the exposure of the droplets to evaporation and wind.

Swath Adjustment

When applications are made with a crosswind, the swath will be displaced downwind. Therefore, on the up and downwind edges of the field, the applicator must compensate for this displacement by adjusting the path of the aircraft upwind. Swath adjustment distance should increase, with increasing drift potential (higher wind spee d, smaller droplets, etc.).

Wind

Drift potential is lowest between wind speeds of 2 to 10 miles per hour. However, many factors, including droplet size and equipment type determine drift potential at any given wind speed. Application should be avoided when wind speeds are below 2 miles per hour due to variable wind direction and high inversion potential. **NOTE:** Local terrain can influence wind patterns. Every applicator should be familiar with local wind patterns and how they affect drift.

Temperature and Humidity

When making applications in low relative humidity, adjust equipment to produce larger droplets to compensate for evaporation. Droplet evaporation is most severe when conditions are both hot and dry.

Temperature Inversions

Applications should not be made during a temperature inversion because drift potential is high. Temperature inversions restrict vertical air mixing, which causes small suspended droplets to remain in a concentrated cloud. This cloud can move in unpredictable directions due to the light variable winds common during inversions. Temperature inversions are characterized by increasing temperatures with altitude and are common on nights with limited cloud cover and light to no wind. They begin to form as the sun sets and often continue into the morning. Their presence can be indicated by ground fog; however, if fog is not present, movement of smoke produced by a ground source or an aircraft smoke generator can also identify temperature inversions. Smoke that layers and moves laterally in a concentrated cloud (under low wind conditions) indicates an inversion, while smoke that moves upward and rapidly dissipates indicates good vertical air mixing.

Sensitive Areas

Apply this product only when the potential for drift to sensitive areas (e.g., residential areas, bodies of water, known habitat for threatened or endangered species, non-target crops) is minimal (e.g., when wind is blowing away from the sensitive areas).

7.2 Ground Broadcast Equipment

Use the recommended rates of this product in 3 to 40 gallons of water per acre as a broadcast spray unless otherwise specified. As density of weeds increases, spray volume should be increased within the recommended range to ensure complete coverage. Carefully select proper nozzles to avoid spraying a fine mist. For best results with ground application equipment, use flat-fan nozzles. Check for even distribution of spray droplets.

7.3 Backpack or Hand-Held Equipment

Apply to foliage of vegetation to be controlled on a spray-to-wet basis; do not spray to the point of runoff. Spray coverage should be uniform and complete. Use coarse sprays only.

7.4 Selective Equipment

This product may be diluted with water and applied through recirculating spray systems, shielded applicators, hooded sprayers, wiper applicators or sponge bars, to listed weeds growing in any non-crop site specified on this label.

A recirculating spray system directs the spray solution onto weeds growing above desirable vegetation, while spray solution not intercepted by weeds is collected and returned to the spray tank for reuse.

AVOID CONTACT OF HERBICIDE WITH DESIRABLE VEGETATION. Contact of this product with desirable vegetation may result in unwanted plant damage or destruction.

Application equipment used above desired vegetation should be adjusted so that the lowest spray stream or wiper contact point is at least 2 inches above the desirable vegetation. Droplets, mist, foam or splatter of the herbicide solution settling on desirable vegetation is likely to result in discoloration, stunting or destruction.

Better results may be obtained when more of the weed is exposed to the herbicide solution. Weeds not contacted by the herbicide solution will not be affected. This may occur in dense clumps, severe infestations or when the height of the weeds varies so that not all weeds are contacted. In these instances, repeat treatment may be necessary.

Shielded and Hooded Applicators

A shielded or hooded applicator directs the herbicide solution onto weeds, while shielding desirable vegetation from the herbicide. Use nozzles that provide uniform coverage within the treated area. Keep shields on these sprayers adjusted to protect desirable vegetation. EXTREME CARE MUST BE EXERCISED TO AVOID CONTACT OF HERBICIDE WITH DESIRABLE VEGETATION.

Wiper Applicators and Sponge Bars

A wiper or sponge applicator applies the herbicide solution onto weeds by rubbing the weed with an absorbent material containing the herbicide solution. Equipment must be designed, maintained and operated to prevent the herbicide solution from contacting desirable vegetation. Operate this equipment at ground speeds no greater than 5 miles per hour. Performance may be improved by reducing speed in areas of heavy weed infestations to ensure adequate wiper saturation. Better results may be obtained if two (2) applications are made in opposite directions.

Avoid leakage or dripping onto desirable vegetation. Adjust height of applicator to ensure adequate contact with weeds. Keep wiping surfaces clean. Be aware that, on sloping ground, the herbicide solution may migrate, causing dripping on the lower end and drying of the wicks on the upper end of a wiper applicator.

Do not use wiper applicators when weeds are wet.

Mix only the amount of solution to be used during a 1-day period, as reduced activity may result from use of leftover solutions. Clean wiper parts immediately after using this product by thoroughly flushing with water.

For Rope or Sponge Wick Applicators: Use solutions ranging from 33 to 75 percent of this product in water.

For Panel Applicators and Pressure-Feed Systems: Use solutions ranging from 33 to 100 percent of this product in water.

When applied as recommended above, this product CONTROLS the following weeds:

Corn, volunteer
Panicum, Texas
Rye, common
Shattercane
Sicklepod
Spanishneedles
Starbur, bristly

When applied as recommended above, this product SUPPRESSES the following weeds:

Beggarweed, Florida
Bermudagrass
Dogbane, hemp
Dogfennel
Guineagrass
Johnsongrass
Milkweed
Nightshade, silverleaf
Pigweed, redroot
Ragweed, common
Ragweed, giant
Smutgrass
Sunflower
Thistle, Canada
Thistle, musk
Vaseygrass
Velvetleaf

7.5 Injection Systems

This product may be used in aerial or ground injection spray systems. It may be used as a liquid concentrate or diluted prior to injecting into the spray st ream. Do not mix this product with the undiluted concentrate of other prod ucts when using injection systems unless specifically recommended.

7.6 CDA Equipment

The rate of this product applied per acre by controlled droplet application (CDA) equipment must not be less than the amount recommended in this label when applied by conventional broadcast equipment. For vehicle-mounted CDA equipment, apply in 2 to 15 gallons of water per acre.

CDA equipment produces a spray pattern that is not easily visible. Extreme care must be exercised to avoid spray or drift contacting the foliage or any other green tissue of desirable vegetation, as damage or destruction is likely to result.

ANNEX 129

United States Roundup SL Label, United States Pesticide Product Label System, Registration No. 524-308 (15 Nov. 2001)

524-308 11/15/2001 Page 1 of 13

Roundup SL Herbicide

Complete Directions for Use

EPA Reg. No. 524-308

Herbicide for ground and aerial application to remove undesirable vegetation in non-agricultural sites

AVOID CONTACT OF HERBICIDE WITH FOLIAGE, GREEN STEMS, EXPOSED NON-WOODY ROOTS, OR FRUIT OF CROPS, DESIRABLE PLANTS AND TREES, BECAUSE SEVERE INJURY OR DESTRUCTION MAY RESULT.

Read the entire label before using this product.

Use only according to label instructions.

Read the "LIMIT OF WARRANTY AND LIABILITY" statement at the end of the label before buying or using. If terms are not acceptable, return at once unopened.

THIS IS AN END-USE PRODUCT. MONSANTO DOES NOT INTEND AND HAS NOT REGISTERED IT FOR REFORMULATION. SEE INDIVIDUAL CONTAINER LABEL FOR REPACKAGING LIMITATIONS.

Refillable Container Label Statement:

THIS IS AN END-USE PRODUCT. MONSANTO DOES NOT INTEND AND HAS NOT REGISTERED IT FOR REFORMULATION. IT IS INTENDED THAT REPACKAGING BE ONLY IN ACCORDANCE WITH A MONSANTO REPACKAGING OR TOLL REPACKAGING AGREEMENT.

Non-refillable Container Label Statement:

THIS IS AN END-USE PRODUCT. MONSANTO DOES NOT INTEND AND HAS NOT REGISTERED IT FOR REFORMULATION OR REPACKAGING.

ACTIVE INGREDIENT:	
*Glyphosate, N-(phosphonomethyl)glycine, in the form of its isopropylamine salt	41.0%
OTHER INGREDIENTS:	59.0%
	100.0%

*Contains 480 grams per litre or 4 pounds per U.S. gallon of the active ingredient glyphosate, in the form of its isopropylamine salt. Equivalent to 356 grams per litre or 3 pounds per U.S. gallon of the acid, glyphosate.

IMPORTANT PHONE NUMBERS

2 8 13

1. FOR PRODUCT INFORMATION OR ASSISTANCE IN USING THIS PRODUCT, CALL TOLL-FREE,
   1-800-332-3111

2. IN CASE OF AN EMERGENCY INVOLVING THIS HERBICIDE PRODUCT, OR FOR MEDICAL ASSISTANCE, CALL COLLECT, DAY OR NIGHT,

   (314)-694-4000

ACCEPTED
NOV 15 2001
Under the Federal Insecticide, Fungicide, and Rodenticide Act, as amended, for the pesticide registered under EPA Reg. No 524-308

PRECAUTIONARY STATEMENTS

Hazards to Humans and Domestic Animals

Keep out of reach of children.

DANGER! PELIGRO!

Si usted no entiende la etiqueta, busque a alguien para que se la explique a usted en detalle. (If you do not understand the label, find someone to explain it to you in detail.

CAUSES IRREVERSIBLE EYE DAMAGE.

HARMFUL IF SWALLOWED OR INHALED.

MAY CAUSE SKIN IRRITATION.

Do not get in eyes, on skin, or on clothing.

Avoid breathing vapor or spray mist.

FIRST AID:	Call a poison control center or doctor for treatment advice.
IF IN EYES:	• Hold eye open and rinse slowly and gently with water for 15 - 20 minutes. • Remove contact lenses if present after the first 5 minutes then continue rinsing eye.
IF ON SKIN	• Take off contaminated clothing. • Rinse skin immediately with plenty of water for 15 - 20 minutes.
IF INHALED	• Move person to fresh air. • If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably mouth-to-mouth, if possible.
IF SWALLOWED:	• Have person sip a glass of water if able to swallow. • Do not induce vomiting unless told to do so by the poison control center or doctor. • Do not give anything by mouth to an unconscious person.
NOTE TO PHYSICIAN:	Probable mucosal damage may contraindicate the use of gastric lavage.

1 gal	2/3 oz	1-1/3 oz	2 oz	2-2/3 oz	6-1/2 oz	13 oz
25 gal	1 pt	1 qt	1-1/2 qt	2 qt	5 qt	10 qt
100 gal	2 qt	1 gal	1-1/2 gal	2 gal	5 gal	10 gal

2 tablespoons = 1 fluid ounce

For use in knapsack sprayers, it is suggested that the recommended amount of this product be mixed with water in a larger container. Fill sprayer with the mixed solution.

Aerial Application Equipment

Use the recommended rates of this herbicide in 2 to 15 gallons of total spray volume per acre unless otherwise specified on this label. Refer to the individual use area sections of this label for recommended volumes, application rates, and further instructions.

Avoid direct application to any body of water.

AVOID DRIFT—DO NOT APPLY DURING INVERSION CONDITIONS, WHEN WINDS ARE GUSTY OR UNDER ANY OTHER CONDITION WHICH FAVORS DRIFT. DRIFT MAY CAUSE DAMAGE TO ANY VEGETATION CONTACTED TO WHICH TREATMENT IS NOT INTENDED. TO PREVENT INJURY TO ADJACENT DESIRABLE VEGETATION, APPROPRIATE BUFFER ZONES ARE RECOMMENDED.

Coarse sprays are less likely to drift; therefore, do not use nozzles or nozzle configurations which dispense spray as fine spray droplets. Do not angle nozzles forward into the airstream and do not increase spray volume by increasing nozzle pressure.

Drift control additives may be used. When a drift control additive is used, read and carefully observe the cautionary statements and all other information appearing on the additive label.

Ensure uniform application - To avoid streaked, uneven or overlapped application, use appropriate marking devices.

Thoroughly wash aircraft, especially landing gear, after each day of spraying to remove residues of this product accumulated during spraying or from spills. PROLONGED EXPOSURE OF THIS PRODUCT TO UNCOATED STEEL SURFACES MAY RESULT IN CORROSION AND POSSIBLE FAILURE OF THE PART. LANDING GEAR IS MOST SUSCEPTIBLE. The maintenance of an organic coating (paint), which meets aerospace specification MIL-C-38413, may prevent corrosion.

Application Sites

This product may be used as recommended for:

- Control of undesired annual and perennial herbaceous weeds in non-cropped rangelands.
- Control of undesired woody brush and small trees.
- Aid to burning treatment to establish and maintain fuel breaks, fire perimeters, and black lines.
- Along roads and utility rights-of-way.
- Around industrial sites, parking, buildings, fencing, etc.

Application techniques, timing and rate

General Recommendations. Always use the higher rate of this product per acre within the recommended range when weed growth is heavy or dense or weeds are growing in an undisturbed area.

ANNEX 130

(DOCUMENT INTENTIONALLY OMITTED)

ANNEX 131

C. André Lévesque & James E. Rahe,
Herbicide Interactions with Fungal Root Pathogens, with Special Reference to Glyphosate, Annu. Rev. Phytopathol., Vol. 30 (1992)

Annual Reviews
www.annualreviews.org/aronline

Annu. Rev. Phytopathol. 1992. 30:579–602
Copyright (C) by Annual Reviews Inc. All rights reserved

Annu. Rev. Phytopathol. 1992.30:579-602. Downloaded from arjournals.annualreviews.org
by Joanne Blinn on 03/03/09. For personal use only.

HERBICIDE INTERACTIONS WITH FUNGAL ROOT PATHOGENS, WITH SPECIAL REFERENCE TO GLYPHOSATE

C. André Lévesque and James E. Rahe

Center for Pest Management, Department of Biological Sciences, Simon Fraser University, Burnaby, British Columbia, Canada, V5A 1S6

KEY WORDS: plant disease, microorganism, microflora, predisposition, phytotoxicity

INTRODUCTION

Weeds are the most economically important of all pests with respect to sales of pesticides and limitations to crop yields (62). Herbicide sales represent more than two thirds of the 436 $\times$ 10^6 kg of pesticides used annually in United States (113), and almost one half of the $21 billion worldwide pesticide market (8). Numerous cases where an herbicide treatment influences disease outcome have been studied by plant pathologists as well as weed scientists. The concepts and the literature on interactions between herbicides, microorganisms, and plant diseases have been extensively reviewed (2–4, 40, 51, 59, 78, 129, 150). Most of the literature on herbicides deals with their direct effects on weeds and the effects of weed control on crops (Figure 1A). The effects of herbicides coming in direct contact with crops are considered secondarily in the weed-management literature (Figure 1B). The protection or predisposition of crops to disease that is sometimes observed following the use of herbicides is of particular interest to plant pathologists.

As we document in this review, herbicides can alter soil ecosystems by having a direct effect on various components of the soil microflora, such as

0066-4286/92/0901-0579$02.00

Annual Reviews
www.annualreviews.org/aronline

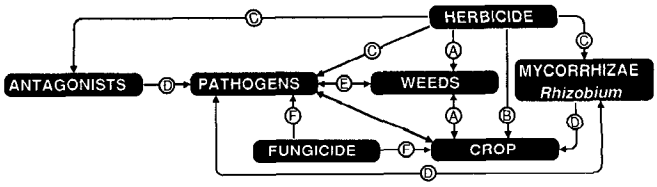


Figure 1 Theoretical direct and indirect effects of herbicides on biotic components of crop pathosystem.

Annu. Rev. Phytopathol. 1992.30:579-602. Downloaded from arjournals.annualreviews.org
by Joanne Blinn on 03/03/09. For personal use only.

plant pathogens, antagonists, or mycorrhizae (Figure 1C). These effects can result in increased or decreased incidence of plant disease, for example through promotion or suppression of the activities of beneficial microorganisms (Figure 1D). Nonspecialized pathogens can increase their inoculum potential on weeds and subsequently affect crops (Figure 1E). As still another effect, herbicides can predispose pathogens to fungicides or act as synergists (Figure 1F).

Natural fluctuations in the physical environment and changes in microenvironment that occur as a result of weed control can also influence the interactions described above, but these effects are not discussed here. This review covers the recent reports on the types of herbicide-disease interactions that are depicted in Figure 1. The characteristics and interactions of glyphosate with soil fungi are emphasized because of: (*a*) the extensive applied and fundamental literature on its properties and effects summarized below, which provides good examples of the key information essential to define principles in herbicide-disease interactions; (*b*) the widespread use and economic importance of this herbicide; (*c*) the increased attention to development of glyphosate-tolerant crops (65, 125) and its use as a crop desiccant to accelerate ripening (35, 149); and (*d*) the fact that its herbicidal action is strongly influenced by the presence of certain soil fungi—a new concept in herbicidal activity (70, 91a, 117). Finally, some of the new or potential uses of herbicides in phytopathology are discussed.

CHARACTERISTICS OF GLYPHOSATE

Glyphosate (*N*-[phosphonomethyl]glycine) is a broad-spectrum, water-soluble herbicide sold under the trade names of Kleenup, Roundup, Rodeo, and Vision. It can effectively control 76 of the world's 78 worst weeds (43). Total sales of Roundup recently topped $1 billion, and its share of the $9 billion a year world herbicide market (8) is expected to increase (75). In 1988, 4 years after its registration for use in forestry in Canada, glyphosate was used on 176,536 ha, representing 81% of the overall Canadian forest area treated with herbicides that year (20).

Annual Reviews
www.annualreviews.org/aronline

Annu. Rev. Phytopathol. 1992.30:579-602. Downloaded from arjournals.annualreviews.org
by Joanne Blinn on 03/03/09. For personal use only.

Herbicide-disease interactions must be kept in perspective; they are only one component of the many potential side effects of an herbicide. The effects of glyphosate on litter decomposition (42), insects (63), water fauna (83), aquatic bacteria (27), mineralization of organic matter (11), and general microbial activities in soil (23) have been reviewed.

The detection of herbicide residues in various parts of the plant, in the rhizosphere, and in the soil is essential to study its role in herbicide-disease interactions. Persistence and availability are key properties in the development and expression of any side-effect of a pesticide (104). The fate and behavior of several herbicides in soils was recently reviewed (147). One major difficulty in studying herbicide-disease interactions is to separate direct effects that an herbicide might have on pathogens or beneficial microorganisms in the rhizosphere from indirect effects such as root colonization owing to predisposition of the plants by the herbicide. Reliable routine assays of herbicide residue are essential to distinguish between direct and indirect effects. For most herbicides, and for glyphosate in particular, detection of herbicide residues in plants and soil is difficult. The usual method of detection of glyphosate is by gas chromatography following extraction, fractionation, and derivatization steps; and research efforts to develop improved techniques for routine assay are ongoing (119, 137, 140).

Despite these technical difficulties, there is a growing body of literature on the fate of glyphosate in agricultural and forest ecosystems. Once in contact with the soil, glyphosate is readily adsorbed to soil particles by electrostatic force and hydrogen bonding (45, 120, 130, 131), and it also forms insoluble metal complexes (135). Adsorption of glyphosate to soil particles is positively correlated with clay content (45) and generally decreases as pH decreases (80, 100). Glyphosate can be degraded by various microorganisms (58, 114, 116) and by ultraviolet light (93). In forests of northern Sweden, 8% of applied glyphosate was still present in the soil after two years, whereas only 1% of applied glyphosate could still be recovered from soils of southern forests after one year (138). In western Canada, glyphosate residues in soil decreased by 50% within 45–60 days after being aerially applied on a forest canopy by plane at a rate of 2 kg/ha (41). After one year, the residue concentration was 6–18% of that seen immediately after spraying. Almost all the glyphosate residues were in the top 15 cm of soil.

One reason for the popularity of glyphosate is its effect on root or rhizome systems following foliar application. Glyphosate is readily translocated throughout the plant within a few days after treatment (123, 132). Both glyphosate and its major metabolite, aminomethylphosphonic acid, were recovered from roots after foliar application of Roundup (99). Roots of hydroponically grown soybean seedlings showed arrested cell division three days after application of glyphosate to the hydroponic solution or to the

Annual Reviews
www.annualreviews.org/aronline

cotyledons (144). As plants mature toward flowering or dormancy, their ability to translocate glyphosate to the roots decreases (55, 151). Very little is know about the extent of exudation of glyphosate from roots of treated plants. Residue leakage from the leaves of yellow nutsedge treated with glyphosate was not detected (22).

The mode of action of an herbicide, both on plants and the plant- and soil-associated microorganisms, must be known to understand its effect on plant disease. There is convincing evidence that the primary target of glyphosate in plants and microorganisms is an enzyme of the shikimic acid pathway, namely, 5-enolpyruvylshikimate-3-phosphate (EPSP) synthase (13, 29, 69, 134). It is worth noting that in the same year in which the mode of action of glyphosate was described, Baillie et al (6) reported their unsuccessful attempt to develop an herbicide that would block the shikimic acid pathway. They reasoned that such an herbicide would be desirable because the absence of the shikimic acid pathway in animals would render it nontoxic to animals. Glyphosate was one of the synthesized putative metabolites of phosphonic acid, a product that had shown weak herbicidal activity in perennials (152).

Annu. Rev. Phytopathol. 1992.30:579-602. Downloaded from arjournals.annualreviews.org
by Joanne Blinn on 03/03/09. For personal use only.

NATURE OF HERBICIDE EFFECTS ON ROOT DISEASES

Predisposition of Crops to Disease

One of the most commonly reported problems of herbicide use on crops is direct damage due to phytotoxicity, including cases where the enhancement of disease is obvious. A higher incidence of rotted potato tubers after desiccation of foliage with paraquat has been reported (54). Soil-incorporated trifluralin produced swelling and cracking of soybeans through which *Fusarium oxysporum* infected the plants (24). Inoculation of rice plants at the 4–5 leaf stage with both an isolate of *Pythium arrhenomanes* (from plants with"Dead Tiller Syndrome" (86)) and the herbicide fenoxapop caused 48% plant mortality, whereas *P. arrhenomanes* or fenoxapop alone caused 4% and 10% mortality of the plants, respectively (F.N. Lee & J. Hoy, personal communications). In Chehalis sandy loam soil, injury and death of Italian ryegrass (*Lolium multiflorum)* after glyphosate treatment were attributed to *Pythium* spp., whereas in Crooked sandy loam the damage appeared to be caused solely by the chemical (80). The mechanisms through which a plant is predisposed are unknown for most of the reported cases.

It is generally accepted that herbicide-induced weakening of the plant can predispose the plant to infection by facultative-type pathogens. Current knowledge on mechanisms of disease resistance in plants can be integrated with information on the mode of action of herbicides to better understand the mechanisms of predisposition (49). By blocking the synthesis of phenylalanine-derived phenols via the inhibition of the EPSP synthase, glyphosate

Annual Reviews
www.annualreviews.org/aronline

Annu. Rev. Phytopathol. 1992.30:579-602. Downloaded from arjournals.annualreviews.org
by Joanne Blinn on 03/03/09. For personal use only.

inhibits the production of phenolics, including lignin precursors and some classes of phytoalexins involved in resistance of plants to diseases. Glyphosate blocked the production of phaseollin, phaseollinisoflavan, phaseollidin, and kievitone in bean (71, 72), as well as glyceollin in soybean (64). Sublethal doses of glyphosate inhibited the expression of resistance in soybean to *Phytophthora megasperma* f.sp. *glycinae* (81), in bean to *Colletotrichum lindemuthianum* (71) and in tomato to *Fusarium* spp. (15). The production of lignin in asparagus (122) and flax (127), as well as phenolic compounds in roots of tomato seedlings (15) and bulbs of *Cyperus esculentus* (21) were reduced by glyphosate. The implications for pest management strategies of using glyphosate, or any other pesticide that alters production of secondary metabolites such as phytoalexins, were reviewed by Lydon & Duke (95).

Sublethal Doses of Herbicides on Crops

Several registered uses of herbicides on crops result in intentional or accidental exposure to sublethal amounts of the herbicide. For example, low doses of glyphosate are applied to sugarcane to hasten ripening, enhance sugar content, and permit earlier harvest (38). Sublethal doses of herbicides also reach crops that are intentionally sprayed during a safe window, i.e. when absorption or translocation in those crops is minimal compared with the target weed species. Glyphosate application to conifers follows the latter principle and can provide a rapid increase in growth of desired tree species (94, 151). With tools and techniques for directed application, small amounts of herbicides unavoidably reach some of the crop plants, particularly when the weeds are within the rows (148). Our research program on glyphosate was started as a result of empirical observations on young apple trees that accidentally received a few drops of 1% Roundup spray on their bark—trees that the next year showed poor vigor, which appeared to be associated with root rot.

Low doses of glyphosate can be applied to certain crop species to control parasitic plants. Foliar applied glyphosate selectively killed broomrape (*Orobanche* spp.) parasitic in the roots of beans (5, 124) or sunflowers (25), and controlled dodder (*Cuscuta* spp.) in alfalfa (33). Methods for controlling parasitic plants with herbicides, including glyphosate, were reviewed recently (112).

Protection of Plants from Disease

Obviously not all herbicides shift the host-pathogen interaction toward increased disease. Bruckart et al (17) found that bentazon, which they applied at low concentrations to improve the efficacy of the rust fungus *Puccinia canaliculata* for biological control of yellow nutsedge, actually reduced

Annual Reviews
www.annualreviews.org/aronline

disease by 50%. This result is not surprising since obligate parasites such as rust fungi do best when growth rate and vigor of their plant host is high.

Dinitroaniline herbicides applied in soil or on leaves caused a 40–98% reduction in infection of tomato seedlings by the vascular wilt pathogen *Fusarium oyysporum* f. sp. *lycopersici* compared to control plants (52). Two months after harvest, potato tubers from plants in plots treated with the postemergence herbicide metribuzin showed a 25% decrease in tuber rot caused by *Erwinia carotovora* ssp. *atroseptica* compared to tubers from plots where weeds were controlled by mechanical cultivation (92).

Herbicides might be able to stimulate a disease-resistance response through a mechanism similar to what has been described for the phosphates that induce resistance in plants against pathogens (34, 48). This mechanism may explain why it took 1000 times more of the systemic herbicide dicamba than the systemic fungicide cyproconazole to inhibit 90% of the radial growth of *Rhizoctonia cerealis* in vitro, whereas when applied to wheat leaves, it took only three times more dicamba than cyproconazole to achieve 90% control of infection (79).

Annu. Rev. Phytopathol. 1992.30:579-602. Downloaded from arjournals.annualreviews.org
by Joanne Blinn on 03/03/09. For personal use only.

Direct Effect of Herbicides on Soil Microorganisms

Unlike the effect of herbicides on plants, very little is known on the mode of action of herbicides on fungi. Glyphosate blocks the shikimic acid pathway in *Neurospora crassa* (14) and, presumably, could have the same effect in other fungal species. The addition of phenylalanine to agar medium reversed the inhibitory effect of glyphosate on radial growth and germination of *Colletotrichum lindemuthianum* (72). Certain combinations of phenylalanine, tyrosine, and tryptophan increased growth of *Calonectria crotalariae* in a medium amended with glyphosate but did not support growth equal to that on the medium without glyphosate (10). On the other hand, Wardle & Parkinson (146) found a strong negative correlation between growth of seven fungal species on water agar and their occurrence in soil with glyphosate at 200 μg g^{-1}; the fungal species most strongly inhibited by glyphosate on water agar plates were among those least suppressed and even stimulated by glyphosate in soil. A better correlation occurred between growth on glyphosate-amended soil extract agar and populations in amended soil, but there were still some important discrepancies. For example, glyphosate at 200 μg g^{-1} reduced the radial growth of *Fusarium oxysporum* by 70% on soil extract agar, whereas the same concentration in soil had no effect on the population of this fungus (146). Dicamba was by far the least toxic out of four herbicides tested for inhibiting in vitro growth of *Rhizoctonia cerealis*, whereas it was one order of magnitude better than the closest other herbicide when tested for control of *Rhizoctonia* infection on wheat seedlings (79).

Annual Reviews
www.annualreviews.org/aronline

Annu. Rev. Phytopathol. 1992.30:579-602. Downloaded from arjournals.annualreviews.org
by Joanne Blinn on 03/03/09. For personal use only.

In vivo studies are complicated because of the heterogeneity of the soil environment and the diversity of fungal populations. The effect of triazine herbicides on soilborne conidia of *Cochliobolus* spp. was investigated for different species of *Cochliobolus* and different isolates of *C. sativus* (66). These herbicides induced germination of conidia under fungistasis in certain isolates of *C. sativus* but not in other isolates of that species or in other species of this genus. The effect was also dependent on soil type. Further testing with atrazine showed that the deleterious effect of this triazine on populations of *C. sativus* in soil could not be explained by the effect of this herbicide on microflora components that induce fungistasis (68). The negative effect of atrazine on *C. sativus* was increased by lowering soil pH or increasing humic acid content (67).

Little is known about the effects of herbicides on antagonists of plant pathogens. In vitro growth tests showed that bacterial antagonism to *Phytophthora cactorum* was not affected by a range of herbicides (142). Trifluralin did not affect in vitro growth of *Trichoderma viride,* whereas paraquat resulted in retarded growth and a decrease in total fatty acids present in cell lipids (44). The addition of glyphosate to raw soil increased the conduciveness of the soil to take-all of wheat caused by *Gaeumannomyces graminis* var. *tritici* (101). It appeared that glyphosate selectively suppressed the activity of microorganisms antagonistic to *G. g.* var. *tritici* and increased the incidence of take-all via this indirect effect on some component of the soil microflora (101, 102). If the relevant antagonistic component of the soil microflora were known, this hypothesis might be testable with glyphosate-resistant antagonists.

Herbicides can also affect plant symbioses in the rhizosphere. Effects of pesticides on mycorrhizal fungi were reviewed by Trappe et al (139). Following application of glyphosate to a single pine needle (*Pinus banksiana* or *P. taeda*), translocation occurred to roots and to two mycorrhizal species, but glyphosate was not detected in roots of untreated pine seedlings growing in the same container (76). A sublethal dose of glyphosate increased the incidence of infection by vesicular arbuscular mycorrhizal *Glomus* spp. (106). In contrast to this positive effect, glyphosate, diclofop-methyl, and amitrole each reduced nodulation of *Rhizobium trifolii* in *Trifolium subterraneum* (39). Analogous to the effect of herbicides on the incidence of disease in specialized host-fungi pathosystems, it is possible that a detrimental effect on the health of a plant caused by an herbicide has a negative effect on the symbiotic associations. The effect of propazine and chlorthal dimethyl on root morphology and physiology of *Pinus radiata* appeared to have been the reason for the reduction in root infection by mycorrhizae (97). Glyphosate at 0.54 and 3.23 kg/ha did not affect plant growth or root infection by *Paxillus involutus* in seedlings of *Pinus resinosa* (26).

Annual Reviews
www.annualreviews.org/aronline

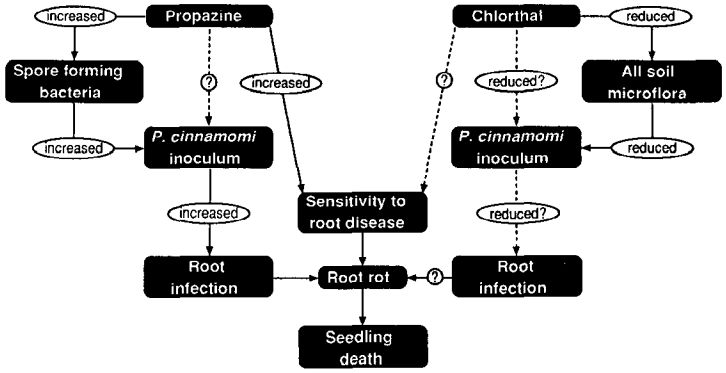


Figure 2 Diagrammatic illustration of direct and indirect effects of herbicides propazine and chlorthal dimethyl on incidence of Phytophthora root rot in seedlings of *Pinus radiata* in soil infested with *Phytophthora cinnamomi*. (Adapted from Marks & Cerra (98) with permission from R. Cerra and the widow of G. C. Marks.)

One example from Australia of an herbicide-induced root disease problem includes several of the effects discussed above. When radiata pine was established in the mid-1960s in a nursery at Benalla, Victoria, root diseases were not a significant problem (98). By the mid-1970s, the incidence of damping off and root rot caused by *Pythium* spp. and *Phytophthora cinnamomi*, respectively, increased to the point where they could not be controlled with metalaxyl (77). However, these diseases ceased to be problems soon after the herbicide propazine was replaced by chlorthal dimethyl. A model was constructed by evaluating the effects of these two herbicides on incidence of the Phytophthora root rot in steamed, naturally conducive and naturally suppressive soils and their effects on growth of several components of the soil microflora in vitro and in vivo (Figure 2). The empirical observations that chlorthal dimethyl reduced and propazine increased Phytophthora root rot were verified. In the rhizoplane, chlorthal dimethyl suppressed populations of Gram-positive and -negative as well as spore-forming bacteria by about 90%, whereas propazine increased them (98). The spore-forming bacteria stimulated by propazine increased sporangial production in *P. cinnamomi*. More work is needed to verify the proposed mechanisms, but this example illustrates the potential complexity of herbicide-disease interactions in soils.

Herbicide-Fungicide Interactions

Some herbicides can increase the efficacy of fungicides via direct synergism. On wheat seedlings inoculated with *Rhizoctonia cerealis*, the herbicides DNOC, dicamba, ioxynil, and bromoxynil, when sprayed onto leaves in combination with the fungicide cyproconazole, controlled infection up to 1.9,

Annu. Rev. Phytopathol. 1992.30:579-602. Downloaded from arjournals.annualreviews.org
by Joanne Blinn on 03/03/09. For personal use only.

Annual Reviews
www.annualreviews.org/aronline

Annu. Rev. Phytopathol. 1992.30:579-602. Downloaded from arjournals.annualreviews.org
by Joanne Blinn on 03/03/09. For personal use only.

2.4, 3.3, and 4.6 times more effectively, respectively, than the expected additive effects of these fungicide-herbicide combinations (79). This effect could be the result of either direct herbicide-fungicide synergism or herbicide-induced resistance. In vitro, the same herbicides were up to 3.1, 4.8, 2.3, and 2.4 times more effective, respectively, in inhibiting radial growth than the expected additive effects of individual cyproconazole-herbicide combinations. Another example was reported with the herbicide metribuzin and the fungicide chlorothalonil, which are both commercially used on potatoes. In vitro tests on *Alternaria solani,* the causal agent of early blight, showed that the presence of metribuzin in the agar medium reduced the efficacy of chlorothalonil (60). There are few studies on such interactions, which is surprising considering the common use of herbicide-fungicide tank mixes or sequential applications of herbicides and fungicides in the field.

Some herbicides apparently have the potential to predispose fungi to effects of a fungicide. Radial growth of *Pseudocercosporella herpotrichoides* subcultured on unamended PDA after exposure to dicamba, ioxynil, bromoxynil, or no herbicide was the same regardless of herbicide composition or dose (79), but if 5-mm disks from the edge of colonies growing on an herbicide-amended medium were transferred to PDA containing various concentrations of the fungicide cyproconazole, the concentrations resulting in 90% inhibition of radial growth (EC_{90}) were drastically reduced compared to colonies established from herbicide-free PDA. Cyproconazole was 5, 2.6, and 1.4 times more effective as an inhibitor of colony growth if the fungus had been previously exposed to dicamba, bromoxynil, and ioxynil, respectively, regardless of the herbicide concentration. These herbicides did not predispose *Rhizoctonia cerealis* to greater sensitivity to cyproconazole. If one assumes a negligible concentration of herbicide in the inoculum disk, a somewhat stable herbicide-induced physiological change must have taken place to account for the predisposition of *P. herpotrichoides*.

Certain herbicides might also predispose plant pathogenic fungi to the effect of antagonists. Just as it is important to understand the effects of herbicides on mechanisms of plant disease resistance, a better understanding of the effects of herbicides on susceptibility of pathogens to antagonists is needed to clarify pathogen-antagonist interactions in the presence of herbicides.

Inoculum Density and Damage to Crops

The first microorganism to occupy the tissues of dying weeds after herbicide treatment has an advantage over other would-be colonists of this substratum. If an herbicide applied to control weeds selectively or nonselectively causes an increase in certain groups of unspecialized, facultative-type pathogens in the root systems of treated plants, the effect of this herbicide might be to

Annual Reviews
www.annualreviews.org/aronline

Annu. Rev. Phytopathol. 1992.30:579-602. Downloaded from arjournals.annualreviews.org
by Joanne Blinn on 03/03/09. For personal use only.

increase the population of such microorganisms in the soil, and thus to increase the incidence of disease on susceptible crops subsequently grown in this soil. Although primary colonization of plant parts and the natural succession of colonists in the breakdown of crop residues have been extensively studied (18, 19), relatively little attention has been given to colonization of plants following herbicide treatment. Phytophthora root rot caused a 44% reduction in the stand of soybean in a no-till system where chloramben, sethoxydim, and metribuzin had been used compared to moldboard plowing without herbicides (143). Lynch & Penn (96) showed that rhizomes of quackgrass (*Elymus repens)* treated with glyphosate were readily colonized by *Fusarium culmorum,* and that an increase in the population of this fungus was associated with an adverse effect on barley subsequently planted in the same pots. Mielke (103) observed a similar situation and reported increased incidence of take-all on wheat after application of glyphosate to control quackgrass. Germinating barley seedlings were heavily colonized by *Pythium* spp. after ryegrass cover was killed with glyphosate, paraquat, or by hand cutting (12). Lévesque et al (91) showed that treatment of weed cover with glyphosate was followed by an increase in populations of *Fusarium* spp. in both the weed roots and soil, but no increased damage was observed on subsequently planted crops. A major difficulty in this type of study is to separate the damage caused by residual herbicide or toxic degradation byproducts released from the roots of treated weeds from the damage caused by a buildup of pathogen inoculum on the roots of the weeds. It is not known, for example, why the yield of winter rape directly sown in glyphosate-treated quackgrass was reduced by at least threefold (110).

Killing weeds with herbicide does not necessarily result in enhanced root colonization or increased fungal inoculum. Populations of *Fusarium* or *Pythium* spp. in the soil or in the roots of soybeans were not affected by the application of alachlor or trifluralin in a soybean/corn rotation (105). A mixture of diquat, paraquat, and dicamba applied to weeds was often associated with a decrease in both propagule counts of *G. g.* var. *tritici* and the incidence of take-all (128). Similarly, treatment of weeds with paraquat decreased root rot in germinating subterranean clover (7). The populations of fluorescent *Pseudomonas* spp. in the cortex of wheat seedlings two weeks after foliar application of mecoprop were increased drastically compared with untreated plants (49). It is possible that an increase in the populations of beneficial organisms in the rhizosphere or in the root tissue of treated weeds could result in a suppression of certain soilborne diseases in the subsequent crops.

Weeds and volunteer (self-sown) crop plants can serve as hosts for plant pathogens, and their control can make crop rotation or fallow a more effective management strategy for limiting disease. In a sorghum/cotton rotation,

Annual Reviews
www.annualreviews.org/aronline

killing the sorghum roots with glyphosate before plowing reduced the incidence of root disease caused by *Phymatotrichum omnivorum* in different locations and years compared to plowing alone, although the effect was not always consistent (121). In an attempt to reduce take-all, glyphosate was used to accelerate the death of volunteer wheat on which inoculum of *G. g.* var. *tritici* normally builds up (16). The density of the volunteers was correlated to take-all incidence on the subsequent crop, but the carry-over of inoculum of *G. g.* var. *tritici* was not affected by treatment of volunteer plants with glyphosate before cutting the volunteers.

Annu. Rev. Phytopathol. 1992.30:579-602. Downloaded from arjournals.annualreviews.org
by Joanne Blinn on 03/03/09. For personal use only.

SOIL MICROFLORA AND GLYPHOSATE

Role of Soil Microorganisms in the Herbicidal Action of Glyphosate

Soil microorganisms can mediate the herbicidal action of glyphosate in beans. All bean seedlings growing in vermiculite or autoclaved soil survived a 10-μg dose of glyphosate while all seedlings grown in raw soil or in autoclaved soil infested with *Pythium* spp. were killed by this same dose of glyphosate (70). Seedlings inoculated with *Pythium* spp. were protected from the herbicidal effect of glyphosate by the systemic fungicide metalaxyl applied to the seedlings and soil. Seedlings of six different plant species were less sensitive to glyphosate when growing in heat-treated soil than in the corresponding raw soil (117). In autoclaved soil, the herbicidal effect of glyphosate was restored by the addition of an aqueous extract from raw soil but not if the extract was filtered (0.2 μm) or autoclaved (91a). These findings clearly indicate a role of soil microorganisms in the lethal effect of glyphosate on these plants. A similar insensitivity to glyphosate has been reported in plants grown hydroponically (108, 141). In some plant species that have a small leaf-surface for a given amount of biomass, or that have received a low dose of herbicide because of nonuniform spraying, we suspect that microorganisms can be significant synergists to the herbicidal action of glyphosate in commercial field use. Field application of glyphosate at 1.44–2.88 kg/ha to flax plants resulted in as little as 18–28 μg of glyphosate per plant in some patches (56). It is likely that efficacy will vary with the available soil microflora in cases where the dose received is low.

No differences were found in the quantity of foliar-applied 2,4-D or paraquat needed to kill 50% of bean seedlings grown in autoclaved or raw soil (Figure 3). In contrast, about ten times more glyphosate was required to kill the seedlings grown in autoclaved soil as compared to those in raw soil (91a). Apparently, differential sensitivity of plants grown in raw and heat-treated soils is not a common phenomenon for herbicides in general.

Annual Reviews
www.annualreviews.org/aronline

Annu. Rev. Phytopathol. 1992.30:579-602. Downloaded from arjournals.annualreviews.org
by Joanne Blinn on 03/03/09. For personal use only.

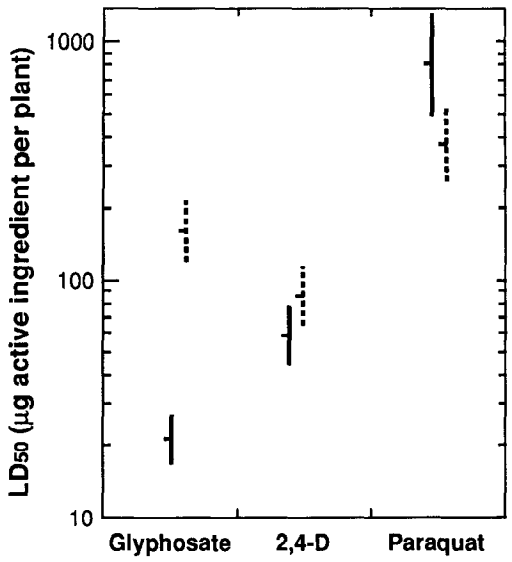


Figure 3 Differences in LD_{50} values of three different herbicides sprayed on two-week old bean seedlings grown in either raw _____ or autoclaved - - - - - loam soil. Vertical lines indicate S.E. of estimates. (Adapted from Lévesque et al (91a).)

Soil/Site Factors and Variation in the Efficacy of Glyphosate

Glyphosate applied at recommended rates is slow acting and rarely kills plants within one week following treatment. Glyphosate treatment of field bindweed required at least three weeks (37) and volunteer potato plants up to one month (85) to be lethal. Poor control was obtained during the first year but excellent control was obtained during the two subsequent years when reduced doses (0.45–1.23 kg/ha) of glyphosate were used on quackgrass (9). In pin cherry and trembling aspen, percent mortality, leaf and stem length, as well as visual rating of injury were still affected two years after low doses (0.04–0.5 kg/ha) of glyphosate had been applied (133).

Glyphosate still appears to be one of the best herbicides for chemical control of weeds in forestry. It provided better control of willows (*Salix* spp.) than 2,4-D or hexazinone (115). Yet Canadian forest managers find that the efficacy of herbicides in forestry varies considerably for reasons that still have to be elucidated (20). No long-term studies have been conducted in Canada on the effect of herbicides on forest vegetation (20). Depending on locations, site preparation with glyphosate had either a positive or no effect on the survival of conifer seedlings compared to unsprayed controls (111). In three out of the five tree species studied in the southeastern United States, the mean efficacy

Annual Reviews
www.annualreviews.org/aronline

Annu. Rev. Phytopathol. 1992.30:579-602. Downloaded from arjournals.annualreviews.org
by Joanne Blinn on 03/03/09. For personal use only.

of aerially applied glyphosate, expressed as the percent decrease in wood volume, was lower than the corresponding standard deviation (32). Among several weather and physiological parameters measured, only sugar content in white oak at the time of glyphosate application was positively correlated with efficacy of glyphosate. For the other three hardwood species, none of the parameters could be correlated to efficacy.

There are also inconsistencies in the efficacy of glyphosate used in agriculture. Better consistency was the reason why paraquat and HOE 3986 were preferred over glyphosate as preplant/postemergence herbicides in sorghum or soybeans for the control of three different species of legume cover crop (50). In an evaluation of the efficacy of glyphosate in controlling regrowth of oatgrass (*Arrhenatherum elatius* var. *bulbosum*) from corms, the best control was obtained at the growth stage where translocation to corms was the lowest (136). Complete control of regrowth was obtained when glyphosate was applied at the 4–5 or 6–7 leaf stage, compared to 45% regrowth if applied at the 2–3 leaf stage, whereas the proportion of absorbed ^{14}C from ^{14}C-glyphosate translocated to corms was 3–7 times higher in plants that had been treated at 2–3 leaf stage compared to the stages that had been completely controlled.

Reported site variations in efficacy of glyphosate led us to compare the efficacy of glyphosate on bean grown under controlled conditions with five different autoclaved and raw soils. Three of the soils were from an arid interior region (southern Okanagan Valley of British Columbia) under commercial apple production, and two were from a humid coastal region (Fraser Valley of British Columbia) under commercial vegetable and nursery crop production. The interior soils varied in cropping and apple root disease histories and were designated on this basis as "virgin", "crown-rot", and "replant" soils. A tenfold range in the LD_{50} values for beans was observed among the five raw soils under otherwise experimentally identical conditions (Figure 4). The virgin soil required the highest dose of glyphosate to kill the bean seedlings, and the muck soil the lowest. These differences between soil types were less apparent in autoclaved soils, where 15–20 times more glyphosate was needed to kill bean seedlings than was required in the corresponding raw soils. We hypothesize that the range in sensitivity of beans to glyphosate in these different soils is due to differences in the fungal populations in these soils, and that higher doses of glyphosate were required in the virgin soil because fewer fungi capable of root colonization were present in this soil. Two unpublished observations support this hypothesis: (*a*) fewer fungal colonies were detected on dilution plates of the virgin soil than of the other two interior soils, and (*b*) there was virtually no colonization, and thus no chance for a difference in colonization, of the roots of untreated and glyphosate-treated apple seedlings grown in the raw virgin soil, nor did we find any difference in LD_{50} values for apple seedlings

Annual Reviews
www.annualreviews.org/aronline

Annu. Rev. Phytopathol. 1992.30:579-602. Downloaded from arjournals.annualreviews.org
by Joanne Blinn on 03/03/09. For personal use only.

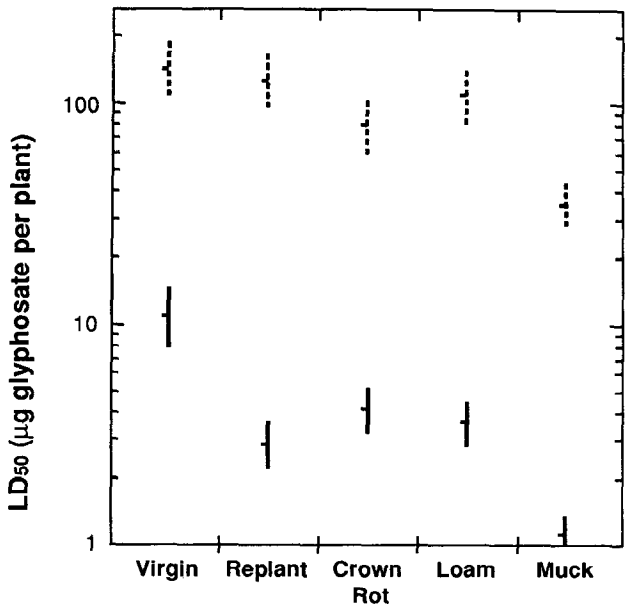


Figure 4 Effect of soil types on LD_{50} values of glyphosate applied in 10-μl volume on 2-week-old bean seedlings grown in either raw _____ or autoclaved - - - - - soils. Vertical lines indicate S.E. of estimates. (Adapted from Lévesque et al (91a).)

grown in autoclaved and raw virgin soil (117). Soil-associated factors other than differences in the resident fungal microflora could also affect the sensitivity of bean seedlings to glyphosate, because significant differences in LD_{50} values were detected in soils even after autoclaving. Such differences might reflect variations in available plant nutrients and hence plant vigor among the soils, or quantitative and qualitative differences in the microflora that colonize these soils after autoclaving.

Fungal Colonization of Glyphosate-Treated Plants

Fungal colonization of the roots occurs very rapidly after glyphosate is applied on plants. One day after glyphosate treatment of seedlings of a tomato cultivar (CR6) resistant to the crown and root rot agent, *Fusarium oxysporum* f. sp. *radicis-lycopersici*, the pathogen entered the root epidermis. A day later, it had penetrated the suberized hypodermis, and after that, the hyphae had penetrated the endodermis (15). Hyphae grew inter- and intracellularly similar to growth in the fully susceptible tomato cultivar MR13, yet roots of untreated resistant CR6 seedlings were not colonized by the pathogen. In the field, rapid colonization of several weed species by *Fusarium* spp. occurred after glyphosate treatment (91). In bean and wheat seedlings grown in pots,

Annual Reviews
www.annualreviews.org/aronline

Annu. Rev. Phytopathol. 1992.30:579-602. Downloaded from arjournals.annualreviews.org
by Joanne Blinn on 03/03/09. For personal use only.

colonization by *Pythium* spp., measured as the number of colony-forming units present in the intact root system (88), was detected at an increasing frequency starting 24 hr after glyphosate treatment at two different temperatures and soil moistures (87, 89), whereas *Pythium* spp. could not be isolated from the roots of the untreated seedlings. *P. sylvaticum* was the predominant colonizer of glyphosate-treated bean and wheat seedlings grown in a loam soil, whereas *P. ultimum* was prevalent in treated seedlings grown in a muck soil (87, 90). Because of this rapid colonization of the roots and potential buildup of inoculum, herbicides should be used with some caution to control vegetation around small experimental plots (109) or to simulate plant death in yield loss assessment studies (73).

Pathogenicity and Host Specificity of Glyphosate-Associated Colonizing Fungi

Knowledge of specialization and pathogenicity of fungal colonists of plant roots is an important aspect in studying the effect of glyphosate on inoculum buildup in soil after killing weed cover. The *Pythium* spp. that colonized roots of glyphosate-treated wheat and bean seedlings caused pre- and/or postemergence blight of these plants in the absence of glyphosate (90). There was no indication among the isolates tested of host specialization, i.e. isolates of *Pythium* obtained from wheat did not cause a higher incidence of seedling blight on wheat than on beans and vice versa.

Three fungal genera, namely, *Pythium*, *Fusarium* and *Cylindrocarpon*, were the predominant fungal root colonizers of glyphosate-treated apple seedlings grown in the crown rot and replant soils (C. A. Lévesque & J. E. Rahe, unpublished data). A representative isolate from each genus, and one representative isolate of *P. ultimum* obtained from glyphosate-treated bean seedlings grown in organic soil, were established in autoclaved loam soil. On McIntosh apple seedlings, *Pythium* sp. and *Fusarium* sp. isolated originally from apple resulted in lower LD_{50} values for glyphosate (91a). In contrast, *P. ultimum* from beans and *Cylindrocarpon* sp. from apple did not affect the LD_{50} values of glyphosate on apple seedlings compared with those values recorded in autoclaved soil alone, demonstrating that the synergistic effect does not apply to all host-colonist combinations. Much more remains to be learned about the host specificity of glyphosate synergistic fungi.

NEW WAYS OF EXPLOITING HERBICIDE-MICROORGANISM INTERACTIONS

Melanconis alni is a weak pathogen that produces cankers on alder, a species presently considered an important weed in forests of British Columbia (36). This pathogen does not kill the trees directly, nor does glyphosate cause

Annual Reviews
www.annualreviews.org/aronline

Annu. Rev. Phytopathol. 1992.30:579-602. Downloaded from arjournals.annualreviews.org
by Joanne Blinn on 03/03/09. For personal use only.

detectable damage to the trees when used at one-twentieth of the recommended dose to control alder. However, when this sublethal rate of glyphosate is applied in combination with *M. alni*, the trees die because of the canker (C. E. Dorworth, personal communication).

Gotlieb & Watson (46) tested up to 12 different herbicides for synergism with *Alternaria cassiae*, *Colletotrichum coccodes*, *C. truncatum*, and *Fusarium lateritium* for biological weed control. The most effective synergistic effect under greenhouse conditions was observed using a combination of sethoxydim (Poast) and *A. cassiae* to control sickle pod (*Cassia obtusifolia*). Neither the herbicide nor the microbial agent had any effect on the weed species when tested alone, but 100% control was achieved when they were used in combination.

Cylindrocarpon destructans is a natural colonizer of roots of thimbleberry (*Rubus parviflorus*), considered a weed in some forests of British Columbia (145). It caused little more than leaf spots or foliar browning of the upper portion of thimbleberry when added to soil, but plants either wilted, lost 60–90% of their leaves, or died when *C. destructans* was used in combination with a low dose of glyphosate (145a). Glyphosate alone caused about 50% leaf damage. The use of soilborne fungi for biocontrol of weeds has received very little attention (74).

The combination of a weak pathogen and sublethal doses of herbicide offers the advantage of restricting the spread of the biocontrol agent in both time and space. This is particularly appropriate when the weed to be controlled is a desirable plant in other situations. Because herbicides can also increase efficacy of biocontrol agents, microorganisms shown to be ineffective in killing weeds, such as *Exserohilum turcicum*, *Colletotricum graminicola*, *Bipolaris halepense*, and *Gloeocercospora sorghi* tested by Chiang et al (28) to control johnsongrass, should be investigated further in combination with low doses of herbicides.

Combining microorganisms with herbicides can also expand host range of a microbial weed-control agent, a desirable characteristic for marketing. For example, bacterial plant pathogens with a narrow host range can be effectively combined with low doses of herbicides (31). It appears that stress on plants caused by the herbicide can increase the host range of some of the bacteria being tested (A. L. Christy, personal communication). The details are still classified at this time.

Herbicide-microorganism combinations could also be used to increase the selectivity of an herbicide and thereby reduce predisposition of crops to disease caused by pathogens in soils that have residues of persistent herbicides. Seeds of soybean and peas inoculated with dicamba-degrading strains of *Pseudomonas* sp. or *Moraxella* sp. grew much better than uninoculated seeds in soil treated with dicamba in both growth chambers and the field (84). The concentration of dicamba in soil treated with the inoculated seeds was

Annual Reviews
www.annualreviews.org/aronline

rapidly reduced. The effect of inoculation in the absence of the herbicide was minimal.

Paraquat can be used as a research tool to detect infection of lupines (*Lupinus angustofolius*) by *Phomopsis leptostromiformis* earlier than is otherwise possible (30). Lack of symptoms in the early stage of this disease makes epidemiological studies difficult. Likewise, it might be possible to use glyphosate-treated plants to assess the presence and activity of certain soilborne fungi since fungal colonization occurs very rapidly after treatment (89).

Annu. Rev. Phytopathol. 1992.30:579-602. Downloaded from arjournals.annualreviews.org
by Joanne Blinn on 03/03/09. For personal use only.

CONCLUSION

General rules regarding the management of weeds without increasing and preferably while minimizing disease are difficult to develop, given the many variables that can affect, positively or negatively, herbicide-plant disease interactions. At present, it is difficult to predict the circumstances under which disease incidence will increase or will be reduced after an herbicide application. It is likely that the result of herbicide-disease interactions will be specific to certain geographical areas or crop production systems and will depend on fungal populations and herbicide residues. Monoclonal antibodies used in Enzyme Linked Immunosorbent Assay (ELISA) and DNA probes with nonradioactive labeling systems should make detection and quantification of key fungal pathogens involved in herbicide-disease interactions easier to perform on a routine basis and provide essential information to generate reliable recommendations. ELISA can even be used to detect herbicide residues (82). These technologies will lead to an ever-increasing quantity of data and known parameters for making management decisions with respect to herbicide-disease interactions. Conspicuous variables such as weed composition, density, size, crop cultivar, cultivation method, herbicide choices, costs and methods of application, and information about yield are already numerous enough to justify the use of computers and expert systems to provide "intelligent" herbicide recommendations adjusted to local conditions (1, 47, 107). It will be necessary to have herbicide-disease prediction models included in such expert systems with as many relevant variables as possible to be able to recommend herbicides that optimize disease management.

Better standardization of experimental protocols and cooperation between working groups will be necessary to accumulate a data base in the area of herbicide-disease interactions applicable for routine recommendations. Heitefuss (59) outlined five basic points that should have priority in studying herbicide-disease interactions. These summarized points are: (*a*) practical relevance of the side effects; (*b*) significance of crop rotation or alternate hosts; (*c*) relationships with weed density; (*d*) use of proper weed-free controls; and (*e*) distinction between direct and indirect effects. To this we would add the importance of reporting accurately what was used as potting soil for

Annual Reviews
www.annualreviews.org/aronline

any type of controlled herbicide experiments, and whether the soil was pasteurized, fumigated, or sterilized, information that all too often is missing. An impressive amount of data on side effects of pesticides on beneficial organisms has resulted from the joint testing program of the entomologically oriented Pesticides and Beneficial Organisms working group of the International Organization for Biological Control (57). This group has developed a standard sequential approach where the side effects are studied in laboratory, semifield, and field conditions. Such a team approach might be applicable to the study of herbicide-disease interactions. Collaborations between weed scientists and plant pathologists are increasing due to growing interests in microbial herbicides, and there are good reasons for such collaborations to expand into various areas of herbicide-disease interactions.

Annu. Rev. Phytopathol. 1992.30:579-602. Downloaded from arjournals.annualreviews.org
by Joanne Blinn on 03/03/09. For personal use only.

SUMMARY

Sublethal doses of herbicides may either protect or predispose crops to disease. Herbicides can directly alter the nature of soil ecosystems through promotion or suppression of activities of plant pathogens or beneficial microorganisms. Recently, it has been shown that herbicides can predispose pathogens or act as synergists to fungicides. Fungal colonization of roots rapidly follows the application of certain herbicides. Nonspecialized facultative-type pathogens can increase their inoculum potential on weeds or volunteers treated with herbicide and subsequently cause more disease on crops grown on that site. Soilborne fungi can also act as synergists in the herbicidal action of glyphosate, possibly because glyphosate blocks the production of phenolics involved in disease resistance of plants to these pathogens. Combinations of weakly pathogenic fungi and low doses of herbicides may have potential for weed control. Fundamental information on mode of action and effects of herbicides on crops and microorganisms is needed to better understand and predict the interactions between herbicides and fungal root pathogens. New tools for rapid detection of fungi and herbicide residues, as well as expert systems to make recommendations based on many variables, should help plant pathologists and weed scientists in optimizing herbicide efficacy and minimizing damage caused by diseases.

ACKNOWLEDGMENTS

We thank F. N. Lee, J. Hoy, R. Prasad, S. F. Shamoun, C. E. Dorworth, and A. L. Christy for sharing unpublished information. We are grateful to R. J. Cook, Z. K. Punja, T. C. Vrain, M. McCann, L. Ward, H. S. Pepin, and R. Stace-Smith who provided critical reviews for this manuscript. Our work reported in this review has been supported by the Natural Sciences and Engineering Research Council of Canada and by Agriculture Canada.

Annual Reviews
www.annualreviews.org/aronline

Annu. Rev. Phytopathol. 1992.30:579-602. Downloaded from arjournals.annualreviews.org
by Joanne Blinn on 03/03/09. For personal use only.

Literature Cited

1. AI Applications. 1990. HEX herbicide recommendation expert system. *AI Appl. Nat. Resour. Manage.* 4:62
2. Altman, J., Campbell, C. L. 1977. Effect of herbicides on plant diseases. *Annu. Rev. Phytopathol.* 15:361–85
3. Altman, J., Neate, S., Rovira, A. D. 1990. Herbicide-pathogen interactions and mycoherbicides as alternative strategies for weed control. See Ref. 61, pp. 240–59
4. Altman, J., Rovira, A. D. 1989. Herbicide-pathogen interactions in soil-borne root diseases. *Can. J. Plant Pathol.* 11:166–72
5. Arjona-Berral, A., Mesa-Garcia, J., Garcia-Torres, L. 1990. Distribution of ^{14}C-glyphosate in legumes parasitised by *Orobanche crenata*. *Weed Res.* 30:53–59
6. Baillie, A. C., Corbett, J. R., Dowsett, J. R., McCloskey, P. 1972. Inhibitors of shikimate dehydrogenase as potential herbicides. *Pestic. Sci.* 3:113–20
7. Barbeti, M. J. 1984. Effects of spray-seed on the growth of subterranean clover and its susceptibility to root rot fungi. *Australas. Plant Pathol.* 13:40–43
8. Belcher, J. E. 1989. *Monsanto Company* Chicago: Duff & Phelps, Inc. 31 pp.
9. Belzile, L., Rioux, R., Dubé, Y. 1987. Effectiveness of reduced doses of glyphosate for control of couchgrass (*Agropyron repens*). *Phytoprotection* 68:132 (Abstr.)
10. Berner, D. K., Berggren, G. T., Snow, J. P. 1991. Effects of glyphosate on *Calonectria crotalariae* and red crown rot of soybean. *Plant Dis.* 75:809–13
11. Bliev, Y. K. 1983. Influence of glyphosate on the organic matter mineralization and enzymatic activity of the soddy-podzolic soil. *Pochvovedenie* 4:74–79
12. Blowes, W. M. 1987. Effect of ryegrass root residues, knockdown herbicides, and fungicides on the emergence of barley in sandy soils. *Aust. J. Exp. Agric.* 27:785–90
13. Bode, R., Schauer, F., Birnbaum, D. 1986. Comparative studies on the enzymological basis for growth inhibition by glyphosate in some yeast species. *Biochem. Physiol. Pflanz.* 181:39–46
14. Boocock, M. R., Coggins, J. R. 1983. Kinetics of 5-enolpyruvylshikimate-3-phosphate synthase inhibition by glyphosate. *FEBS Lett.* 154:127–33
15. Brammal, R. A., Higgins, V. J. 1988. The effect of glyphosate on resistance of tomato to *Fusarium* crown rot and root rot disease and on the formation of host structural defense barriers. *Can. J. Bot.* 66:1547–55
16. Brassett, P. R., Gilligan, C. A. 1990. Effects of self-sown wheat on levels of the take-all disease on seedlings of winter wheat grown in a model system. *Phytopathol. Z.* 129:46–57
17. Bruckart, W. L., Johnson, D. R., Frank, J. R. 1988. Bentazon reduces rust-induced disease in yellow nutsedge, *Cyperus esculentus*. *Weed Technol.* 2:299–303
18. Bruehl, G. W. 1987. *Soilborne Plant Pathogens*. New York: Macmillan. 368 pp.
19. Bruehl, G. W. 1975. Systems and mechanisms of residue possession by pioneer fungal colonists. In *Biology and Control of Soilborne Plant Pathogens*, ed. G. W. Bruehl, pp. 77–83. St. Paul, MN: APS Press. 216 pp.
20. Campbell, R. A. 1990. Herbicide use for forest management in Canada: where we are and where we are going. *For. Chron.* 66:355–60
21. Cañal, M. J., Albuerne, M., Tamés, R. S., Fernandez, B. 1990. Glyphosate injury on *Cyperus esculentus* leaves and basal bulbs: histological study. *Weed Res.* 30:117–22
22. Cañal, M. J., Tamés, R. S., Fernandez, B. 1990. Glyphosate action on abscisic acid levels, stomatal response and electrolyte leakage in yellow nutsedge leaves. *Plant Physiol. Biochem.* 28:215–20
23. Carlisle, S. M., Trevors, J. T. 1988. Glyphosate in the environment. *Water Air Soil Pollut.* 39:409–20
24. Carson, M. L., Arnold, W. E., Todt, P. E. 1991. Predisposition of soybean seedlings to Fusarium root rot with trifluralin. *Plant Dis.* 75:342–47
25. Castejon-Muñoz, M., Romero-Muñoz, F., Garcia-Torres, L. 1990. Control of broomrape (*Orobanche cernua*) in sunflower (*Helianthus annuus* L.) with glyphosate. *Crop Prot.* 9:332–36
26. Chakravarty, P., Chatarpaul, L. 1990. Non-target effect of herbicides: II. The influence of glyphosate on ectomycorrhizal symbiosis of red pine (*Pinus resinosa*) under greenhouse and field conditions. *Pestic. Sci.* 28:243–47
27. Chan, K. Y., Leung, S. C. 1986. Effects of paraquat and glyphosate on growth, respiration, and enzyme activity

Annual Reviews
www.annualreviews.org/aronline

of aquatic bacteria. *Bull. Environ. Contam. Toxicol.* 36:52–59
28. Chiang, M. Y., Van Dyke, C. G., Chilton, W. S. 1989. Four foliar pathogenic fungi for controlling seedling johnsongrass (*Sorghum halapense*). *Weed Sci.* 37: 802–9
29. Cole, D. J. 1985. Mode of action of glyphosate--a literature analysis. See Ref. 53, pp. 48–74
30. Cowling, W. A., Wood, P. M., Brown, A. G. P. 1984. Use of paraquat-diquat herbicide for the detection of *Phomopsis leptostromiformis* infection in lupins. *Australas. Plant Pathol.* 13:45–46
31. Crop Genet. Int. 1990. Do chemical and biological inputs mix? *Agrichem. Age* Oct:34
32. D'Anieri, P., Zedaker, S. M. Variation in glyphosate efficacy in commercial loblolly-pine release operations in Virginia. *For. Ecol. Manage.* 31:233–43
33. Dawson, J. H. 1990. Dodder (*Cuscuta* spp.) control in newly seeded alfalfa (*Medicago sativa*) with glyphosate. *Weed Technol.* 4:880–85
34. Descalzo, R. C., Rahe, J. E., Mauza, B. 1990. Comparative efficacy of induced resistance for selected diseases of greenhouse cucumber. *Can. J. Plant. Pathol.* 12:16–24
35. Don, R., Bartz, J., Bryant, G. F. M., Van-Geffen, A., Lunn, G., et al. 1990. Germination and tetrazolium testing of treated barley seed samples from glyphosate treated crops in seven ISTA stations. *Seed Sci. Technol.* 18:641–52
36. Dorworth, C. E. 1990. Use of indigenous microorganisms for forest weed biocontrol—the PFC enhancement process. In *Alternatives to the Chemical Control of Weeds,* ed. C. Brassett, L. J. Whitehouse, J. A. Zabkiewicz, pp. 116–19. *Proc. Int. Conf. Rotorua, NZ, 1989.* Min. For., For. Res. Inst. Bull. 155. 159 pp.
37. Duncan, C. N., Weller, S. C. 1987. Heritability of glyphosate susceptibility among biotypes of field bindweed. *J. Hered.* 78:257–60
38. Dusky, J. A., Kang, M. S., Glaz, B., Miller, J. D. 1986. Response of eight sugarcane cultivars to glyphosine and glyphosate ripeners. *J. Plant Growth Regul.* 4:225–35
39. Eberbach, P. L., Douglas, L. A. 1989. Herbicide effects on the growth and nodulation potential of *Rhizobium trofolii* with *Trifolium subterraneum* L. *Plant Soil* 119:15–23
40. Edwards, C. A. 1989. Impact of herbicides on soil ecosystems. *CRC Crit. Rev. Plant Sci.* 8:221–57
41. Feng, J. C., Thompson, D. G. 1990. Fate of glyphosate in a Canadian forest watershed. 2. Persistence in foliage and soils. *J. Agric. Food Chem.* 38:1118–25
42. Fletcher, K., Freedman, B. 1986. Effects of the herbicide glyphosate, 2,4,5-trichlorophenoxyacetic acid on forest litter decomposition. *Can. J. For. Res.* 16:6–9
43. Franz, J. E. 1985. Discovery, development and chemistry of glyphosate. See Ref. 53, pp. 3–17
44. Ghannoum, M. A., Afzal, M., Hasan, R. A. H., Dhami, M. S. I. 1989. Variation in growth and fatty acid contents of *Trichoderma viride* induced by herbicides. *J. Environ. Sci. Health* 24:957–66
45. Glass, R. L. 1987. Adsorption of glyphosate by soils and clay minerals. *J. Agric. Food Chem.* 35:497–500
46. Gotleib, A. R., Watson, A. K. 1989. Synergistic herbicidal compositions comprising microbial herbicides and plant growth regulators. *US Patent 4,808,207*
47. Gottesbüren, B., Pestemer, W., Wang, K., Wischnewsky, M. B., Zhao, J. 1990. Prognose der Persistenz von Herbiziden und deren Auswirkungen auf Nachbaukulturen mit Hilfe des computergestützten Expertensystems HERBASYS. *Z. Pflanzenkr. Pflanzenschutz* 97:394–415
48. Gottstein, H. D., Kúc, J. A. 1989. Induction of systemic resistance to anthracnose in cucumber by phosphates. *Phytopathology* 79:176–79
49. Greaves, M. P., Sargent, J. A. 1986. Herbicide-induced microbial invasion of plant roots. *Weed Sci.* 34(Suppl.1):50–53
50. Griffin, J. L., Dabney, S. M. 1990. Preplant-postemergence herbicides for legume cover-crop control in minimum tillage systems. *Weed Technol.* 4:332–36
51. Griffiths, E. 1981. Iatrogenic plant diseases. *Annu. Rev. Phytopathol.* 19:69–82
52. Grinstein, A., Lisker, N., Katan, J., Eshel, Y. 1984. Herbicide-induced resistance to plant wilt diseases. *Physiol. Plant Pathol.* 24:347–56
53. Grossbard, E., Atkinson, D., eds. 1985. *The Herbicide Glyphosate.* London: Butterworths. 490 pp.
54. Hammes, P. S. 1990. Chemiese loofdoding by aartappels. *Appl. Plant Sci.* 4:36–39
55. Harvey, B. M. R., Spence, L., Crothers, S. H. 1985. Pre-harvest retting of flax with glyphosate: effect of growth stage at application on uptake, transloca-

Annu. Rev. Phytopathol. 1992.30:579-602. Downloaded from arjournals.annualreviews.org
by Joanne Blinn on 03/03/09. For personal use only.

Annual Reviews
www.annualreviews.org/aronline

Annu. Rev. Phytopathol. 1992.30:579-602. Downloaded from arjournals.annualreviews.org
by Joanne Blinn on 03/03/09. For personal use only.

tion and efficacy of glyphosate. *Ann. Appl. Biol.* 107:263–70
56. Harvey, B. M. R., Watson, S., Bailie, J. E., Saunders, A., McMordie, I. 1990. Pre-harvest retting of flax with glyphosate: effects of novel methods of spray application on penetration of the canopy and uniformity of deposition. *Ann. Appl. Biol.* 116:111–18
57. Hassan, S. A., Bigler, F., Bogenschütz, H., Boller, E., Brun, J., et al. 1991. Results of the fifth joint pesticide testing programme carried out by the IOBC/WPRS-Working Group "Pesticides and Beneficial Organisms." *Entomophaga* 36:55–67
58. Heinonen-Tanski, H. 1989. The effect of temperature and liming on the degradation of glyphosate in two arctic forest soils. *Soil Biol. Biochem.* 21:313–17
59. Hcitefuss, R. 1988. Assessment of herbicide effects on interaction of weeds, crop plants, pathogens and pests. *Monogr. Br. Crop Prot. Counc.* 40: 265–74
60. Hill, T. L., Stratton, G. W. 1991. Interactive effects of the fungicide chlorothalonil and the herbicide metribuzin towards the fungal pathogen *Alternaria solani*. *Bull. Environ. Contam. Toxicol.* 47:97–103
61. Hoagland, R. E., ed. 1990. *Microbes and Microbial Products as Herbicides. ACS Symp. Ser.* 439. 341 pp.
62. Hoagland, R. E. 1990. Microbes and microbial products as herbicides, an overview. See Ref. 61, pp. 2–52
63. Holck, A. R., Meek, C. L. 1987. Dose-mortality responses of crawfish and mosquitoes to selected pesticides. *J. Am. Mosq. Control Assoc.* 3:407–11
64. Holliday, M. J., Keen, N. T. 1982. The role of phytoalexins in the resistance of soybean leaves to bacteria: effect of glyphosate on glyceollin accumulation. *Phytopathology* 72:1470–74
65. Horsch, R. B., Fraley, R. T., Rogers, S. G., Klee, H. J., Fry, J., et al. 1988. *Agrobacterium*-mediated gene transfer to plants; engineering tolerance to glyphosate. *Iowa State J. Res.* 62:487–502
66. Isakeit, T., Lockwood, J. L. 1989. Lethal effect of atrazine and other triazine herbicides on ungerminated conidia of *Cochliobolus sativus* in soil. *Soil Biol. Biochem.* 21:809–17
67. Isakeit, T., Lockwood, J. L. 1990. Abiotic soil factors influencing the deleterious effect of atrazine on ungerminated conidia of *Cochliobolus sativus*. *Soil Biol. Biochem.* 22:35–41
68. Isakeit, T., Lockwood, J. L. 1990. Evaluation of the soil microbiota in producing the deleterious effect of atrazine on ungerminated conidia of *Cochliobolus sativus* in soil. *Soil Biol. Biochem.* 22: 413–17
69. Jaworski, E. G. 1972. Mode of action of *N*-phosphonomethylglycine: inhibition of aromatic amino acid biosynthesis. *J. Agric. Food Chem.* 20:1195–98
70. Johal, G. S., Rahe, J. E. 1984. Effect of soilborne plant-pathogenic fungi on the herbicidal action of glyphosate on bean seedlings. *Phytopathology* 74:950–55
71. Johal, G. S., Rahe, J. E. 1988. Glyphosate, hypersensitivity and phytoalexin accumulation in the incompatible bean anthracnose host-parasite interaction. *Physiol. Mol. Plant Pathol.* 32:267–81
72. Johal, G. S., Rahe, J. E. 1990. Role of phytoalexins in the suppression of resistance of *Phaseolus vulgaris* to *Colletotrichum lindemuthianum* by glyphosate. *Can. J. Plant. Pathol.* 12:225–35
73. Johnson, C. S. 1991. Plant mortality distribution and crop losses in flue-cured tobacco. *Plant Dis.* 75:390–94
74. Jones, R. W., Hancock, J. G. 1990. Soilborne fungi for biological control of weeds. See Ref. 61, pp. 276–86
75. Jordan, J. J. 1989. *Monsanto Company*. Philadelphia:Provident National Bank. 21 pp.
76. Kaps, M. A., Kuhns, L. J. 1987. Glyphosate transfer between plants via mycorrhizal fungi. *HortScience* 22:1128 (Abstr.)
77. Kassaby, F. Y., Hepworth, G. 1987. *Phytophthora cinnamomi*: effects of herbicides on radial growth, sporangial production, inoculum potential and root disease in *Pinus radiata*. *Soil Biol. Biochem.* 19:437–41
78. Katan, J., Eshel, Y. 1973. Interactions between herbicides and plant pathogens. *Residue Rev.* 45:145–77
79. Kataria, H. R., Gisi, U. 1990. Interactions of fungicide-herbicide combinations against plant pathogens and weeds. *Crop Prot.* 9:403–9
80. Kawate, M. K., Appleby, A. P. 1987. Effect of soil pH on availability of glyphosate in soil to germinating ryegrass seedlings. *J. Appl. Seed Prod.* 5:45–49
81. Keen, N. T., Holliday, M. J., Yoshikawa, M. 1982. Effects of glyphosate on glyceollin production and the expression of resistance to *Phytophthora megasperma* f.sp. *glycinae* in soybean. *Phytopathology* 72:1467–70
82. Koppatschek, F. K., Liebl, R. A., Kriz,

Annual Reviews
www.annualreviews.org/aronline

A. L., Melhado, L. L. 1990. Development of an enzyme-linked immunosorbent assay for the detection of the herbicide clomazone. *J. Agric. Food Chem.* 38:1519–22
83. Kreutzweiser, D. P., Kingsbury, P. D., Feng, J. C. 1989. Drift response of stream invertebrates to aerial applications of glyphosate. *Bull. Environ. Contam. Toxicol.* 42:331–38
84. Krueger, J. P., Butz, R. G., Cork, D. J. 1991. Use of dicamba-degrading microorganisms to protect dicamba susceptible plant species. *J. Agric. Food Chem.* 39:1000–3
85. Lamondia, J. A., Brodie, B. B. 1986. The effect of potato trap crops and fallow on decline of *Globodera rostochiensis*. *Ann. Appl. Biol.* 108:347–52
86. Lee, F. N. 1990. Rice Dead Tiller Syndrome in Arkansas. *Phytopathology* 80:1005 (Abstr.)
87. Lévesque, C. A. 1990. *The nature and significance of fungal colonizers in the herbicidal effect of glyphosate*. PhD thesis. Simon Fraser Univ., Burnaby, BC. 119 pp.
88. Lévesque, C. A., Rahe, J. E. 1988. A new technique for studying fungal colonization of roots. *Can. J. Plant Pathol.* 10:368 (Abstr.)
89. Lévesque, C. A., Rahe, J. E. 1989. Fungal colonization of glyphosate-treated plants. *Can. J. Plant Pathol.* 11:193–94 (Abstr.)
90. Lévesque, C. A., Rahe, J. E. 1990. Site, host specificity, and pathogenicity of *Pythium* spp. colonizers of glyphosate treated seedlings. *Can. J. Plant Pathol.* 12:336 (Abstr.)
91. Lévesque, C. A., Rahe, J. E., Eaves, D. M. 1987. Effects of glyphosate on *Fusarium* spp.: its influence on root colonization of weeds, propagule density in the soil, and crop emergence. *Can. J. Microbiol.* 33:354–60
91a. Lévesque, C. A., Rahe, J. E., Eaves, D. M. 1992. The effect of soil heat treatment and microflora on efficacy of glyphosate in seedlings. *Weed Res.* 32: In press
92. Lewosz, W. 1989. The influence of some post-emergence herbicides on the incidence of blackleg and soft rot in potato. *Proc. Brighton Crop Prot. Conf.* 1:241–42
93. Lünd-Høie, K., Firestad, H. O. 1986. Photodegradation of the herbicide glyphosate in water. *Bull. Environ. Contam. Toxicol.* 36:723–29
94. Lünd-Høie, K. 1985. Efficacy of glyphosate in forest plantations. See Ref. 53, pp. 328–38
95. Lydon, J., Duke, S. O. 1989. Pesticide effects on secondary metabolism of higher plants. *Pestic. Sci.* 25:361–73
96. Lynch, J. M., Penn, D. J. 1980. Damage to cereals caused by decaying weed residues. *J. Sci. Food Agric.* 31:321–24
97. Marks, G. C., Becker, S. L. 1990. Influence of propazine and chlorthal-dimethyl on mycorrhizal development in *Pinus radiata* seedlings. *Aust. J. Bot.* 38:341–49
98. Marks, G. C., Cerra, R. 1991. Effects of propazine and chlorthal dimethyl on *Phytophthora cinnamomi* root disease of *Pinus radiata* seedlings and associated soil microflora. *Soil Biol. Biochem.* 23:157–64
99. Marshall, G., Kirkwood, R. C., Martin, D. J. 1987. Studies of the mode of action of asulam, aminotriazole and glyphosate in *Equisetum arvense* L. (field horsetail) I. The uptake and translocation of [^{14}C]asulam, [^{14}C]aminotriazole and [^{14}C]glyphosate. *Pestic. Sci.* 18:55–64
100. McConnell, J. S., Hossner, L. R. 1985. pH-dependent adsorption isotherms of glyphosate. *J. Agric. Food Chem.* 33: 1075–78
101. Mekwatanakarn, P., Sivasithamparam, K. 1987. Effect of certain herbicides on saprophytic survival and biological suppression of the take-all fungus. *New Phytol.* 106:153–59
102. Mekwatanakarn, P., Sivasithamparam, K. 1987. Effect of certain herbicides on soil microbial populations and their influence on saprophytic growth in soil and pathogenicity of take-all fungus. *Biol. Fertil. Soils* 5:175–80
103. Mielke, H. 1983. Untersuchungen zum *Gaeumannomyces graminis* Befall an Winterweizen unter Berücksichtigung einer Quenckenbekämpfung mit "Roundup". *Gesunde Pflanz.* 35:46–49
104. Moorman, T. B. 1989. A review of pesticide effects on microorganisms and microbial processes related to soil fertility. *J. Prod. Agric.* 2:14–23
105. Moorman, T. B., Dowler, C. C. 1991. Herbicide and rotation effects on soil and rhizosphere microorganisms and crop yields. *Agric. Ecosyst. Environ.* 35:311–25
106. Morandi, D. 1989. Effect of xenobiotics on endomycorrhizal infection and isoflavonoid accumulation in soybean roots. *Plant Physiol. Biochem.* 27:697–701
107. Mortensen, D. A., Coble, H. D., Smart, J. R., Bauer, T. A. 1990. Use of an expert system for integrating weed con-

Annu. Rev. Phytopathol. 1992.30:579-602. Downloaded from arjournals.annualreviews.org
by Joanne Blinn on 03/03/09. For personal use only.

Annual Reviews
www.annualreviews.org/aronline

Annu. Rev. Phytopathol. 1992.30:579-602. Downloaded from arjournals.annualreviews.org
by Joanne Blinn on 03/03/09. For personal use only.

trol strategies in a weed science laboratory. *J. Agron. Educ.* 19:181–83
108. Mugnier, J. 1988. Behaviour of herbicides in dicotyledonous roots transformed by *Agrobacterium rhizogenes*. I. Selectivity. *J. Exp. Bot.* 39:1045–56
109. Nelson, L. R., Ward, S., Collins, F. 1989. Glyphosate sled for alley cleanup in research plots. *Crop. Sci.* 29:1567–68
110. Nilsson, H., Hallgren, E. 1989. Direct sowing of winter rape in stands of *Elymus repens* after application of Roundup (glyphosate). A greenhouse experiment. *Swed. Crop Prot. Conf.* 2:257–63
111. Oskarsson, U., Ottósson, J. G. 1990. Plantation establishment success of *Pinus contorta* Dougl. ex Loud. and *Larix sibirica* (Munchh.) Ledeb. using various methods and stock. *Scand. J. For. Res.* 5:205–14
112. Parker, C. 1991. Protection of crops against parasitic weeds. *Crop Prot.* 10:6–22
113. Pimentel, D., McLaughlin, L., Zepp, A., Lakitan, B., Kraus, T., et al. 1991. Environmental and economic effects of reducing pesticide use. *BioScience* 41:402–9
114. Pipke, R., Amrhein, N. 1988. Isolation and characterization of a mutant of *Arthrobacter* sp. strain-GLP-1 which utilizes the herbicide glyphosate as its sole source of phosphorus and nitrogen. *Appl. Environ. Microbiol.* 54:2868–70
115. Pollack, J. C., LePage, P., Van Thienen, F. 1990. Some effects of different forest herbicides on upland *Salix* spp. *Can. J. For. Res.* 20: 1271–76
116. Quinn, J. P., Peden, J. M. M., Dick, R. E. 1988. Glyphosate tolerance and utilization by the microflora of soils treated with the herbicide. *Appl. Microbiol. Biotechnol.* 29:511–16
117. Rahe, J. E., Lévesque, C. A., Johal, G. S. 1990. Synergistic role of soil fungi in the herbicidal efficacy of glyphosate. See Ref. 61, pp. 260–75
118. Deleted in proof
119. Roy, D. N., Konar, S. K. 1989. Development of an analytical method for the determination of glyphosate and (aminomethyl) phosphonic acid residues in soils by nitrogen selective gas chromatography. *J. Agric. Food Chem.* 37:441–43
120. Roy, D. N., Konar, S. K., Banerjee, S., Charles, D. A., Thompson, D. G., et al. 1989. Persistence, movement, and degradation of glyphosate in selected Canadian boreal forest soils. *J. Agric. Food Chem.* 37:437–40
121. Rush, C. M., Gerik, T. J. 1989. Relationship between postharvest management of grain sorghum and Phymatotrichum root rot in the subsequent cotton crop. *Plant Dis.* 73:304–5
122. Salveit, M. E. 1988. Post harvest glyphosate application reduces toughening, fiber content, and lignification of stored aspagagus spears. *J. Am. Soc. Hortic. Sci.* 113:569–72
123. Sandberg, C. L., Meggitt, W. F., Penner, D. 1980. Absorption, translocation and metabolism of ^{14}C-glyphosate in several weed species. *Weed Res.* 20:195–200
124. Sauerborn, J., Saxena, M. C., Meyer, A. 1989. Broomrape control in faba bean (*Vicia faba* L.) with glyphosate and imazaquin. *Weed Res.* 29:97–102
125. Shah, D. M., Horsch, R. B., Klee, H. J., Kishore, G. M., Winter, J. A. et al. 1986. Engineering herbicide tolerance in transgenic plants. *Science* 233:478–81
126. Deleted in proof
127. Sharma, H. S. S. 1986. Effect of glyphosate treatment on lignification of fibers of some flax cultivars. *Ann. Appl. Biol.* 108(Suppl.):114–15
128. Sivasithamparam, K., Bolland, M. D. A. 1985. Effect of herbicide sprays on the infectivity and propagule numbers of take-all fungus (*Gaeumannomyces graminis* var. *tritici*) and the effect on propagule size and soil temperature on infectivity. *Australas. Plant Pathol.* 14: 22–25
129. Smith, A. E. 1982. Herbicides and the soil environment in Canada. *Can. J. Soil Sci.* 62:433–60
130. Sprankle, P., Meggitt, W. F., Penner, D. 1975. Rapid inactivation of glyphosate in the soil. *Weed Sci.* 23:224–28
131. Sprankle, P., Meggitt, W. F., Penner, D. 1975. Adsorption, mobility, and microbial degradation of glyphosate in the soil. *Weed Sci.* 23:229–34
132. Sprankle, P., Meggitt, W. F., Penner, D. 1975. Absorption, action, and translocation of glyphosate. *Weed Sci.* 23:235–40
133. Stasiak, M. A., Hofstra, G., Payne, N. J., Prasad, R., Fletcher, R. A. 1991. Alterations of growth and shikimic acid levels by sublethal glyphosate applications on pin cherry and trembling aspen. *Can. J. For. Res.* 21:1086–90
134. Steinrücken, H. C., Amrhein, N. 1980. The herbicide glyphosate is a potent inhibitor of 5-enolpyruvylshikimic acid-3-phosphate synthase. *Biochem. Biophys. Res. Commun.* 94:1207–12
135. Subramaniam, V., Hoggard, P. E. 1988. Metal complexes of glyphosate. *J. Agric. Food Chem.* 36:1326–29

Annual Reviews
www.annualreviews.org/aronline

136. Tanphiphat, K., Appleby, A. P. 1990. Absorption, translocation, and phytotoxicity of glyphosate in bulbous oatgrass (*Arrhenatherum elatius* var. *bulbosum*). *Weed Sci.* 38:480–83
137. Thompson, D. G., Cowell, J. E., Daniels, R. J., Staznik, B., MacDonald, L. M. 1989. Liquid chromatographic method for quantitation of glyphosate and metabolite residues in organic and mineral soils, streams, sediments, and hardwood foliage. *J. Assoc. Off. Anal. Chem.* 72:355–60
138. Torstensson, N. T. L., Lundgren, L. N., Stenström, J. 1989. Influence of climatic and edaphic factors on persistence of glyphosate and 2,4-D in forest soils. *Ecotoxicol. Environ. Saf.* 18:230–39
139. Trappe, J. M., Molina, R., Castellano, M. 1984. Reaction of mycorrhizal fungi and mycorrhiza formation to pesticides. *Annu. Rev. Phytopathol.* 22:331–59
140. Tuinstra, L. G. M. T., Kienhuis, P. G. M. 1987. Automated two-dimensional HPLC residue procedure for glyphosate on cereals and vegetables with post column fluoregenic labeling. *Chromatographia* 24:696–700
141. Tworkoski, T. J., Sterrett, J. P. 1987. Modification of root bud growth in Canada thistle with selected plant growth regulators: effects on translocation of glyphosate. *J. Plant Growth Regul.* 6:221–32
142. Utkhede, R. S. 1982. Effects of six herbicides on the growth of *Phytophthora cactorum* and a bacterial antagonist. *Pestic. Sci.* 13:693–95
143. Vasilas, B. L., Esgar, R. W., Walker, W. M., Beck, R. H., Mainz, M. J. 1988. Soybean response to potassium fertility under four tillage systems. *Agron. J.* 80:5–8
144. Vaughn, K. C., Duke, S. O. 1986. Ultrastructural effects of glyphosate on *Glycine max* seedlings. *Pestic. Biochem. Physiol.* 26:56–65
145. Wall, R. E., Shamoun, S. F. 1990. Diseases of *Rubus parviflorus* in British Columbia. *Can. Plant Dis. Surv.* 70:133–35
145a. Wall, R. E., Shamoun, S. F. 1990. Experiments on vegetation control with native pathogenic fungi in the southern interior of British Columbia. *Canada/BC FRDA Rep. 134.* 18 pp.
146. Wardle, D. A., Parkinson, D. 1990. Influence of the herbicide glyphosate on soil microbial community structure. *Plant Soil* 122:29–37
147. Weber, J. B. 1991. Fate and behaviour of herbicides in soils. *Appl. Plant Sci.* 5:27–41
148. Westerman, R. B., Murray, D. S. 1990. Cotton (*Gossypium hirsutum*) response to glyphosate spot applied. *Weed Technol.* 4:759–64
149. Whigham, D. K., Stoller, E. W. 1979. Soybean desiccation by paraquat, glyphosate and ametryn to accelerate harvest. *Agron. J.* 71:630–33
150. Willis, A. J. 1990. Ecological consequences of modern weed control systems. In *Weed Control Handbook: Principles*, ed. R. J. Hance, K. Holly, pp. 501–19. Oxford: Blackwell. 582 pp. 8th ed.
151. Willis, R. G., Stephenson, G. R., Fletcher, R. A., Prasad, R. 1989. Seasonal variations in jackpine (*Pinus banksiana*) and white spruce (*Picea glauca*) tolerance to glyphosate and triclopyr. *Weed Technol.* 3:33–38
152. Worthy, W. 1990. Monsanto's John E. Franz wins 1990 Perkin Medal. *Chem. Eng. News* 68:29–30

Annu. Rev. Phytopathol. 1992.30:579-602. Downloaded from arjournals.annualreviews.org
by Joanne Blinn on 03/03/09. For personal use only.

ANNEX 132

United States Environmental Protection Agency,
Glyphosate Reregistration Eligibility Decision Fact Sheet (Sep. 1993)

United States Environmental Protection Agency | Prevention, Pesticides And Toxic Substances (7508W) | EPA-738-F-93-011 September 1993

EPA

R.E.D. FACTS

Glyphosate

Pesticide Reregistration

All pesticides sold or distributed in the United States must be registered by EPA, based on scientific studies showing that they can be used without posing unreasonable risks to people or the environment. Because of advances in scientific knowledge, the law requires that pesticides which were first registered years ago be reregistered to ensure that they meet today's more stringent standards.

In evaluating pesticides for reregistration, EPA obtains and reviews a complete set of studies from pesticide producers, describing the human health and environmental effects of each pesticide. The Agency imposes any regulatory controls that are needed to effectively manage each pesticide's risks. EPA then reregisters pesticides that can be used without posing unreasonable risks to human health or the environment.

When a pesticide is eligible for reregistration, EPA announces this and explains why in a Reregistration Eligibility Decision (RED) document. This fact sheet summarizes the information in the RED document for glyphosate.

Use Profile

Glyphosate is a non-selective herbicide registered for use on many food and non-food field crops as well as non-crop areas where total vegetation control is desired. When applied at lower rates, glyphosate also is a plant growth regulator.

Glyphosate is among the most widely used pesticides by volume. It ranked eleventh among conventional pesticides used in the U.S. during 1990-91. In recent years, approximately 13 to 20 million acres were treated with 18.7 million pounds of glyphosate annually. The largest use sites include hay/pasture, soybeans and field corn.

Three salts of glyphosate are used as active ingredients in registered pesticide products. Two of these active ingredients, plus technical grade glyphosate, are contained in the 56 products that are subject to this RED.

The isopropylamine salt, an active ingredient in 53 registered products, is used as a herbicide to control broadleaf weeds and grasses in many food and non-food crops and a variety of other sites including ornamentals, lawns and turf, residential areas, greenhouses, forest plantings and industrial rights-of-way. It is formulated as a liquid, solid or pellet/tablet, and is applied using ground or aerial equipment.

The sodium salt of glyphosate, an active ingredient in two registered pesticide products, is used as a plant growth regulator for peanuts and sugarcane, to modify plant growth and hasten the ripening of fruit. It is applied as a ground spray to peanut fields and as an aerial spray to sugarcane. Preharvest intervals are established for both crops.

The monoammonium salt of glyphosate is an active ingredient in an additional seven herbicide/growth regulator products. This form of glyphosate was initially registered after November 1984, so it is not subject to reregistration or included in this RED. However, in reassessing the existing glyphosate tolerances (maximum residue limits in or on food and feed), EPA included those for the monoammonium salt.

Regulatory History

EPA issued a Registration Standard for glyphosate in June 1986 (NTIS PB87-103214). The Registration Standard required additional phytotoxicity, environmental fate, toxicology, product chemistry and residue chemistry studies. All of the data required have been submitted and reviewed, or were waived.

Human Health Assessment

Toxicity

Glyphosate is of relatively low oral and dermal acute toxicity. It has been placed in Toxicity Category III for these effects (Toxicity Category I indicates the highest degree of acute toxicity, and Category IV the lowest). The acute inhalation toxicity study was waived because glyphosate is non-volatile and because adequate inhalation studies with end-use products exist showing low toxicity.

A subchronic feeding study using rats showed blood and pancreatic effects. A similar study with mice showed reduced body weight gains in both sexes at the highest dose levels. A dermal study with rabbits showed slight reddening and swelling of the skin, decreased food consumption in males and decreased enzyme production, at the highest dose levels.

Several chronic toxicity/carcinogenicity studies using rats, mice and beagle dogs resulted in no effects based on the parameters examined, or resulted in findings that glyphosate was not carcinogenic in the study. In June 1991, EPA classified glyphosate as a Group E oncogen--one that shows evidence of non-carcinogenicity for humans--based on the lack of convincing evidence of carcinogenicity in adequate studies.

In developmental toxicity studies using pregnant rats and rabbits, glyphosate caused treatment-related effects in the high dose groups including diarrhea, decreased body weight gain, nasal discharge and death.

One reproductive toxicity study using rats showed kidney effects in the high dose male pups; another study showed digestive effects and decreased body weight gain. Glyphosate does not cause mutations.

In one metabolism study with rats, most of the glyphosate administered (97.5 percent) was excreted in urine and feces as the parent compound; less than one percent of the absorbed dose remained in tissues and organs, primarily in bone tissue. Aminomethyl phosphonic acid (AMPA) was the only metabolite excreted. A second study using rats showed that very little glyphosate reaches bone marrow, that it is rapidly eliminated from bone marrow, and that it is even more rapidly eliminated from plasma.

Dietary Exposure

The nature of glyphosate residue in plants and animals is adequately understood. Studies with a variety of plants indicate that uptake of glyphosate or AMPA from soil is limited. The material which is taken up is readily translocated throughout the plant and into its fruit. In animals, most glyphosate is eliminated in urine and feces. Enforcement methods are available to detect residues of glyphosate and AMPA in or on plant commodities, in water and in animal commodities.

85 tolerances have been established for residues of glyphosate and its metabolite, AMPA, in or on a wide variety of crops and crop groups, as well as in many processed foods, animal feed and animal tissues (please see 40 CFR 180.364, 40 CFR 185.3500 and 40 CFR 186.3500). EPA has reassessed the existing and proposed tolerances for glyphosate. Though some adjustments will be needed, no major changes in existing tolerances are required. EPA also has compared the U.S. tolerances with international Codex maximum residue limits (MRLs), and is recommending certain adjustments to achieve greater compatibility.

EPA conducted a dietary risk assessment for glyphosate based on a worst-case risk scenario, that is, assuming that 100 percent of all possible commodities/acreage were treated, and assuming that tolerance-level residues remained in/on all treated commodities. The Agency concluded that the chronic dietary risk posed by glyphosate food uses is minimal.

A reference dose (RfD), or estimate of daily exposure that would not cause adverse effects throughout a lifetime, of 2 mg/kg/day has been proposed for glyphosate, based on the developmental toxicity studies described above.

Occupational and Residential Exposure

Occupational and residential exposure to glyphosate can be expected based on its currently registered uses. However, due to glyphosate's low acute toxicity and the absence of other toxicological concerns (especially carcinogenicity), occupational and residential exposure data are not required for reregistration.

Some glyphosate end-use products are in Toxicity Categories I or II for primary eye irritation or skin irritation. In California, glyphosate ranks high among pesticides causing illness or injury to workers, who report numerous incidents of eye and skin irritation from splashes during mixing and loading.

EPA is not adding any personal protective equipment (PPE) requirements at this time, but any existing PPE label requirements must be retained.

The Worker Protection Standard (WPS) for Agricultural Pesticides (please see 40 CFR 156 and 170) established an interim restricted entry interval (REI) of 12 hours for glyphosate. The Agency has decided to retain this REI as a prudent measure to mitigate risks to workers. During the REI, workers may reenter areas treated with glyphosate only in the few, narrow exceptions allowed in the WPS. The REI applies only to glyphosate uses within the scope of the WPS, so homeowner and commercial uses are not included.

Human Risk Assessment

EPA's worst case risk assessment of glyphosate's many registered food uses concludes that human dietary exposure and risk are minimal. Existing and proposed tolerances have been reassessed, and no significant changes are needed to protect the public.

Exposure to workers and other applicators generally is not expected to pose undue risks, due to glyphosate's low acute toxicity. However, splashes during mixing and loading of some products can cause injury, primarily eye and skin irritation. EPA is continuing to recommend PPE, including protective eye wear, for workers using end-use products that are in Toxicity Categories I or II for eye and skin irritation. To mitigate potential risks associated with reentering treated agricultural areas, EPA is retaining the 12 hour REI set by the WPS.

Environmental Assessment

Environmental Fate

Glyphosate adsorbs strongly to soil and is not expected to move vertically below the six inch soil layer; residues are expected to be immobile in soil. Glyphosate is readily degraded by soil microbes to AMPA, which is degraded to carbon dioxide. Glyphosate and AMPA are not likely to move to ground water due to their strong adsorptive characteristics. However, glyphosate does have the potential to contaminate surface waters due to its aquatic use patterns and through erosion, as it adsorbs to soil particles suspended in runoff. If glyphosate reached surface water, it would not be broken down readily by water or sunlight.

Ecological Effects

Glyphosate is no more than slightly toxic to birds and is practically non-toxic to fish, aquatic invertebrates and honeybees. Due to the presence of a toxic inert ingredient, some glyphosate end-use products must be labeled, "Toxic to fish," if they may be applied directly to aquatic environments. Product labeling does not preclude off-target movement of glyphosate by drift. EPA therefore is requiring three additional terrestrial plant studies to assess potential risks to nontarget plants.

EPA does not expect that most endangered terrestrial or aquatic organisms will be affected by the registered uses of glyphosate. However,

many endangered plants as well as the Houston toad (due to its habitat) may be at risk. EPA is deferring any use modifications or labeling amendments until it has published the Endangered Species Protection Plan and has given registrants guidance regarding endangered species precautionary labeling.

Ecological Effects Risk Assessment

Based on current data, EPA has determined that the effects of glyphosate on birds, mammals, fish and invertebrates are minimal. Under certain use conditions, glyphosate may cause adverse effects to nontarget aquatic plants. Additional data are needed to fully evaluate the effects of glyphosate on nontarget terrestrial plants. Risk reduction measures will be developed if needed, once the data from these studies are submitted and evaluated.

Additional Data Required

EPA is requiring three generic studies (Tier II Vegetative Vigor, Droplet Size Spectrum, and Drift Field Evaluation) which are not part of the target data base and do not affect the reregistration eligibility of glyphosate. The Agency also is requiring product-specific data including product chemistry and acute toxicity studies, as well as revised Confidential Statements of Formula and revised labeling.

Product Labeling Changes Required

All end-use glyphosate products must comply with EPA's current pesticide product labeling requirements. In addition:

- **Protection of Aquatic Organisms**

Non-Aquatic Uses - End-use products that are not registered for aquatic uses must bear the following label statement:

Do not apply directly to water, to areas where surface water is present or to intertidal areas below the mean high water mark. Do not contaminate water when disposing of equipment washwaters and rinsate.

Aquatic Uses - End-use products registered for aquatic uses must bear the following label statement:

Do not contaminate water when disposing of equipment washwaters and rinsate. Treatment of aquatic weeds can result in oxygen loss from decomposition for dead plants. This loss can cause fish kills.

- **Worker Protection Standard (WPS) Requirements**

Any product whose labeling permits use in the production of an agricultural plant on any farm, forest, nursery or greenhouse must comply with the labeling requirements of:

• PR Notice 93-7, "Labeling Revisions Required by the Worker Protection Standard (WPS)," and

• PR Notice 93-11, "Supplemental Guidance for PR Notice 93-7."

Unless specifically directed in the RED, all statements required by these two PR Notices must appear on product labeling exactly as instructed in the Notices. Labels must be revised by April 21, 1994, for products distributed or sold by the primary registrant or supplementally registered distributors, and by October 23, 1995, for products distributed or sold by anyone.

- **Personal Protective Equipment (PPE)**

No new PPE requirements must be added to glyphosate labels. However, any existing PPE requirements on labels must be retained.

- **Entry Restrictions**

Products Not Primarily Intended for Home Use:

- Uses Within the Scope of the WPS - A 12-hour restricted entry interval (REI) is required for all products with uses within the scope of the WPS, except products intended primarily for home use. The PPE for early entry should be that required for applicators of glyphosate, except any applicator requirement for an apron or respirator is waived. This REI and PPE should be inserted into the standardized statements required by PR Notice 93-7.

  • Sole Active Ingredient End-Use Products - Labels must be revised to adopt the entry restrictions set forth in this section. Any conflicting entry restrictions on current labeling must be removed.

  • Multiple Active Ingredient Products - Registrants must compare the entry restrictions set forth in this section to those on their current labeling and retain the more protective. A specific time period in hours or days is considered more protective than "until sprays have dried" or "dusts have settled."

- Uses Not Within the Scope of the WPS - No new entry restrictions must be added. However, any entry restrictions on current product labeling with these uses must be retained.

Products Primarily Intended for Home Use:

- No new entry restrictions must be added. However, any entry restrictions on current product labeling must be retained.

Regulatory Conclusion

The use of currently registered pesticide products containing the isopropylamine and sodium salts of glyphosate in accordance with the labeling specified in this RED will not pose unreasonable risks or adverse effects to humans or the environment. Therefore, all uses of these products are eligible for reregistration.

These glyphosate products will be reregistered once the required product-specific data, revised Confidential Statements of Formula and revised labeling are received and accepted by EPA.

Products which contain active ingredients in addition to glyphosate will not be reregistered until all their other active ingredients also are eligible for reregistration.

For More Information

EPA is requesting public comments on the Reregistration Eligibility Decision (RED) document for glyphosate during a 60-day time period, as announced in a Notice of Availability published in the Federal Register. To obtain a copy of the RED document or to submit written comments, please contact the Pesticide Docket, Public Response and Program Resources Branch, Field Operations Division (7506C), Office of Pesticide Programs (OPP), US EPA, Washington, DC 20460, telephone 703- 305-5805.

Following the comment period, the glyphosate RED document will be available from the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA 22161, telephone 703-487-4650.

For more information about EPA's pesticide reregistration program, the glyphosate RED, or reregistration of individual products containing glyphosate, please contact the Special Review and Reregistration Division (7508W), OPP, US EPA, Washington, DC 20460, telephone 703-308-8000.

For information about the health effects of pesticides, or for assistance in recognizing and managing pesticide poisoning symptoms, please contact the National Pesticides Telecommunications Network (NPTN). Call toll-free 1-800-858-7378, between 8:00 am and 6:00 pm Central Time, Monday through Friday.

ANNEX 133

D.C. Sands et al., *Characterization of a Vascular Wilt of Erythroxylum coca Caused by Fusarium oxyspurum f. sp. Erythrowyli Forma Specialis Nova*, Plant Disease, Vol. 81, No. 5 (May 1997)

Characterization of a Vascular Wilt of *Erythroxylum coca* Caused by *Fusarium oxysporum* f. sp. *erythroxyli* Forma Specialis Nova

D. C. Sands, E. J. Ford, R. V. Miller, B. K. Sally, M. K. McCarthy, T. W. Anderson, M. B. Weaver, C. T. Morgan, and **A. L. Pilgeram,** Department of Plant Pathology, Montana State University, Bozeman 59717; and **L. C. Darlington,** Biocontrol of Plant Diseases Laboratory, USDA, ARS, Beltsville, MD 20705

ABSTRACT

Sands, D. C., Ford, E. J., Miller, R. V., Sally, B. K., McCarthy, M. K., Anderson, T. W., Weaver, M. B., Morgan, C. T., Pilgeram, A. L., and Darlington, L. C. 1997. Characterization of a vascular wilt of *Erythroxylum coca* caused by *Fusarium oxysporum* f. sp. *erythroxyli* forma specialis nova. Plant Dis. 81:501-504.

A new forma specialis of *Fusarium oxysporum* (*F. oxysporum* f. sp. *erythroxyli*) pathogenic to *Erythroxylum coca* and *E. novogranatense* is described. The pathogen was isolated from the vascular tissue of diseased plants from an *Erythroxylum* plantation in Hawaii. This pathogen causes vascular wilt symptoms and death in both *E. coca* and *E. novogranatense* plants as soon as 7 weeks after soil infestation. The pathogenicity of seven isolates from the affected field was determined in field and growth-chamber studies. Genetic variation was not detected among the seven Hawaiian isolates, using arbitrarily primed polymerase chain reaction. The seven isolates could be differentiated from a strain isolated from a diseased *E. coca* plant from South America. All Hawaiian isolates and the South American isolate belonged to a single vegetative compatibility group.

Additional keywords: DNA, mycoherbicide, RAPD

Erythroxylum coca and *E. novogranatense* plants showing symptoms of vascular wilt were observed at a tropical research site on the Hawaiian island of Kauai in 1988. Symptoms included chlorosis, leaf drop, and vascular discoloration, eventually resulting in death. Frequently, the external symptoms were apparent first on a single branch or single side of an affected plant. In the early stages of the disease, symptoms were more apparent after water stress. Cross-sections of stems and twigs from the wilted side of diseased plants revealed darkening of xylem tissue. Vascular discoloration extended from the root tissue through the crown and into the stem tissue of diseased plants. In the initial observations, disease symptoms were more prevalent in *E. coca* plants than in *E. novogranatense*.

The *Erythroxylum* research plantation on the island of Kauai was originally established by a major soft drink manufacturer during the 1960s with 11 coca plants obtained from the Lyon Arboretum, Foster Gardens, and Marks Estates, Honolulu, HI (7). Next, 8,000 seeds were obtained from Trujillo, Peru, but only about 20% germinated. Many of these seedlings succumbed to a damping-off disease characterized by chlorosis, abscission of healthy leaves, and severe wilting. Seedling loss was initially believed to be due to the potting mixture or water supply. The next year, 8,000 additional seeds were received from Cuzco, Peru. Fewer than 300 of these developed into mature *Erythroxylum* plants.

The incidence of wilt at the plantation increased throughout the 1970s (7). During this time, dead plants were removed from the field and immediately replaced with healthy seedlings. Dissection of the branches of dead plants showed brown discoloration of the vascular bundles and cambial layer. The disease was observed in both seedlings and mature plants and was suspected to be caused by a fungus or bacterium that clogged the vascular system. *Fusarium oxysporum* was identified as the wilt organism during the 1980s, and its dispersal throughout the research plots eventually resulted in termination of the breeding project.

The U.S. Department of Agriculture continued to use this secure site for herbicide studies on *E. coca* and *E. novogranatense*. Research was continually hindered by high disease incidence. In 1987, *E. coca* plants grown from Peruvian seed and *E. novogranatense* plants grown from Venezuelan seed were transplanted into the research site (7). From this planting, 153 of 852 *E. coca* plants and 1 of 370 *E. novogranatense* plants died within 3 months. *F. oxysporum* was again isolated from the diseased plants, confirming its potential as a mycoherbicide for control of coca.

The objectives of this study were to characterize the *F. oxysporum* isolates, determine their pathogenicity to *Erythroxylum* and selected crop species, and analyze genetic variation within the group by arbitrarily primed polymerase chain reaction (PCR).

MATERIALS AND METHODS

Isolation of fungi from diseased tissue. In 1988, isolations were made from discolored vascular tissue from symptomatic *E. coca* and *E. novogranatense* plants collected from the field and from symptomatic seedlings of *E. novogranatense* grown in shade houses at the experiment station. Shade-house seedlings were started from seeds collected from mature plants within the infested area and planted in a commercial potting mix. Stem tissue was cross-sectioned into 1- to 2-mm-thick slices and surface-sterilized in a 0.8% solution of sodium hypochlorite for 60 s. The tissue sections were rinsed in sterile distilled water and placed on 2% water agar supplemented with 50 µg of streptomycin and 15 µg of tetracycline per ml and incubated at ambient temperature for a minimum of 24 h.

The predominant fungi that grew out into the agar from each section of diseased tissue were transferred to potato dextrose agar (PDA) (Difco Laboratories, Detroit), Komada's medium (11), or Nash-Snyder medium (14). Morphologically similar isolates of *Fusarium* were recovered from all diseased tissue tested and were identified as *F. oxysporum* (1,2,15). Single-spore subcultures of seven isolates of *F. oxysporum* (strains Ec1, Ec2, Ec3, En1, En2, En3, and En4) were arbitrarily selected for pathogenicity and molecular studies. Strains Ec1, Ec2, and Ec3 were isolated from *E. coca*. Strains En1, En2, En3, and En4 were isolated from *E. novogranatense. F. oxysporum* strain SA1 was isolated from the crown of a diseased *E. coca* plant from South America.

Preservation of fungi. Cultures of each *F. oxysporum* isolate were transferred to PDA and incubated at 28°C for 48 to 72 h. Sterile birch-wood toothpicks were placed on the expanding colony, and the cultures were incubated further at 28°C until the toothpicks were completely colonized by fungal mycelia (72 to 96 h). Approximately 20 colonized toothpicks were placed in a sterilized No. 2 dram screw-cap vial (Wheaton Scientific, Milleville, NJ). The toothpicks were dried by placing the uncapped

Corresponding author: D. C. Sands
E-mail: uplds@montana.edu

Accepted for publication 3 February 1997.

Publication no. D-1997-0312-04R
© 1997 The American Phytopathological Society

tubes in a laminar flow hood for 12 to 24 h. The tubes were capped and stored at 4 to 5°C for up to 5 years. Cultures were recovered readily from storage by placing a single toothpick on a plate of PDA and incubating for 24 to 72 h.

Production of fungal inocula and soil infestation. Colonized millet seed was used to infest soil in both field and growth-chamber virulence studies. Millet seed was moistened with distilled water (1:1, wt/vol) and sterilized with a minimum of three autoclaving cycles (60 min, 120°C). The sterile millet was inoculated with agar plugs from a PDA culture of *F. oxysporum* and incubated at 28°C for 5 to 7 days. After the fungus had colonized the seed completely, the millet formulation was air-dried and stored at 5°C. Control formulations consisted of colonized millet autoclaved prior to soil infestation.

Host-range studies were done in soil infested with a rice formulation of *F. oxysporum*. Strains of *F. oxysporum* were cultured in potato dextrose broth (PDB) at ambient temperature, with agitation for 72 h, and primarily yielded microconidia. The concentration of conidia in the culture was estimated with a hemacytometer and was mixed with sterilized, dehulled, milled rice grains at a rate of 3.3×10^5 conidia per g of rice. The control consisted of noninoculated PDB poured over sterile rice. The treated rice was air-dried in a laminar flow hood for 12 to 24 h and was mixed uniformly with steamed greenhouse soil (1:100, wt/wt). The rice/soil mixture was moistened, and the fungus was allowed to ramify throughout the soil for 1 to 3 weeks.

Field inoculations. Six- to twelve-month-old *E. coca* and *E. novogranatense* seedlings were transplanted to the field from an on-site nursery during the fall of 1988. Individual research plots contained two *E. coca* and two *E. novogranatense* transplants at 60-cm intervals. Plots were separated by 4 m. During the spring of 1989, plots were infested with millet formulations of the seven Hawaiian isolates of *F. oxysporum* or with control formulations. Two methods of field infestation were compared. In the first method, a 2-cm-deep, V-shaped trench was formed in the soil 10 cm from one side of each *Erythroxylum* plant; millet inoculum (5.0 g per plot) was added to the trench and covered with 2 to 3 cm of soil. Four plots were infested with millet formulations of each fungal isolate, and seven control plots were infested with the sterilized millet formulation. In the second infestation method, millet inoculum was applied directly to the soil surface of each research plot approximately 10 cm from one side of each row of plants (5.0 g per plot). The millet inoculum was protected from predation with a mesh screen. Fungal treatments were replicated twice, and control treatments were replicated three times using this infestation protocol. After soil infestation, plants were watered with trickle irrigation.

Plants in infested and noninfested soil were evaluated for disease after 4, 7, 8, 9, 10, and 15 months. Individual plants were rated for disease severity on a scale of 0 to 2, where 0 = no disease, 1 = wilt, and 2 = plant death. Vascular tissue from both symptomatic and asymptomatic plants was cultured directly on Komada's medium.

Growth-chamber inoculations and host-range experiments. Millet formulations of each strain of *F. oxysporum* also were used to infest soil in environmental growth-chamber studies (12 h of light per 12 h of dark photoperiod; 30°C day, 28°C night). Thirty-centimeter pots of pasteurized greenhouse soil containing 6-month- to 1-year-old plants were infested by drilling three 10-cm holes in the soil equidistant from the base of each plant and placing 10 colonized millet seeds in each hole. Six pots containing *Erythroxylum* plants and six pots containing tomato plants were infested with each of the *F. oxysporum* isolates from Hawaii (strains Ec1-3 and En1-4) and with strain SA1 from a diseased *Erythroxylum* plant from South America. Control treatments consisted of soil infested with sterilized millet formulations, nontreated soil, and soil infested with a millet formulation of *F. oxysporum* f. sp. *lycopersici*. Each plant received 80 to 100 ml of water per day dispensed by an automatic sprinkle watering system and was fertilized with Peter's general purpose fertilizer (Peter's Fertilizer Products, Fogelsville, PA) when leaves showed signs of chlorosis. Plants were evaluated visually for disease weekly and were maintained for a period of 3.5 months. Stem tissue from 5 cm above the soil line was collected from all plants at the termination of the test and cultured on Komada's medium.

The host ranges of strains En4, Ec2, and SA1 were evaluated on 26 plant species in environmental growth chambers. Host species included *Hordeum vulgare* (cv. Gallatin), *Phaseolus vulgaris* (cv. Bush Blue Lake), *Beta vulgaris* (cv. Burpee's Red Ball), *Cucumis melo* var. *cantalupensis* (cv. Burpee's Hybrid), *Daucus carota* subsp. *sativus* (cv. Toudo Hybrid), *Capsicum annuum* (cv. Super Chile), *Zea mays* (cv. Sakota), *Gossypium barbadense* (cv. LA860518), *Vigna unguiculata* (cv. Mississippi Silver), *Cucumis sativus* (cv. Burpee's Hybrid II), *Lactuca sativa* (cv. Tango), *Abelmoschus esculentus* (cv. Clemson Spineless), *Allium cepa* (cv. Yellow Sweet Spanish), *Pisum sativum* (cv. Alaska), *Arachis hypogaea* (variety not specified), *Cucurbita moschata* (cv. Triple Treat), *Raphanus sativus* (cv. Plum Purple), *Oryza sativa* (cv. Lemont), *Carthamus tinctorius* (variety not specified), *Sorghum bicolor* (cv. 1210), *Glycine max* (cv. Hartz Variety H4464), *Helianthus annuus* (cv. Sunspot), *Lycopersici esculentum* (cv. Burpee's Early Pick), *Citrullus lanatus* (cv. Bush Sugar Baby), *Triticum aestivum* (cv. Neeley), and *E. coca*. All test species, except *Erythroxylum*, were exposed to the pathogens by planting pregerminated seeds in infested soil. Due to slow seed germination, *Erythroxylum* seedlings were wounded by cutting off approximately 30% of the root tissue and transplanted into pots containing infested soil. Wounded and nonwounded control plants were transplanted into soil amended with sterile rice grains. Tomato seeds and *E. coca* seedlings also were planted in soil that had been infested previously with *F. oxysporum* f. sp. *lycopersici*.

Hosts were randomized within treatments, with some limitations due to plant growth patterns. Treatments consisted of five plants of each species replicated twice. Conditions in the growth chambers and disease evaluations were as previously described. At the termination of the experiment, one arbitrary plant from each treatment was assessed for the presence of *Fusarium* by plating crown tissue on Komada's medium.

Determination of vegetative compatibility groups. Nitrogen nonutilizing auxotrophs were selected from wild-type strains of En4, En3, En1, Ec2, Ec3, and SA1 (4). Auxotrophs were paired in all combinations to determine vegetative compatibility among the *Erythroxylum* isolates.

DNA extraction and PCR amplification. DNA was isolated from fresh mycelial cultures of *F. oxysporum*, using a modification of the method of Doyle and Doyle (9). Specifically, mycelia were harvested from a 50-ml culture of PDB, transferred to a sterile 50-ml centrifuge tube, and lyophilized overnight. The dried mycelia were ground and resuspended in 3 ml of DNA extraction buffer (2% cetyltrimethylammoniumbromide, 20 mM EDTA, 0.1 M Tris [pH 8.0], 1.4 M NaCl without 2-mercaptoethanol). The extractions were incubated at 65°C for 4 to 24 h and extracted twice with an equal volume of chloroform/isoamyl alcohol (24:1, vol/vol). DNA was precipitated with a 0.67 volume of isopropanol, air-dried, and resuspended in 1 ml of dH_2O.

The DNA was amplified in a 50-µl reaction mixture containing 1× Promega reaction buffer (without $MgCl_2$), 3.0 mM $MgCl_2$, 0.2 mM each dNTP, 5 pM primer, 5 to 50 ng of genomic DNA, and 1 unit of *Taq* polymerase (Promega, Madison, WI) overlaid with mineral oil. Amplifications were performed in a Perkin Elmer/Cetus (Norwalk, CT) thermocycler model 480 programmed for 45 cycles of 94°C for 1 min, 35°C for 1 min, and 72°C for 1 min, followed by a final extension at 72°C for 10 min. DNA from isolates En1, En3, En4, Ec2, Ec3, and SA1 was amplified with six 10-base random amplified polymorphic DNA primers (AC08, AC17, AD04, AD08, AD14, and AD18) (5,6,13). In addition, DNA was amplified with two primers derived from minisatellite sequences (primer $(GACA)_4$ [5′-GACA GACA GACA GACA] and primer $(GTG)_5$ [5′-GTG GTG GTG GTG GTG GTG]) (10). Primers were obtained from Operon Technologies (Alameda, CA). PCR products were visualized by UV-fluorescent

staining with ethidium bromide (16). Amplification reactions were repeated a minimum of three times.

RESULTS

Field inoculations. The first symptoms of disease on *Erythroxylum* plants were leaf drop and the deaths of a few lower stems. Plant death was recorded 7 weeks after soil infestation. The period of time between initial symptoms and plant death was variable, ranging from days to months. The average disease ratings of plants grown in soil infested with *F. oxysporum* were significantly higher than the disease ratings of the control plants in both field experiments (Table 1). The mean disease rating from the subsurface and surface infestations were not significantly different. Strain En4 was the most virulent isolate in both studies. *F. oxysporum* was recovered routinely from both symptomatic and asymptomatic plants from infested plots, as well as from symptomatic plants from control plots.

Table 1. Comparison of the effects of surface and subsurface field infestations on the pathogenicity of seven isolates of *Fusarium oxysporum* f. sp. *erythroxyli* to *Erythroxylum* spp.

	Disease severity[z]		
Isolate	**Subsurface**	**Surface**	**Mean**
Control	0.74	0.65	0.71 a
Ec3	0.84	1.23	0.97 b
En2	1.00	1.15	1.05 bc
En3	1.08	1.08	1.08 b–d
En1	1.44	0.68	1.18 cd
Ec1	1.35	1.05	1.25 de
Ec2	1.26	1.28	1.27 de
En4	1.46	1.30	1.41 e
Mean	1.10 A	1.03 A	

[z] Average disease ratings of *Erythroxylum* plants in soil infested with a subsurface application (four replications per fungal treatment and eight replications per control treatment) or a surface application (two replications per fungal treatment and four replications per control treatment) of *F. oxysporum.* Disease ratings are averages of 7-, 8-, 9-, 10-, and 15-month readings. Disease was rated on a scale of 0 to 2, where 0 = no symptoms, 1 = wilt symptoms, and 2 = death. Numbers in columns or rows followed by the same letter are not significantly different according to Student's least significant difference test (LSD = 0.1931) at $P = 0.05$.

Table 2. Disease severity in *Erythroxylum coca* and *E. novogranatense* plants grown in field soil infested with *Fusarium oxysporum* f. sp. *erythroxyli* isolates

	Disease rating[z]	
Treatment	***E. coca***	***E. novogranatense***
Control	0.86 b	0.56 a
Ec3	1.12 c–e	0.81 ab
En1	1.17 de	1.20 de
En2	1.22 e	0.88 bc
En3	1.22 e	0.93 b–d
Ec1	1.25 e	1.25 e
Ec2	1.57 f	0.97 b–e
En4	1.67 f	1.15 c–e
Mean	1.22 A	0.93 B

[z] Average disease ratings of *E. coca* or *E. novagranatense* plants at 7, 8, 9, 10, and 15 months after soil infestation with *F. oxysporum.* Disease was rated on a scale of 0 to 2, where 0 = no symptoms, 1 = wilt symptoms, and 2 = death. Numbers in columns or rows followed by the same letter are not significantly different according to Student's least significant difference test (LSD = 0.2720) at $P = 0.05$.

The mean disease rating of *E. coca* plants was significantly higher than the mean disease rating of *E. novogranatense* (Table 2). The disease ratings of *E. coca* plants treated with *F. oxysporum* were significantly higher than the disease ratings of nontreated plants, indicating that all seven isolates were pathogenic to *E. coca*. The average disease ratings of *E. novogranatense* plants treated with six of the seven *F. oxysporum* strains were significantly higher than the control (Table 2). The disease rating of *E. novogranatense* plants treated with strain Ec3 was not significantly different from the disease rating of the control. For four of the six strains that were virulent on both *Erythroxylum* species, the average disease rating on *E. coca* was higher than the average disease rating on *E. novogranatense.* The average disease rating of control *E. coca* plants in the naturally infested field was higher than the average disease rating of control *E. novogranatense* plants.

Differences in the progression of the disease on *E. coca* and *E. novogranatense* also were apparent (Fig. 1). At the 7-month evaluation, 43% of the *E. coca* plants treated with *F. oxysporum* had died, whereas only 30% of the *E. novogranatense* plants had died. Dead *Erythroxylum* plants were not observed in any of the control plots at this time. Disease progression remained constant in the treated plots over the next three evaluations (at 8, 9, and 10 months). However, during this time, disease incidence rapidly progressed within the control plots. At the 10-month evaluation, 43% of the control *E. coca* plants and 38% of the control *E. novogranatense* plants had died. The percentage of treated plants that had died increased to 63% for *E. coca* and 50% for *E. novogranatense*. At the final disease evaluation, 94% of all *E. coca* plants had died, whereas only 49% of all *E. novogranatense* had died.

Growth-chamber inoculations. In contrast to field results, severe disease was not observed in the growth-chamber pathogenicity studies. For example, in initial studies in which *Erythroxylum* seedlings were exposed to the pathogen after transplantation, only two of six *E. coca* plants died after treatment with strain En4 (data not shown). External wilt symptoms were not observed on the remaining plants. However, at the termination of the experiment, discoloration was observed in the vascular tissues. Similar results were obtained for the other strains. Wilt or vascular discoloration was not observed in *Erythroxylum* plants grown in noninfested soil.

Transplantation into infested soil was a more effective means of inoculating *Erythroxylum* plants in growth-chamber studies. *Erythroxylum* plants began showing characteristic wilt symptoms 3 weeks after transplantation. Early symptoms rapidly developed into severe wilt and death. Disease symptoms were observed in *Erythroxylum* plants transplanted into soil infested with strains En4, Ec2, and SA1 but were not observed in transplants in noninfested soil. The symptoms observed in these diseased *Erythroxylum* plants were identical to the wilt symptoms observed in the field. *F. oxysporum* was recovered from all diseased tissue and was morphologically indistinguishable from strains of *F. oxysporum* recovered from field isolations.

Host range. With the exception of *Erythroxylum*, symptoms of *Fusarium* wilt were not observed on any of the host plants infested with *F. oxysporum* strain En4, Ec2, or SA1. *F. oxysporum* was recovered from

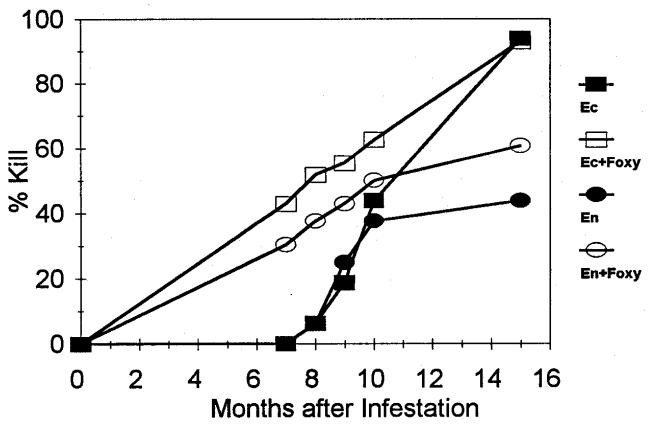


Fig. 1. Progression of Fusarium wilt disease in treated and control plots of *Erythroxylum coca* and *E. novogranatense*.

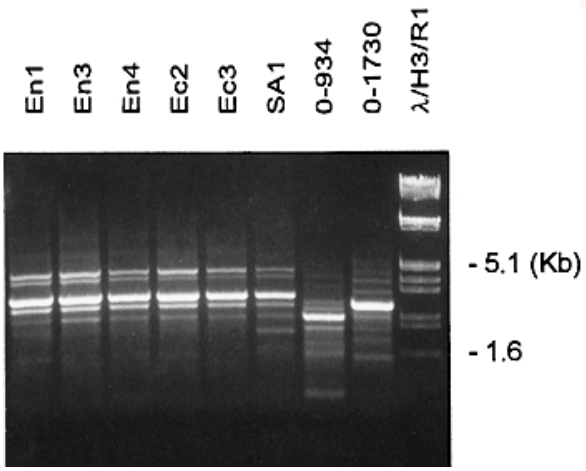


Fig. 2. Arbitrarily primed polymerase chain reaction fingerprints for isolates of *Fusarium oxysporum* f. sp. *erythroxyli* (Hawaiian strains Ec2-3, En1, and En3-4 and South American strain SA1), *F. oxysporum* f. sp. *capsici* (strain 0-934), and *F. oxysporum* f. sp. *niveum* (strain 0-1722) primed with random amplified polymorphic DNA primer AD14 (5′-GAACGAGGGT). DNA size markers (lambda DNA cut with restriction enzymes *Hin*dIII and *Eco*RI) are indicated in kilobase pairs to the right.

the crown of most plants seeded in infested soil. Wilt symptoms were observed in tomato plants seeded in soil infested with *F. oxysporum* f. sp. *lycopersici* but were not observed in *Erythroxylum* transplants in *F. oxysporum* f. sp. *lycopersici*-infested soil.

Vegetative compatibility and DNA analysis. Strains of *F. oxysporum* from Hawaii were vegetatively compatible with each other and with South American strain SA1. Arbitrarily primed-PCR with any of the eight selected primers did not discriminate between the Hawaiian isolates and the South American isolate (Fig. 2; data not shown). The *Erythroxylum* isolates of *F. oxysporum* could be distinguished from *F. oxysporum* f. sp. *capsici* strain 0-1722 and *F. oxysporum* f. sp. *niveum* strain 0-934 by seven of the eight arbitrary primers.

DISCUSSION

Few diseases of *Erythroxylum* have been described (12). However, *Fusarium* spp. were listed as a cause of wilt in *Erythroxylum* in a report on major diseases of plants in Peru (8). In our study, *F. oxysporum* was isolated from *Erythroxylum* plants showing severe wilt symptoms at a research station in Hawaii. The pathogenicity of the isolates of *F. oxysporum* to *E. coca* and *E. novogranatense* was verified in field and growth-chamber studies. Host-specificity studies did not reveal any pathogenicity outside the host genus, although the fungus could grow as a saprophyte on many nonhost plants. Saprophytic survival of these pathogens on nonhost plants is a well-documented phenomenon and contributes to the soil longevity of the pathogen (3). The pathogenicity and novel host range indicate that the pathogen is a distinct forma specialis of *F. oxysporum*, hereafter referred to as *F. oxysporum* f. sp. *erythroxyli*.

Significant differences in the field pathogenicity of the Hawaiian strains to *E. coca* and *E. novogranatense* were observed. South American isolate SA1 was not tested in field experiments. The fungus was highly aggressive and was disseminated rapidly throughout the original infested field. The initial progression of the disease was more pronounced in infested plots than in the control plots. However, containment of the fungus proved challenging, as evidenced by late development of disease in control plots (Fig. 1). These late infections could have resulted from resident *F. oxysporum* f. sp. *erythroxyli* populations or from the movement of the introduced pathogen throughout the field.

Koch's postulates were confirmed in growth-chamber studies. Disease incidence was higher under field conditions than under growth-chamber conditions. Environmental factors, such as temperature fluctuations, water stress, soil type, and interactions with other soil organisms, may influence the activity and survival of the pathogen or disease progress and severity. For example, wilt symptoms were more pronounced in the field after a period of drought. Drought conditions were not experienced under growth-chamber conditions.

Molecular analyses and vegetative compatibility studies of the *F. oxysporum* f. sp. *erythroxyli* strains indicated that the Hawaiian and South American isolates were closely related. The most apparent difference between the Hawaiian strains and the South American strain was colony pigmentation on PDA. The vegetative compatibility and genetic similarity of the Hawaiian isolates and strain SA1 suggest that the Hawaiian pathogens may have originated from the South American transplants used to establish the Hawaiian plantation.

ACKNOWLEDGMENTS

We thank J. Antognini and L. Christy, formerly of the Weed Science Laboratory, BARC, for their encouragement in the early stages of this research and J. Jessell and R. Hohne for their contributions in the preparation of the manuscript.

LITERATURE CITED

1. Barnett, H. L., and Hunter, B. B. 1987. Illustrated Genera of Imperfect Fungi. Macmillan Publishing Company, New York.
2. Brayford, D. 1993. The identification of *Fusarium* species. Pages 1-119 in: Workshop Manual. International Mycological Institute. CAB International, Wallingford, England.
3. Burgess, L. W. 1981. General ecology of the fusaria. Pages 225-235 in: *Fusarium*: Diseases, Biology, and Taxonomy. P. E. Nelson, T. A. Toussoun, and R. J. Cook, eds. The Pennsylvania State University Press, University Park, PA.
4. Correll, J. C., Klittich, C. J. R., and Leslie, J. F. 1987. Nitrate nonutilizing mutants of *Fusarium oxysporum* and their use in vegetative compatibility tests. Phytopathology 77:1640-1646.
5. Crowhurst, R. N., Hawthorne, B. T., Rikkerink, E. H. A., and Templeton, M. D. 1991. Differentiation of *Fusarium solani* f. sp. *cucurbitae* races 1 and 2 by random amplified polymorphic DNA. Curr. Genet. 20:391-396.
6. Crowhurst, R. N., King, F. Y., Hawthorne, B. T., Sanderson, F. R., and Choi-Pheng, Y. 1995. RAPD characterization of *Fusarium oxysporum* associated with wilt of angsana (*Pterocarpus indicus*) in Singapore. Mycol. Res. 99:14-18.
7. Darlington, L. 1996. History of *Erythroxylum* and notes on diseases and pests at Kauai Field Site. Page 43 in: 1st Int. *Fusarium* Biocon. Workshop. USDA-ARS, Beltsville, MD.
8. de Segura, C. B. 1959. Principales Enfermedades de las Plantas en el Perú. Fitopatógia de las Estaciones Experimentales Agricolas de las Asociaciones de Agriculturas de Cañete e I. C. A. y del Comité de Defensa Técnica del Algodonero de la Sociedad Nacional Agraria, Cañete, Perú.
9. Doyle, J. J., and Doyle, J. L. 1987. A rapid DNA isolation procedure for small quantities of fresh tissue. Phytochem. Bull. 19:11-15.
10. Freeman, S., and Rodriguez, R. J. 1995. Differentiation of *Colletotrichum* species responsible for anthracnose of strawberry by arbitrarily primed PCR. Mycol. Res. 99:501-504.
11. Komada, H. 1975. Development of a selective medium for quantitative isolation of *Fusarium oxysporum* from natural soil. Rev. Plant Prot. Res. 8:114-124.
12. Lentz, P. L., Lipscomb, B. R., and Farr, D. F. 1975. Fungi and diseases of *Erythroxylum*. Phytologia 30:350-368.
13. Manulis, S., Kogan, N., Reuven, M., and Ben-Yephet, Y. 1994. Use of the RAPD technique for identification of *Fusarium oxysporum* f. sp. *dianthi* from carnation. Phytopathology 84: 98-101.
14. Nash, S. M., and Snyder, W. C. 1962. Quantitative estimations by plate counts of propagules of the bean root rot *Fusarium* in field soils. Phytopathology 52:567-572.
15. Nelson, P. E., Toussoun, T. A., and Marasas, W. F. O. 1983. *Fusarium* Species: An Illustrated Manual for Identification. Pennsylvania State University Press, University Park, PA.
16. Sambrook, J., Fritsch, E. F., and Maniatis, T. 1989. Molecular Cloning: A Laboratory Manual. Cold Spring Harbor Laboratory Press, Cold Spring Harbor, NY.

ERRATUM / Volume 81, Number 5, 1997

In the article "Characterization of a vascular wilt of *Erythroxylum coca* caused by *Fusarium oxysporum* f. sp. *erythroxyli* forma specialis nova" by D. C. Sands, E. J. Ford, R. V. Miller, B. K. Sally, M. K. McCarthy, T. W. Anderson, M. B. Weaver, C. T. Morgan, A. L. Pilgeram, and L. C. Darlington, the affiliation for L. C. Darlington should be: Weed Science Laboratory, USDA, ARS, Beltsville, MD 20705.

ANNEX 134

United States Environmental Protection Agency,
GLYPHOSATE – Report of the
Hazard Identification Review Committee (20 Apr. 1998)

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

64 IA
012586
12

DATE: April 20, 1998

OPP OFFICIAL RECORD
HEALTH EFFECTS DIVISION
SCIENTIFIC DATA REVIEWS
EPA SERIES 361

OFFICE OF
PESTICIDES AND TOXIC
SUBSTANCES

MEMORANDUM

SUBJECT: ***GLYPHOSATE*** - Report of the Hazard Identification Assessment Review Committee.

FROM: William Dykstra, Toxicologist. William Dykstra 4/20/98
Registration Action Branch 1
Health Effects Division (7509C)
and
Jess Rowland, Executive Secretary 4/20/98
Hazard Identification Assessment Review Committee
Health Effects Division (7509C)

THROUGH: K. Clark Swentzel, Chairman, K. Clark Swentzel 4/21/98
Hazard Identification Assessment Review Committee
Health Effects Division (7509C)
and
Mike Metzger, Co-Chairman
Hazard Identification Assessment Review Committee 4/21/98
Health Effects Division (7509C)

TO: Melba Morrow, Branch Senior Scientist
Registration Action Branch 1
Health Effects Division (7509C)

PC Code: 417300

On March 26, 1998, the Health Effects Division's Hazard Identification Assessment Review Committee evaluated the toxicology data base of **GLYPHOSATE,** re-assessed the Reference Dose (RfD) established in 1992 as well as the toxicological endpoints selected for acute dietary and occupational/residential exposure risk assessments. The HIARC also addressed the potential enhanced sensitivity of infants and children from exposure to glyphosate as required by the Food Quality Protection Act (FQPA) of 1996. The Committee's conclusions are presented in this report.

Printed on Recycled Paper

Committee Members in Attendance

Members present were: Mike Metzger (Co-Chairman), Clark Swentzel (Chairman), Bill Burnam, Sue Makris, Melba Morrow, Karen Hammernik, Karl Baetcke, Robert Fricke, John Redden, and Jess Rowland (Executive Secretary) . Member(s) in absentia: None. Data was presented by William Dykstra of the Registration Action Branch 1.

In attendance was also Julianna Cruz of Registration Action Branch 1.

Data Presentation:
and
Report Presentation

William Dykstra.
Toxicologist

Report Concurrence:

Jess Rowland
Executive Secretary

I. INTRODUCTION

On March 26, 1998, the Health Effects Division's Hazard Identification Assessment Review Committee evaluated the toxicology data base of Glyphosate, re-assessed the Reference Dose (RfD) established in 1992 as well as the toxicological endpoints selected for acute dietary and occupational/residential exposure risk assessments. The HIARC also addressed the potential enhanced sensitivity of infants and children from exposure to glyphosate as required by the Food Quality Protection Act (FQPA) of 1996.

II. HAZARD IDENTIFICATION

A. Acute Reference Dose (RfD)

Study Selected: None §

MRID No.: None

Executive Summary:

Dose and Endpoint for Risk Assessment: Not Applicable

Comments about Study/Endpoint: A review of the rat and rabbit developmental studies did not provide a dose or endpoint that could be used for acute dietary risk purposes. Additionally, there were no data requirements for acute or subchronic rat neurotoxicity studies since there was no evidence of neurotoxicity in any of the toxicology studies at very high doses and glyphosate lacks a leaving group. Therefore, it would not seem likely to inhibit esterases, which is the presumptive neurotoxic mechanism of concern for all organophosphates.

Uncertainty Factor (UF): None

This Risk Assessment is **NOT** required.

B. Chronic RfD

Study Selected: Rabbit Developmental study § 83-3(b)

MRID No.: 00046363

Executive Summary: Groups of 16/dose Dutch Belted rabbits were dosed with technical glyphosate at doses of 0, 75, 175, or 350 mg/kg/day between gestation days 6 to 27. Maternal effects were seen at only the high dose and consisted of diarrhea, nasal discharge and death [10/16]. Developmental effects were not seen at any dose tested. Therefore, the NOEL and LOEL for maternal toxicity were 175 mg/kg/day and 350 mg/kg/day, respectively.

Dose and Endpoint for Establishing RfD: NOEL = 175 mg/kg/day based on death, diarrhea, and nasal discharge at 350 mg/kg/day (LOEL).

Uncertainty Factor(s): 100 (10 x for interspecies extrapolation and 10 x for intraspecies variation).

$$\textbf{Chronic RfD} = \frac{\text{175 mg/kg/day (NOEL)}}{\text{100 (UF)}} = \textbf{2.0 mg/kg/day}$$

Comments about Study/Endpoint/Uncertainty Factor: The NOEL for maternal toxicity in the rabbit developmental study was the lowest NOEL of all the major studies which include the 24-month mouse carcinogenicity study [NOEL = 750 mg/kg/day], the 1-year dog study [NOEL = 500 mg/kg/day], 2-year chronic/onco rat study [NOEL = 400 mg/kg/day], 2-generation rat reproduction study [NOEL = 500 mg/kg/day] and rat developmental study [NOEL = 1000 mg/kg/day]

This risk assessment is required.

C. Occupational/Residential Exposure

1. Dermal Absorption

Dermal Absorption Factor: A dermal absorption factor is not applicable since dermal risk assessments are not required.

2. Short-Term Dermal - (1-7 days)

Study Selected: None §

MRID No.: None

Executive Summary: None

Dose and Endpoint for Risk Assessment: Not Applicable.

Comments about Study/Endpoint:. No systemic or dermal toxicity was seen following repeated dermal applications of technical glyphosate at 0, 100, 1000 or 5000 mg/kg/day, 6 hours/day, 5 days/week for three consecutive weeks to male and female New Zealand rabbits. The NOEL was 1000 mg/kg/day and the LOEL was 5000 mg/kg/day based on decreased food consumption in females [MRID No. 00098460]. In addition, the use of a 3% dermal absorption rate (estimated) in conjunction with the oral NOEL of 175 mg/kg/day established in the rabbit developmental study yields a dermal equivalent dose of > 5000 mg/kg/day.

This risk assessment is **NOT** required.

3. Intermediate-Term Dermal (7 Days to Several Months)

Study Selected: None

MRID No.: None

Executive Summary: None

Dose/Endpoint for Risk Assessment: Not Applicable

Comments about Study/Endpoint: See short term

This risk assessment is **NOT** required.

4. Long-Term Dermal (Several Months to Life-Time)

Study Selected: None

MRID No.: None

Executive Summary: None

Dose and Endpoint for Risk Assessment: Not Applicable

Comments about Study/Endpoint:. See short term

This risk assessment is **NOT** required.

5. Inhalation Exposure (Any Time period).

Study Selected: None

MRID No.: None

Executive Summary: None

Dose/Endpoint for Risk Assessment: Not Applicable

Comments about Study/Endpoint: Based on the low toxicity of the formulation products (Toxicity Category III or IV) and the physical characteristics of the technical product (wetcake) there is minimal concern for potential inhalation exposure or risk. The acute inhalation study was waived for technical glyphosate.

This risk assessment is **NOT** required.

D. Recommendation for Aggregate Exposure Risk Assessments

There are no registered residential uses at the present time. Therefore, aggregate exposure risk assessments will be limited to food + water.

III. CLASSIFICATION OF CARCINOGENIC POTENTIAL

1. Combined Chronic Toxicity/Carcinogenicity Study in Rats

Executive Summary : Randomized groups of 60/sex/dose Sprague-Dawley rats were fed glyphosate at dietary levels of 0, 2000, 8000, or 20,000 ppm [male: 0, 89, 362, or 940 mg/kg/day; female: 0, 113, 457, or 1183 mg/kg/day]. The NOEL was 8000 ppm [362 mg/kg/day for males and 457 mg/kg/day for females] and the LOEL was 20,000 ppm [940 mg/kg/day for males and 1183 mg/kg/day for females] based on decreased weight gain in females, decreased urinary pH in males, increased incidence of cataracts and lens abnormalities in males, and increased absolute and relative liver weight in males. The carcinogenic potential was negative.

MRID No. 41643801

Discussion of Tumor Data: The study showed a slightly increased incidence of pancreatic islet cell adenomas in the low and high dose males; hepatocellular adenomas in the low and high dose males; and thyroid C-cell adenomas in the mid and high dose males and females. The Agency concluded that these adenomas were not treatment-related and glyphosate was not considered to be carcinogenic in this study. The pancreatic islet cell adenomas did not display a positive dose-trend in their occurrence; there was no progression to carcinoma and the incidence of pancreatic hyperplasia was not dose-related. The hepatocellular adenomas were not statistically significant by pair-wise comparison; the incidence was within the range of historical controls; there was no progression to carcinoma and the hyperplasia was not compound-related. The C-cell adenomas were statistically significant by pair-wise comparison and were not dose-related; there was no progression to carcinoma and there was no significant dose-related increase in severity or incidence of hyperplasia in either sex.

Adequacy of the Dose Levels Tested: The highest dose tested was the limit dose of 20,000 ppm in both sexes.

2. Carcinogenicity Study in Mice

Executive Summary: Randomized groups of 50/sex/dose CD-1 mice were fed glyphosate in the diet for 2 years at doses of 0, 1000, 5000, or 30,000 ppm [0, 150, 750, or 4500 mg/kg/day]. The systemic NOEL was 5000 ppm and the LOEL was 30,000 ppm based on decreased weight gain in both sexes, hepatocyte necrosis and interstitial nephritis in males and increased incidence of proximal tubule epithelial basophilia and hypertrophy in females. The carcinogenic potential was negative.

MRID No. 00130406, 00150564

Discussion of Tumor Data The incidence in males of renal tubular adenomas, a rare tumor, was 1, 0, 1, and 3 in the control, low, mid, and high dose groups, respectively. Although the trend was significant, there was no statistical significance by pairwise comparison of the control and high dose group. The incidence at the high dose exceeded the occurrence of historical controls from the testing laboratory. The non-neoplastic findings in the male kidney did not occur in a increased dose-related manner and the tumorigenic findings in the kidney were considered to occur by chance rather than as a result of treatment.

Adequacy of the Dose Levels Tested: The highest dose tested [30,000 ppm] exceeded the limit dose of 7000 ppm for both sexes of mice.

3. Classification of Carcinogenic Potential The OPP Cancer Peer Review Committee classified glyphosate as a "Group E " pesticide [no evidence for carcinogenicity in two acceptable species].

IV. FQPA CONSIDERATIONS

1. Neurotoxicity:

There were no data requirements for acute or subchronic rat neurotoxicity studies since there was no evidence of neurotoxicity in any of the toxicology studies at very high doses and glyphosate lacks a leaving group. Therefore, it would not seem likely to inhibit esterases, which is the presumptive neurotoxic mechanism of concern for all organophosphates.

2 Developmental Toxicity

In a prenatal developmental toxicity study , pregnant Sprague-Dawley rats received oral administration of glyphosate (98.7%) in 0.5% aqueous methocel at 0, 300, 1000 or 3500 mg/kg/day during gestation days 6 through 19. For maternal toxicity, the NOEL was 1000 mg/kg/day and the LOEL was 3500 mg/kg/day based on diarrhea, decreased mean body weight gain, breathing rattles, inactivity, red matter around the nose and mouth, and on forelimbs and dorsal head, decreases in total implantations/dam and inviable fetuses/dam, and death (24% of the group). For developmental toxicity, the NOEL was 1000 mg/kg/day and the LOEL was 3500 mg/kg/day based on increased number of litters and fetuses with unossified sternebrae, and decreased mean fetal body weights (MRID # 00046362).

In a prenatal developmental toxicity study, pregnant New Zealand white rabbits received oral administration of glyphosate (98.7%) in 0.5% aqueous methocel at 0, 75, 175 or 350 mg/kg/day during gestation days 6 through 27. For maternal toxicity, the NOEL was 175 mg/kg/day and the LOEL was 350 mg/kg/day based on diarrhea, nasal discharge, and death (62.5% of does died by gestation day 21). Developmental toxicity was not observed at any dose tested. For developmental toxicity, the NOEL was ≥ 175 mg/kg/day (insufficient litters were available at 350 mg/kg/day to assess developmental toxicity) (MRID # 00046363).

3. Reproduction Toxicity

In a three-generation reproduction study, Sprague-Dawley rats received diets containing glyphosate at 0, 3, 10 or 30 mg/kg/day for three generations. For parental systemic toxicity, the NOEL was 30 mg/kg/day (highest dose tested). The only effect observed was an increased incidence of focal tubular dilation of the kidney (both unilateral and bilateral combined) in the high-dose male F_{3b} pups. However, this effect (focal tubular dilation of the kidneys) was not observed at the 1500 mg/kg/day level in a 2-generation rat reproduction study discussed below. Therefore, the OPP Developmental Peer Review Committee concluded that the effect seen in the three generation study was a spurious rather than glyphosate-related effect. No reproductive or offspring toxicity was observed; NOELs was ≥30 mg/kg/day (MRID # 00105995).

In a two-generation reproduction study, Sprague-Dawley rats received diets containing glyphosate at 0, 2000, 10,000 or 30,000 ppm for two generations. Treatment-related effects observed at 30,000 ppm included soft stools, very frequent, in the F_0 and F_1 males and females, decreased food consumption and body weight gain of the F_0 and F_1 males and females during the growth (premating) period, and decreased body weight gain of the F_{1a}, F_{2a} and F_{2b} male and female pups during the second and third weeks of lactation. Focal tubular dilation of the kidneys, observed in the 3-generation study, was not observed at any dose level in this study. Based on the above findings, the parental and developmental (pup) NOEL's are 500 mg/kg/day and the parental and developmental (pup) LOEL's are 1500 mg/kg/day. The reproductive toxicity NOEL is ≥1500 mg/kg/day (MRID # 41621501).

4. Additional information from the literature No studies were available

5. Determination of Susceptibility

The data provided no indication of increased susceptibility of rats or rabbits to *in utero* and/or postnatal exposure to glyphosate. In the prenatal developmental toxicity study in rats, developmental toxicity was seen in the presence of maternal toxicity at the highest dose tested. No developmental toxicity was seen in the rabbits. In reproductions toxicity studies, effects in the offspring were observed only at or above treatment levels which resulted in evidence of parental toxicity.

6. Recommendation for a Developmental Neurotoxicity Study

i. Evidence that suggest requiring a developmental neurotoxicity study:

There was no evidence to suggest that a developmental neurotoxicity study was needed.

ii. Evidence that do not support a need for a developmental neurotoxicity study: Rat and rabbit developmental studies and 2-generation rat reproduction study.

7. Determination of the FQPA Safety Factor:

The application of an FQPA factor for the protection of infants and children from exposure to glyphosate required by FQPA, will be determined during risk characterization by the FQPA Safety Committee. However, the HIARC, based on hazard assessment, recommends to the FQPA Safety Factor Committee that the additional 10 x factor should be removed because:

(i) The data provided no indication of increased susceptibility of rats or rabbits to in utero and/or postnatal exposure to glyphosate.

(ii) No evidence of developmental anomalies, including abnormalities in the development of fetal nervous system was observed in the pre-and/or postnatal studies.

(iii) The toxicology data base is complete and there are no data gaps.

V. **DATA GAPS** none

VI SUMMARY OF TOXICOLOGY ENDPOINT SELECTION

The doses and toxicological endpoints selected for various exposure scenarios are summarized below.

EXPOSURE SCENARIO	DOSE (mg/kg/day)	ENDPOINT	STUDY
Acute Dietary	None	No toxicological endpoint attributable to a single dose was identified in oral studies including the rat and rabbit developmental toxicity studies.	
	Acute RfD = None		
Chronic Dietary	NOEL = 175 UF = 100	Mortality, diarrhea, and nasal discharge	Developmental - Rabbit
	Chronic RfD = 2.0 mg/kg/day		
Short-, Intermediate and Long-Term (Dermal)	None	No systemic toxic effects seen at doses up to 1000 mg/kg/day in the 21 day dermal toxicity study. Risk assessment is not required.	
Inhalation (Any Time Period)	None	Based on low toxicity of formulations and technical material [wet cake] inhalation study was waived. Risk assessment is not required.	

ANNEX 135

(DOCUMENT INTENTIONALLY OMITTED)

ANNEX 136

United States Department of Agriculture, Agricultural Research Service, *Discovery and Development and Mechanism of Action of Biocontrol Agents for Perennial and Annual Weeds* (1 Oct. 1993 – 30 Sep. 1998)

Back to Display | Exit to Menu | Exit to Home

Brief Format | Standard Tech. Report

Full w/Pub.History

Item No. 1 of 1

ACCESSION NO: 0147936 **SUBFILE:** CRIS
PROJ NO: 1275-22000-147-00D **AGENCY:** ARS 1275
PROJ TYPE: USDA INHOUSE **PROJ. STATUS:** TERMINATED
START: 01 OCT 1993 **TERM:** 30 SEP 1998 **FY:** 1999

INVESTIGATOR: Lumsden, R. D.; Bailey, B. A.; Lewis, J.

PERFORMING INSTITUTION:
BELTSVILLE AGR RES CENTER
BELTSVILLE, MARYLAND 20705

DISCOVERY DEVELOPMENT AND MECHANISM OF ACTION OF BIOCONTROL AGENTS FOR PERENNIAL AND ANNUAL WEEDS

OLD PRIMARY CLASSIFICATION				
RPA	ACTVTY	CMMDTY	SCNCE	PRCNT
205	4600	2800	0712	010
205	4600	2800	0914	010
205	4600	2800	1112	010
209	4700	2800	0712	010
209	4700	2800	1112	060

OLD PRIMARY HEADINGS: A4600 . Protection Against Diseases, Parasites; C2800 . Miscellaneous and New Crops; F0712 . Microbiology-Plant; R205 . Disease Control-Fruit, Vegetables; F0914 . Nutrition and Metabolism-Other; F1112 . Pathology-Plant; A4700 . Protection Against Weeds; R209 . Weed and Hazard Control-Field Crops

NEW CLASSIFICATION			
RPA	SUBJECT	SCIENCE	PRCNT
212	2221	1103	10
212	2221	1010	10
212	2221	1160	10
213	2221	1103	10
213	2221	1160	60

NEW HEADINGS: R212 . Diseases and Nematodes Affecting Plants; S2221 . Narcotic plants; F1103 . Other microbiology; F1010 . Nutrition and metabolism; F1160 . Pathology; R213 . Weeds Affecting Plants

SPECIAL CLASSIFICATION AND HEADINGS
S2821 . Narcotic Plants -- 100%
PST1 . Target I - Biology -- 050%
PST2 . Target II - Nonpesticidal Control -- 030%

BASIC 020% **APPLIED** 070% **DEVELOPMENTAL** 010%

OBJECTIVES: Develop natural herbicides from microorganisms for use against annual and perennial weeds, including narcotic plants. Determine epidemiology and infection processes to optimize disease development through improved fermentation, formulation and delivery systems. Determine mechanism of action in order to enhance biological activity by manipulation of microbe nutrition or by strain selection.

APPROACH: Selected microorganisms, especially fungi such as those causing wilt diseases and root rots, will be obtained from areas with indigenous weed target plants. Koch's postulates will be performed and factors favoring rapid disease development will be determined. Methods will be devised to grow biomass in liquid fermentors and formulate biomass in a form that can be delivered by aerial application. The mode of action will be determined and means for tagging the microorganism for field or plant part detection will be devised with use of modern methods of microbial physiology, biochemistry and molecular biology.

KEYWORDS: weeds; biological control (weeds); mycoherbicides; phytotoxins; natural substances; plant diseases; mechanism of action; biological activity; microorganisms; microbial pathogens; fungi; narcotic plants; aerial application; disease detection

PROGRESS: 1998/01 TO 1998/09
1. What major problem or issue is being resolved and how are you resolving it? The Agricultural Research Service has been charged with the development of control strategies for narcotic crops, including biological control measures. Biological control strategies have potential advantages over chemical control strategies including specificity, low environmental impact, and in some cases, long term control. Extensive research must be carried out to determine the mode of action involved in the biocontrol strategy, to determine the impact of the environment on the biocontrol strategy, to determine the impact of the biocontrol strategy on the environment, and to develop the biocontrol strategy for large scale application. **2. How serious is the problem? Why does it matter?** The illegal use of narcotics derived from the plant species Erythroxylum coca (coca), Papaver somniferum (opium poppy) and Cannabis sativa (marijuana) is pervasive throughout society in the US and around the world. The cost of the illegal use of narcotics to our society in both monetary and human terms is staggering. The monetary loss in the US alone is estimated at $70 billion with 14,000 deaths annually (1997 National Drug Control Strategy, 1997). **3. How does it relate to the National Program(s) and National Component(s) to which it has been assigned?** This project is directly related to the National Program 304 "Crop & Commodity Pest Biology, Control and Quarantine" and 303 "Plant Diseases." Biocontrol of narcotic plants is directly related to both biocontrol of disease and biocontrol of weeds. The fermentation and formulation technologies developed are transferable to both areas. Pathogens related to those being studied have and are being

considered for biocontrol of weeds in many situations. Related organisms are also being considered for control of plant disease. The basic research carried out contributes to the science of plant pathology by increasing our understanding of disease processes and mechanisms of plant-pathogen interactions. **4. What were the most significant accomplishments this past year?** Bioherbicides, which include among other organisms plant pathogenic fungi, are being developed as potential control measures for opium poppy. Two fungi, Pleospora papaveracea and Dendryphion penicillatum were evaluated in 1997 field test in Beltsville, MD. The fungi were of local origin. These initial field tests were designed to identify road blocks limiting the use of these two fungi as bioherbicides for the control of illegal opium poppy production. In addition, the environmental factors which influence disease development in opium poppy by Pleospora papaveracea and Dendryphion penicillatum were evaluated and optimum conditions were determined. A formulation of Fusarium oxysporum pathogenic to coca was developed (Biodac). The formulation produces extensive secondary spores and remains viable for at least 10 months. **5. Describe the major accomplishments over the life of the project including their predicted or actual impact?** . The BPDL has been very successful in developing a biocontrol strategy for Erythroxylum coca (Bailey et al., 1997a). This has included developing the pathogen Fusarium oxysporum f. sp. erythroxyli isolate EN-4 through fermentation and formulation of biomass, and field testing, resulting in a defined biocontrol strategy ready for scale-up and deployment. A liquid fermentation technique was developed which produced a stable chlamydospore preparation (Hebbar et al., 1997) suitable for incorporation into granular formulations (Hebbar et al., 1998). The growth media consist of readily available and inexpensive agricultural byproducts (Hebbar et al., 1996). In addition to the use of available formulation processes, a new formulation was developed which has good storage characteristics. Field tests of the various formulations showed they were excellent at infesting soil with high populations of the pathogen and causing enhanced disease development in coca fields (Bailey et al., 1997b). The fungus remains in the soil at detectable levels for months after treatments (Bailey et al., 1997b). Treatment of diverse soil types with the formulations results in the establishment of similar populations of the pathogen (Bailey et al., 1997b). Temperature and moisture conditions for optimum formulation performance were also defined (Fravel et al., 1996). A protein which causes necrosis of coca leaves and other dicots was identified, purified (Bailey 1995) and has been cloned from F. oxysporum f. sp. erythroxyli isolate EN-4. The protein is produced in high concentrations in liquid culture by many different F. oxysporum isolates as well as some other Fusarium species (Bailey et al., 1997c). In addition to causing necrosis in dicots, the 24 kDa protein induces responses which are characterized as defense responses, including active oxygen production, K+ efflux, and hydrogen peroxide production. The 24 kDa protein has been used to evaluate the sensitivity of coca leaves to stress (Bailey et al., 1997d). This body of work has provided the foundation for more extensive research into biocontrol of narcotic crops and, as directed by Congress, an active effort at implementation of biological control of coca. **6. What do you expect to accomplish, year by year, over the next 3 years?** This project expired 9/30/98. **7. What science and/or technologies have been transferred and to whom? When is the science and/or technology likely to become available to the end user (industry, farmer, other scientists)? What are the constraints if known, to the adoption & durability of the technology product?** All of this research has been made available to the public through publication in refereed scientific journals. This includes fermentation and formulation technologies. The major constraint limiting the use of this technology is that it will require diplomatic consent and active participation of foreign governments. **8. List your most important non-peer reviewed publications and presentations to non-scientific organizations, and articles written about your work(NOTE: this does not replace your peer reviewed publications which are listed below)** . KATZ, L.M. 1998. U.S. funds fungi to kill drug plants. USA Today, October 22, 1998, p. 1. THE ASSOCIATED PRESS 1998.

Researchers test fungus to eradicate drug crops. Frederick Maryland Post.

PUBLICATIONS: 1998/01 TO 1998/09
1. HEBBAR, K.P., LUMSDEN, R.D., LEWIS, J.A., POCH, S.M. and BAILEY, B.A. 1998. Formulation of mycoherbicidal strains of Fusarium oxysporum. Weed Sci. 46:501-507.
2. CONNICK, JR., W.J., DAIGLE, D.J., et al. 1998. Preparation of stable, granular formulations containing Fusarium oxysporum pathogenic to narcotic plants. Biol. Control 13:79-84.
3. NELSON, A.J., APEL-BIRKHOLD, P.C. and BAILEY, B.A. 1998. Sequence Announcement: GenBank accession #: AF036580. Plant Mol. Biol. 38:911-912.

PROGRESS: 1996/01 TO 1996/12
The primary objective of this research is the development of a bioherbicide for control of illicit Erythroxylum coca cultivation using the plant pathogenic fungus Fusarium oxysporum. Stable granular formulations carrying the coca pathogen have been produced and field tested. The formulations have a long shelf life and are easily applied to the field. Significant kill of E. coca has been observed in the field in Hawaii in response to treatments with several different formulations. Studies of a naturally-occurring epidemic of fusarium wilt in Peru have been concluded which verify that the epidemic is progressing and causing significant disease in the coca producing regions of Peru. Already, the natural epidemic of fusarium wilt in the coca producing areas of Peru is causing farmers to abandon their fields. A protein produced by Fusarium oxysporum which is toxic to E. coca has been purified and its gene cloned. The data indicate that a bioherbicide using F. oxysporum which is effective against coca can be produced and proof of concept field tests are being initiated. Control of E. coca cultivation by this host specific bioherbicide would have direct effects on the availability of cocaine in the United States and around the world and reduce the devastating effects of this drug on society.

PUBLICATIONS: 1996/01 TO 1996/12
1. FRAVEL, D. R., STOSZ, S.K. and LARKIN, R.P. 1996. Effect of temperature, soil type, and matric potential on proliferation and survival of Fusarium oxysporum ... from Erythroxylum coca. Phytopathology 86:236-240.
2. HEBBAR, K.P., LEWIS, J. A., POCH, S.M. and LUMSDEN, R.D. 1996. Agricultural by-products ... substrates for growth, conidiation ... mycoherbicide, Fusarium oxysporum strain EN4. Biocont. Sci. Technol. 6:263-275.
3. HEBBAR, K.P., LEWIS, J. A., POCH, S.M. and LUMSDEN, R.D. 1996. Fermentation and formulation of mycoherbicidal strains of Fusarium oxysporum. Phytopathology 86:S8.
4. BAILEY, B. A., Hebbar. P.K. and LUMSDEN, R.D. 1996. Biocontrol of Erythroxylum coca in the field with a formulation of Fusarium oxysporum f. sp. erythroxyli. Phytopathology 86:S9.
5. NELSON, A. J., Jennings, J.
6. C., Anderson, J.D. and Bailey, B.A. 1996. A 24 kDa elicitor from Fusarium oxysporum: Its molecular structure and the effect of culture conditions on its production. Phytopathology 86:S67.

PROGRESS: 1995/01 TO 1995/12
The primary objective of this research is the development of a bioherbicide for control of illicit Erythroxylum coca cultivation using the plant pathogenic fungus Fusarium oxysporum. Culture conditions have been established for production of biomass for use in formulations suitable for field application and with long term storage capability. At present, significant kill of E. coca has been observed in response to an alginate prill formulation in the field. We have isolated several new isolates of Fusarium oxysporum both pathogenic and nonpathogenic on coca from diseased plants in Peru. Genetic analysis of these isolates suggest that two major strains of

the F. oxysporum pathogenic on coca exist in the upper Huallaga valley and these strains are responsible for the epidemic in progress in this area. A protein produced by F. oxysporum which kills coca leaves has been purified and the gene responsible for its production is being isolated. Present data indicate that an effective biocontrol agent for E. coca can be developed for use in the field. Limiting cultivation of E. coca would have direct effects on the availability of cocaine in the United States and around the world and reduce the devastating effects of this drug on society.

PUBLICATIONS: 1995/01 TO 1995/12

1. BAILEY, B.A. 1995. Purification of a protein from culture filtrates of Fusarium oxysporum that induces ethylene and necrosis in leaves of Erythroxylum coca. Phytopathology 85:1250-1255.
2. BAILEY, B.A. 1995. Production of a 24 KDA elicitor from Fusarium oxysporum by fungal isolates and its biological activity among plant species. Phytopathology 85:1144.

PROGRESS: 1994/01 TO 1994/12

Mycoherbicides are being considered as an alternative to other methods for the control of narcotic crops. Identification of pathogens specific for target plant species is required for development of a mycoherbicide. A bioassay was designed for screening Fusarium oxysporum isolates for their pathogenicity on coca (Erythroxylum coca). Conditions were optimized for biomass production of F. oxysporum to be used in mycoherbicides for control of coca. Formulations were prepared from the biomass using various food substrates for determination of their potential as a mycoherbicide. The ecology of how mycoherbicides perform in the environment is being studied. The optimum temperature for proliferation of F. oxysporum in soil was estimated to be 25 C. The interaction between coca and F. oxysporum is being investigated. A protein which kills coca leaves was purified from filtrates of a F. oxysporum pathogenic to coca. The protein was partially sequenced and antibodies are being prepared against the protein. The development of an effective mycoherbicide for the control of narcotic crops would enhance our capabilities to reduce the influx of illegal narcotics into the United States of America and would limit their devastating effects on our society.

PUBLICATIONS: 1994/01 TO 1994/12

No publications reported this period.

PROGRESS: 1993/10 TO 1993/12

Biocontrol of coca using pathogenic fungi is being considered as an alternative to conventional eradication methods. A method for identifying fungi pathogenic to coca was developed. The method requires limited time (four to ten weeks) and space. The method requires the wounding of coca roots, which then are soaked in solutions of fungal spores. The plants are then grown under conditions optimal for disease development. Fungi pathogenic on coca have been identified from soil and plant samples using this method. The method will be used as a standard check for evaluating disease development in coca after treatment with various fungal formulations. A dependable method for identifying fungi pathogenic on coca is required to develop an effective biocontrol strategy. This method will be used by ARS and other scientists to identify fungi pathogenic on coca and other woody perennial plants. This work will aid scientists in identifying biocontrol agents for woody perennial plants as well as the development of control methods for diseases on woody perennial plants. The ultimate goal of eliminating cocaine production through bicontrol methods will greatly benefit society.

PUBLICATIONS: 1993/10 TO 1993/12

No publications reported this period.

CRIS SUPPLEMENTARY DATA: **Region:** 1 **Process Date:** 1998/06/19 **Progress Update:** 2000/02/23

ANNEX 137

United States Department of Agriculture, Agricultural Research Service, *Mechanisms of Microbial-Plant Interactions Related to Biocontrol of Weeds and Narcotic Plants* (1 Oct. 1993 – 30 Sep. 1998)

CURRENT RESEARCH INFORMATION SYSTEM/USDA

ACCESSION NO: 0147447 SUBFILE: CRIS ITEM: 1 of 1
PROJ NO: 1275-22000-145-00D AGENCY: ARS 1275
PROJ TYPE: USDA INHOUSE PROJ. STATUS: TERMINATED
START: 01 OCT 1993 TERM: 30 SEP 1998 FY: 1998

INVEST: Anderson, J. D.

PERFORMING INSTITUTION:
BELTSVILLE AGR RES CENTER
BELTSVILLE, MARYLAND 20705

MECHANISMS OF MICROBIAL-PLANT INTERACTIONS RELATED TO BIOCONTROL OF
WEEDS AND NARCOTIC PLANTS

PROGRESS: 1998/01 TO 1998/09
1. What major problem or issue is being resolved and how are you resolving it? The growing of illicit drug plants represents a major sociological problem for the United States. Currently, one drug producing country uses the non-persistent and environmentally benign herbicide, glyphosate, for controlling the cocaine producing plants, coca, and the morphine (which is converted to heroine) producing plant, poppy. A different strategy would be to use a biological control agent that is specific for the targeted plant. In this way, one might be able to control the target with a single application for years to come, instead of having to constantly retreat fields with herbicide. This would also be more environmentally friendly in that just target plants are affected. 2. How serious is the problem? Why does it matter? Drug production acreage is increasing in South America. Interdiction is very expensive and does not work to keep illicit drugs outside our borders. The use of narcotic drugs is responsible for most of the violent crime that is committed in the US. Reducing the amount of narcotics coming into the US would drive up the price and make it harder to purchase these products. Illicit use of narcotics is taking its toll on the very moral fabric of the US. 3. How does it relate to the National Program(s) and National Component(s) to which it has been assigned? National Program 303 - Plant Diseases (30 percent) - Biological Control. Determining factors influencing efficacy of biological control agents against opium poppies. National Program 304 - Crop and Commodity Pest

Biology, Control, and Quarantine (70 percent) - Investigation of Pest Biology and Development of new and improved pest control technologies. Research emphasis is on understanding mechanisms of how target plants and microbes interact and mechanisms of microbe recognition by the plant. 4. What were the most significant accomplishments this past year? A collaborative field research project using a disease causing organism (Dendryphion sp.) isolated from poppy plants grown at BARC was carried out. This organism shows promise as a possible biological control organism against poppy. A protein produced from the fungus, Fusarium oxysporum, that causes a wilt disease in poppy was isolated previously. This protein, when applied to a variety of weeds was found to induce cellular necrosis in the leaves. This research should lead to development of new natural herbicides 5. Describe the major accomplishments over the life of the project including their predicted or actual impact? . A fungal enzyme, endoxylanase, was found to induce (elicit) the synthesis of the plant hormone, ethylene, and induce death of cells in sensitive plants. A single gene was responsible for sensitivity. This research lead to subsequent findings that the disease causing organism specific for coca (Fusarium oxysporum f.sp. erythroxyli)as well as other isolates of this species, produce a protein that elicits plant responses similar to that of the xylanase. However, the Fusarium protein elicits responses in many broad leafed plants, but not grasses. This protein is active on many different weed species. An F. oxysporum isolate specific for causing disease in poppy was demonstrated to infect and kill poppy seedlings. This isolate also produces the biologically active protein described above. Other collaborative field research using another disease causing organism, Dendryphion sp., isolated from poppy plants grown at BARC, shows promise as a possible biological control organism against poppy. This research concerning biological control of poppies could have tremendous impact on the War on Drugs. This is not used at the current time. The research concerning the protein could lead to new understanding on how microbes interact with plants. These research findings are being used by the scientific community, particularly those scientists involved in plant/microbe interactions. 6. What do you expect to accomplish, year by year, over the next 3 years? We plan to do field studies to obtain information on the efficacy of the potential biocontrol agent (Dendryphion). Also, we will initiate research into how the fungal protein induces responses in plant leaf tissue and to determine if this could be useful as a contact-type natural herbicide. 7. What science and/or technologies have been transferred and to whom? When is the science and/or technology likely to become available to the end user (industry, farmer, other scientists)? What are the constraints if known, to the adoption & durability of the technology product? The research is in a relatively early stage of development. There are many questions

that need to be formulated in order to make the fungal protein and potential biocontrol agents useful. 8. List your most important non-peer reviewed publications and presentations to non-scientific organizations, and articles written about your work(NOTE: this does not replace your peer reviewed publications which are listed below) .

PUBLICATIONS: 1998/01 TO 1998/09

1. BAILEY, B. A., AVNI, A. and ANDERSON, J.D. 1995. The influence of ethylene and tissue age on the sensitivity of xanthi tobacco leaves to a Trichoderma viride xylanase. Plant and Cell Physiology 36:1669-1676.
2. NELSON, A.J., JENNINGS, J.C., ANDERSON, J. D., and BAILEY, B.A. 1996. A 24 KDA elicitor from Fusarium oxysporum: Its molecular structure and the effect of culture conditions on its production. Phytopathology 86:S67.
3. JENNINGS, J.C., BAILEY, B. A., and ANDERSON, J.D. 1996. Physiological responses of various weeds to a protein elicitor from Fusarium oxysporum. Weed Science Society of America Abstracts 36:236.
4. JENNINGS, J.C., BAILEY, B. A., and ANDERSON, J.D. 1996. Induced responses of various weed leaves to a protein elicitor from Fusarium oxysporum. Plant Physiology (suppl) 111:309.

ANNEX 137

Accession No. 0147447
Agency ARS
Div.Station Code 1275
Project No. 1275-22000-145-00D
Investigators Anderson, J. D.
Title MECHANISMS OF MICROBIAL-PLANT INTERACTIONS RELATED TO BIOCONTROL OF WEEDS AND NARCOTIC PLANTS
Process Date 2000/02/23
Progress Period 1996/01 |t 1996/12
Progress Herion abuse is an increasing problem in the United States. Current methods to stop the flow of illicit drugs into this county are not very effective. An approach of eradicating the narcotic plant at the site of production using commercial herbicides or new biological control organisms seems to be an alternative. The eradication of undesirable plants without the use of applying synthetic herbicides is the goal of biological control. Fusarium oxysporum is a fungus that causes a wilt disease of poppy. The majority of young opium poppy plants grown in a growth chamber, die of this disease within three weeks of inoculating the soil with the organism. We are trying to optimize methods to determine if this has good potential for a biological control agent against opium poppy. This research is of interest to the U.S. Department of State, the U.S. Drug Enforcement Administration and the scientific community.
Publications BAILEY, B. A., AVNI, A. and ANDERSON, J.D. 1995. The influence of ethylene and tissue age on the sensitivity of xanthi tobacco leaves to a Trichoderma viride xylanase. Plant and Cell Physiology 36:1669-1676.
Publications NELSON, A.J., JENNINGS, J.C., ANDERSON, J. D., and BAILEY, B.A. 1996. A 24 KDA elicitor from Fusarium oxysporum: Its molecular structure and the effect of culture conditions on its production. Phytopathology 86:S67.
Publications JENNINGS, J.C., BAILEY, B. A., and ANDERSON, J.D. 1996. Physiological responses of various weeds to a protein elicitor from Fusarium oxysporum. Weed Science Society of America Abstracts 36:236.
Publications JENNINGS, J.C., BAILEY, B. A., and ANDERSON, J.D. 1996. Induced responses of various weed leaves to a protein elicitor from Fusarium oxysporum. Plant Physiology (suppl) 111:309.

Accession No.	0147447
Process Date	1997/03/07
Progress Period	1994/01 |t 1994/12
Add'l. Publs.	00
Data Length	1071
Progress	The eradication of undesirable plants without the use of herbicides is a goal ofbiological control. A research project to study the biocontrol of the opium poppy was initiated. To begin, we obtained 12 strains of Fusarium oxysporum that were thought to be specific pathogens of poppy. However, the strains were not very aggressive in causing disease of poppy in growth chamber experiments. Culture filtrates of these strains did induce low levels of hypersensitive-like responses (e.g., ethylene biosynthesis) in poppy leaves. Attempts were made to isolate and identify components responsible for inducing the hypersensitive-type responses. Results with tomato indicate there is a single gene on chromosome 7 that gives sensitivity to the fungal ethylene biosynthesis inducing xylanase elicitor. These results with elicitors are useful to the scientific community to understand how plants interact with microbes. Such an understanding could lead to the development of new strategies for the biocontrol of undesired plants.
Publications	MOREAU, R.A., POWELL, M.J., WHITAKER, B.D., BAILEY, B.A. and ANDERSON, J.D. 1994. Xylanase treatment of plant cells induces glycosylation and fatty acylation of phytosterols. Plant Physiol. 91:575-580.
Publications	AVNI, A., BAILEY, B.A, MATTOO, A.K. and ANDERSON, J.D. 1994. Induction of ... accumulation of 1-aminocylopropane-1-carboxylic acid (ACC) synthase and ACC oxidase transcripts. Plant Physiol. 106:1049-1055.
Publications	AVNI, A., AVIDAN, N., ESHED, Y., ZAMIR, D., BAILEY, B.A., STOMMEL, J.R. and ANDERSON, J.D. 1994. The response of lycopersicon esculentum to ... is controlled by a single dominant gene. Plant Physiol. 105(S):872.

ANNEX 137

Accession No.	0147447
Process Date	1995/03/07
Progress Period	1993/10 |t 1993/11
Add'l. Publs.	00
Data Length	0657
Progress	Research on the mechanism of how microbes induce plant defense responses were carried out. A fungal xylanase induced rapid changes in sterol lipids as well as induced production of new transcripts involved in defense-like responses involved in ethylene biosynthesis, e.g., ACC synthase and ACC oxidase. The results of this research will be used by the scientific community to understand how fungi interact with plants to cause disease like symptoms in plant tissues. Understanding the signal transduction mechanism of such responses could lead to the development of new understanding and strategies for the biocontrol of undesired plants.
Publications	ANDERSON, J., et al. 1993. Fungal xylanase elicits ... responses in tobacco. pp. 197-204. IN: J.C. Pech, et al. (eds). Cellular & molecular ... of plant hormone ethylene. Kluwer Publ., Dordrecht, The Netherlands.
Publications	SHARON, A., FUCHS, Y. and ANDERSON, J.D. 1993. The elicitation of ethylene biosynthesis by a Trichoderma xylanase is not related to the cell wall degradation activity of the enzyme. Plant Physiol. 102:1325-1329.
Publications	TAYLOR, R., INAMINE, G. and ANDERSON, J.D. 1993. Tissue printing as a tool for observing immunological and protein profiles in young and mature celery petioles. Plant Physiol. 102:1027-1031.
Publications	BAILEY, B., KORCAK, R. and ANDERSON, J. 1993. Sensitivity to an ethylene biosynthesis-inducing endoxylanase in Nicotiana tabacum cv xanthi is controlled by a single dominant gene. Plant Physiol. 101:1081-1088.
Publications	MOREAU, R., POWELL, M., BAILEY, B., WHITAKER, B., NORMAN, H. and ANDERSON, J. 1993. Xylanase treatment of plant cells induces glycosylation & fatty acylation of phytosterols. Plant Physiol. (Suppl)102:529.
Publications	BAILEY, B., AVNI, A., et al. 1993. The influence of ethylene on induction of ACC synthase & ACC oxidase in Nicotiana tabacum cv xanthi by an ethylene inducing

xylanase from Trichoderma viride. Plant Physiol.

ANNEX 138

Ron Collins, Agronomist, Weed Science Laboratory,
Agricultural Research Service, United States Department of Agriculture,
Glyphosate Aerial Application to Control Erythroxylum sp. In Colombia: Spray Droplet Evaluation, Draft (23 Dec. 1998)

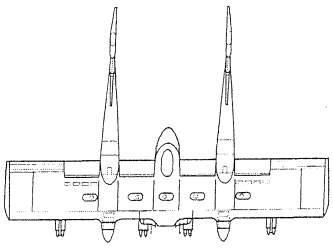
ANNEX 138

Glyphosate Aerial Application to Control *Erythroxylum* sp. in Colombia: Spray Droplet Evaluation

Ron Collins, Agronomist

Weed Science Laboratory
Agricultural Research Service, U.S. Department of Agriculture
Beltsville, Maryland 20705

DRAFT



December 23, 1998

DRAFT

present. The results were then reported as total glyphosate deposited per unit area, at that point on the swath width. The sum of glyphosate deposited, as measured by chemical analysis, gives an accurate estimate of glyphosate reaching the coca plant, across the swath laid out by calibration cards, and under the specific calibration run conditions (weather, plane altitude, etc.).

Results

Problems of Spray Droplet Analysis

For coca spray calibrations, significant problems with using these cards ensued. This was because the cards dried slowly (due to the usual high humidity in the tropics), yet we needed to collect them quickly after a spray pass (to minimize the time between each aircraft pass). Consequently, it was much more difficult to use the cards for direct calculation of swath widths.[4]

The two drift-control agents (Cosmo-Flux 411F and Protrol/Nalcotrol II) are organic. As a spray droplet that contains a drift-control agent dries on the water-sensitive card, an "organic ring" forms around the edge of the drop. Inside of the drop, small organic drops condense. The organic ring and internal organic drops result in an erroneous droplet size analysis. By adjusting the exposure of the optical lens that is used to read water-sensitive cards, the effect of these artifacts (i.e., the rings and internal drops) can be eliminated. In the process of adjusting the exposure, the smaller droplets are underrepresented. Correcting droplet analyses of Protrol-containing solutions is much more difficult than for mixtures that contain only Cosmo-Flux 411F or Nalcotrol II. It

[4] The droplets analysis cards taken in the Guaviare were not usable for droplet analysis because of droplet smearing.

DRAFT

was found that in humid environments such as San Jose del Guaviare, the degree of exposure adjustment necessary to minimize the effect of the organic ring for Protrol resulted in minimal effective swaths. This was not the case for Cosmo-Flux 411F or Nalcotrol II. This is important for two reasons. First, because of the problem discovered with Protrol, there were no droplet analyses of any glyphosate + Protrol samples from San Jose del Guaviare. INL had conducted several tests at Patrick AFB, utilizing water-sensitive cards with and without Nalcotrol II.[5] Initially, it was decided not to use these analyses because the height of aircraft at the time of application was 75 ft. I analyzed one-third of them and a graduate student did the remainder. After comparing the glyphosate-only between San Jose del Guaviare and Patrick AFB, I determined that there was no difference between the two. The results indicate that the effective swath width was the same for both 75- and 100-ft flight altitudes, but the total swath width was greater at 100 ft. This allowed a comparison of glyphosate, with and without Nalcotrol II, for the OV-10. Inexplicably, the graduate student's analyses were overexposed to such a degree that all estimated spray volumes were greatly decreased and, therefore, of no use. This created a problem because I analyzed no water-sensitive cards from a T-65 test done at San Jose Del Guaviare by Greg Smith. Consequently, our data set is much smaller for the T-65 than for the OV-10 airplane.

The volume rate sprayed was set at 2.5 gallons per acre (GPA). However, the first test at San Jose del Guaviare was at 5.0 GPA, for the T-65 (due to a miscommunication). There were three runs: one with no drift control agent, one with Cosmo-Flux 411F, and

[5] I was told that there was very little difference between Protrol and Nalcotrol II. After the droplet analysis problem with Protrol, I contacted Helena Chemical Co.. They said that Protrol had nonionic surfactants (organic) than Nalcotrol II.

DRAFT

one with Protrol. The second San Jose test, done the following day, used two runs (each at 2.5 GPA), one with Protrol and the second, with no drift control agent. As mentioned earlier, I was unable to analyze cards from the Protrol treatment. This left us with one analysis set for the T-65. Consequently, I compared the 5 GPA and the 2.5 GPA rates for the T-65 aircraft. There was no difference in the effective swath width, even though the droplets were somewhat smaller for the 2.5 GPA than for the 5.0 GPA. Again, I was not able to use the analysis of cards containing Protrol. Due to the similarity, I was able to include the cards from the T-65 test at San Jose del Guaviare utilizing 5 GPA.

Individual analyses for each test are included in Appendix I. The use of these analyses in order to calculate effective swath width is included in Table 1. The determination of effective swath is based upon WSL/ARS research at our tropical U.S. field site: there I found that 1 lb/acre [1.12 kg/ha] acid equivalent (a.e.) glyphosate, used with my best surfactant system, was sufficient to make coca nonproductive. The spray solution used for coca eradication in Colombia contains 3.5 lb/acre (ae) [3.8 kg/ha] glyphosate. Any calibration card that showed deposits equivalent to 0.75 GPA (from a nominal application rate of 2.5 GPA) or 1.5 GPA (from an application rate of 5.0 GPA) is considered part of an effective swath. A "sub-effective-rate card" found between two "effective-rate cards" was considered effective, i.e., it was included when calculating the overall effective spray swath width.

ANNEX 139

United States Department of Agriculture, Agricultural Research Service,
Strategies for Controlling Narcotic Plant Production
(30 Sep. 1995 – 29 Sep. 2000)

Back to Display | Exit to Menu | Exit to Home
Brief Format | Standard Tech. Report
Full w/Pub.History

Item No. 1 of 1

ACCESSION NO: 0149774 **SUBFILE:** CRIS
PROJ NO: 1275-22000-146-00D **AGENCY:** ARS 1275
PROJ TYPE: USDA INHOUSE **PROJ. STATUS:** NEW
START: 30 SEP 1995 **TERM:** 29 SEP 2000 **FY:** 1999

INVESTIGATOR: HELLING C S; COLLINS R T; JOHNSON E L; LYDON J

PERFORMING INSTITUTION:
BELTSVILLE AGR RES CENTER
BELTSVILLE, MARYLAND 20705

STRATEGIES OF CONTROLLING NARCOTIC PLANT PRODUCTION

OLD PRIMARY CLASSIFICATION				
RPA	ACTVTY	CMMDTY	SCNCE	PRCNT
209	4700	2800	1312	100

OLD PRIMARY HEADINGS: A4700 . Protection Against Weeds; C2800 . Miscellaneous and New Crops; F1312 . Physiology-Plant; R209 . Weed and Hazard Control-Field Crops

NEW CLASSIFICATION			
RPA	SUBJECT	SCIENCE	PRCNT
216	2221	1140	100

NEW HEADINGS: R216 . Integrated Pest Management Systems; S2221 . Narcotic plants; F1140 . Weed science

SPECIAL CLASSIFICATION AND HEADINGS
S2821 . Narcotic Plants -- 100%

BASIC 040% **APPLIED** 060% **DEVELOPMENTAL** 000%

OBJECTIVES: 1) Evaluate and refine herbicide-adjuvant-carrier systems for controlling narcotic plant production; 2) determine environmental fate of pesticides and their environmental impact in conjunction with narcotic crop eradication; 3) elucidate biochemical or physiological responses to herbicide systems as related to illicit plant control; 4) determine genetic, environmental and management parameters that control alkaloid content in narcotic plants.

APPROACH: 1) Evaluate folar-, basal-, and soil-applied herbicides in greenhouse and field tests; 2) determine environmental transport and dissipation in soils, and biological effects in water of selected herbicides; 3) determine glyphosate uptake and translocation rates in coca; 4) determine herbicide uptake and translocation rates in coca, poppy, and cannabis; 5) determine long term effects of narcotic plant management and genetics on yield and alkaloid levels.

KEYWORDS: NARCOTIC PLANTS ERYTHROXYLUM HERBICIDES ALKALOIDS ENVIRONMENTAL FATE PAPAVER CANNABIS WEEDS

PROGRESS: 1999/01 TO 1999/09
1. What major problem or issue is being resolved and how are you resolving it? Illicit narcotic drugs represent a huge societal problem. One approach toward mitigation is reducing the supply of drug-producing crops (mainly coca, opium poppy, and marijuana) at their source, both within the U.S. and abroad. This requires development of eradication methods that are effective under a wide range of conditions, which are environmentally acceptable to the host countries. Selected herbicides are effective, but additional research is needed toward verifying their field effectiveness, improving their efficacy, increasing the options available for their use, and defining the environmental risks associated with implementing their use. Accurate identification of illicit coca and poppy species/varieties is needed in order to identify trends in production and to better predict potential cocaine (from coca) and opium (from poppy) yield. This problem is being addressed through chemical- and genetic-based means. **2. How serious is the problem? Why does it matter?** Drug abuse is a very serious, long-term health problem, not simply for the individual abuser, but for society, which bears much of its costs. Furthermore, of the estimated (1997) $150 billion total cost of drug use in the U.S., almost 70 percent is attributable to the costs of crime. No single approach can eliminate drug use and abuse, but supply reduction is a critical partner with demand reduction, attacking on the problem. Drug crop production, processing, and distribution is contributing greatly to political destabilization within one major Western Hemisphere country, currently receiving $289 million for counter drug assistance and is proposed for much larger aid. Ecological damage to the rainforest and its streams, caused by coca and poppy production is severe and long-lasting. **3. How does it relate to the National Program(s) and National Component(s) to which it has been assigned?** This research contributes to the National Program 304 Crop and Commodity Pest Biology, Control, and Quarantine. This includes finding safe and effective control methods, developing more accurate indicators of cultivar identification, development of new and improved pest control technology. **4. What were the most significant accomplishments this past year?** Ninety percent control of the illicit coca crop directly exposed to aerially-applied herbicide (glyphosate) has been achieved in the Colombian eradication program. The glyphosate herbicide system applied aerially to control coca was modified, based on ARS Beltsville scientists' research, and performance increased substantially. The same ARS research is leading to a more accurate assessment of the programs success by identifying factors to adjust gross treated acreage to true coca area eradicated. Herbicide rates for coca or marijuana control lowered by selective use of adjuvants or carrier systems. ARS testing led to discovery of specific systems that controlled the illicit crops at herbicide rates as small as one-fourth that of the unmodified commercial products. Use of these systems and recommendations by appropriate action agencies will provide more effective coca or marijuana suppression, with reduced cost and less chemical release into the environment. **5. Describe the major accomplishments over the life of the project including their predicted or actual impact.** Adoption and further modification of the glyphosate herbicide system in Colombia has helped boost coca eradication effectiveness from an unacceptable level of about

70-75 percent to 90 percent control or better. This represents a very significant improvement in the program effectiveness, something of great concern for both the Colombian and United States governments. Knowledge of how this was achieved should provide logical avenues for exploring further improvements to control coca and perhaps other narcotic crops. Field environmental research, complementing testing of herbicidal effectiveness, has shown that chemicals are naturally dissipated faster under tropical conditions, reducing their risk to nontarget species. Detailed study of cocaine and associated alkaloids and flavonoids, within coca grown under various environmental conditions, has provided information which is useful for estimating cocaine yield and for more accurate species identification. **6. What do you expect to accomplish, year by year, over the next 3 years?** During FY 2000 and beyond, glyphosate (the currently used coca herbicide) effectiveness will be improved, through refinements in surfactant systems. Research will commence on utilizing new spray nozzle systems and droplet size analyses which will permit more effective application of this herbicide, with less off-target loss and with more accurate characterization; this will require two years. Basic research on droplet size and distribution as they affect herbicide uptake and translocation throughout the plant will be conducted during FY 2001 and FY 2002. In FY 2000, ARS in cooperation with an international partner will test new, solid glyphosate formulations, since these would offer logistical advantages. Research designed to extend the period of opium poppy control will continue in FY 2000, and will be extended to field trials under tropical and temperate conditions. A number of controlled-release formulations have been synthesized and these will be tested. Completion of broad-scale testing is expected by the end of FY 2001, but advanced field testing could not be completed in less than three years. Characterizing the environmental fate of any pesticide proposed for controlling cultivated narcotic plants is a critical research component in the selection and implementation processes associated with drug control strategy. Analyses and evaluation of the fate, in tropical soil, of herbicides proposed for opium poppy control will be carried out, with completion expected by or within FY 2001. New research in FY 2000 is intended to determine degradation rates and pathways for several herbicides that are highly promising alternatives (for coca eradication) to glyphosate, and to identify microorganisms responsible for the herbicide breakdown. Completion will require one to three years, depending on the inherent speed of degradation and on certain technological barriers that must be overcome. Depending upon field success with poppy herbicides, similar laboratory research would be conducted on those in FY 2001 and FY 2002. Environmental studies require advanced instrumentation in order to identify and measure trace amounts of pesticide residue. As a spinoff from this work, basic research will commence in FY 2000 on the use of a new technique, pressurized fluid extraction. This state-of-the-art method will enhance our ability to extract pesticides or other chemicals found in soil or plant tissue. Cannabis (marijuana) eradication by chemical means is well established, but improvements in herbicide technology for conventional agriculture may be transferable into improved control of cannabis. Initial, highly promising research with triclopyr against cannabis will be expanded in FY 2000 and FY 2001 with field testing of several more herbicides. The results will allow more effective and safe control of this drug plant. Accurate identification of narcotic plants, especially coca species/varieties, is important because yield potential (of cocaine, for example) is affected by plant genetics. More precise identification of the plants has intelligence value, to better track and predict regional movement of new plantings. Promising techniques, especially nuclear magnetic resonance (NMR), will be explored further in FY 2000 and beyond, but in combination with genetic fingerprinting. A chemotaxonomic key for coca species, including alkaloid and flavonoid profiles, will require three or more years for completion. Research is planned for FY 2000 and FY 2001to determine whether specific marker compounds exist in poppy and marijuana plants that would distinguish those grown illicitly in Egypt's Sinai region from other geographic areas where these crops are found. This has intelligence value in tracing the origin of the problem cultivation. Asexual reproduction of coca by generation of

callous tissue would benefit basic research on biosynthesis pathways and on herbicide-plant effects. Earlier work failed to produce fully-developed plants from callous tissue, but recently that goal seems attainable. Research will be conducted in FY 2000 and FY 2001 to develop a method for regenerating coca plants through tissue culture. Organic and inorganic tracer chemicals are used to help understand water and solute (such as pesticides) movement into and through soils. A new, but limited, study of the leaching of 8-10 tracers will be conducted in FY 2000, using several Midwestern and Northeastern soils. **7. What science and/or technologies have been transferred and to whom? When is the science and/or technology likely to become available to the end user (industry, farmer, other scientists)? What are the constraints if known, to the adoption & durability of the technology product?** We recommended herbicide system modifications to the U.S. State Department (DOS) and the Government of Colombia (GOC), that were adopted into their coca eradication program. We provided DOS with on-going technical advice on issues of narcotic crop eradication, and on means to estimate program effectiveness. This included interaction with the Central Intelligence Agency (CIA). ARS scientists also served on a bilateral (U.S.-GOC) verification team for on-site determination of the effectiveness of the current coca eradication program in Colombia. They also recommended ways to improve estimations of the program's accuracy and efficiency. ARS conducted research on controlling cannabis at various growth stages, through use of triclopyr herbicide, and documented this in a report requested by the U.S. Drug Enforcement Administration (DEA). DEA will use this report in an Environmental Impact Statement that informs the public about methods used to eradicate cannabis in the U.S. We developed analytical methodology for determining alkaloid content under storage and transferred this information to the DEA. We also provided methodology for flavonoid extraction and identification to ARS scientists conducting human nutrition research on carotenoids. The major hurdle, before adoption of recommended herbicide eradication technologies, is to convince government authorities (in the country of intended use) of the herbicide's safety, to both people and the environment. Legal restrictions on importing unregistered products raise barriers, as well as special testing requirements, even for products produced in-country. "Real world" testing of herbicides on illicit narcotic crops is generally very difficult, besides the legal and political hurdles, due to logistic and security factors. However, such testing is critical to success since results of both efficacy and environmental fate studies are usually needed within the country of proposed use, under those "real world" conditions, for full acceptance of results and recommendations. Herbicide behavior (especially environmental) is not easily predicted solely from laboratory or temperate-zone field research, if the intended use is in the tropics. A severe financial obstacle is the expense of obtaining radiolabeled herbicides for conducting certain specialized research. **8. List your most important non-peer reviewed publications and presentations to non-scientific organizations, and articles written about your work (NOTE: this does not replace your peer reviewed publications which are listed below).** "Herbicides for Drug Crop Eradication", 5th Office of National Drug Control Policy International Technology Symposium, March 8, 1999. Washington, DC. JOYCE, S. Environmental casualties of the war on drugs. Environ. Health Perspectives 107:A74-A77, Feb. 1999.

PUBLICATIONS: 1999/01 TO 1999/09

1. COLLINS, R.T. 1999. Effect of herbicide formulation, adjuvants, and carriers on the effectiveness of triclopyr to control Cannabis sativa. Weed Sci. Soc. Am. 39:96.
2. COLLINS, R.T. and EDMONSTON, J.P. 1999. Control of Cannabis sativa ... triclopyr ... growth stages. IN: Documentation ... Cannabis Eradication ... Hawaii; Supplement ... Impact Statements. DEA, Washington, DC.
3. JOHNSON, E.L. 1999. Flavonoids as chemotaxonomic markers for Erythroxylum ulei. 16th Int. Bot. Congr., p. 388.

4. YUCEL, U., YLIM, M., GOZEK, K., HELLING, C.S. and SARYKAYA, Y. 1999. Chlorpyrifos degradation in Turkish soil. J. Environ. Sci. Health B34:75-95.

PROGRESS: 1998/01/01 TO 1998/09/30

1. What major problem or issue is being resolved and how are you resolving it? Illicit narcotic drugs represent a huge societal problem. One approach toward mitigation is by reducing the supply of drug-producing crops at their sources, both within the U.S. and abroad. This requires development of eradication methods that are effective under a range of conditions, and also that are environmentally acceptable to the host countries. Selected herbicides have been effective, but much additional research is being directed toward improving this control, increasing the options available for their use, and defining the environmental risks associated with implementing those options. **2. How serious is the problem? Why does it matter?** Drug abuse itself is a very serious, long-term health problem, not simply for the individual abuser, but for society, which bears much of its costs. Furthermore, of the estimated $67 billion (low, by some estimates) total cost of drug use in the U.S., almost 70 percent is attributable to the costs of crime. No single approach can eliminate drug use and abuse, but supply reduction is a critical partner with demand reduction, in our attack on the problem. **3. How does it relate to the National Program(s) and National Component(s) to which it has been assigned?** National Program 304 - Crop and Commodity Pest Biology, Control and Quarantine - This program develops effective, but environmentally safe methods of controlling illicit narcotic crops. **4. What were the most significant accomplishments this past year?** Colombia, now the leading source of coca (from which cocaine is derived), is conducting an active eradication program, with U.S. assistance. Based on research supported by this CRIS project, the herbicide formulation used operationally for coca eradication has been modified. **5. Describe the major accomplishments over the life of the project including their predicted or actual impact?** . The change in coca eradication technique we developed has already helped boost effectiveness from an unacceptable level of about 70-75 percent to 90 percent control or better. This represents a very significant improvement program effectiveness, a program that is important for both the Colombian and United States gobernments. Knowledge of how this was achieved should provide logical avenues for exploring further improvements to control coca and perhaps other narcotic crops. **6. What do you expect to accomplish, year by year, over the next 3 years?** The effectiveness of the currently used coca herbicide, glyphosate, will be improved further, through refinements in use of surfactant systems. Research should begin on utilizing new spray nozzle systems and droplet size analyses that will permit more effective application of this herbicide, with less off-target loss and with more accurate characterization of application. Reseearch designed to extend the period of opium poppy control will continue, and be extended to field trials under tropical and temperate conditions. During the past 2 years, a number of controlled-release formulation were synthesized and these will be tested further. Characterizing the environmental fate of any pesticide proposed for controlling cultivated narcotic plants is a critical research component in the selection and implementation processes associated with drug control strategy. Analyses and evaluation of the fate, in tropical soil, of herbicides proposed for opium poppy control will be carried out. New research will begin to determine degradation rates and pathways for several herbicides that are highly promising alternatives (for coca eradication) to glyphosate. Cannabis (marijuana) eradication by chemical means is well established, but improvements in herbicide technology for conventional agriculture may be transferable into improved control of cannabis. Initial, highly promising research with triclopyr against cannabis will be expanded through field testing of several more herbicides. The results will allow more effective and safe control of this drug plant. Accurate identification of narcotic plants, especially coca species/varieties, is important because yield

potential (of cocaine, for example) is affected by plant genetics. Promising techniques, especially nuclear magnetic resonance (NMR), will be explored further, but in combination with genetic fingerprinting. **7. What science and/or technologies have been transferred and to whom? When is the science and/or technology likely to become available to the end user (industry, farmer, other scientists)? What are the constraints if known, to the adoption & durability of the technology product?** Recommendations for herbicide system modifications were provided to the U.S. State Department (DOS) and the Government of Colombia (GOC), and adopted as possible in their coca eradication program. Expert testimony and written technical materials were provided to DOS and GOC for consideration of alternative approaches to coca control. Scientists also served on a bilateral (U.S./GOC) verification team for on-site determination of the effectiveness of the current coca eradication program in Colombia. They also recommended ways to improve the accuracy of these estimates, and the efficiency of the operation. New research results provided to the Drug Enforcement Administration (DEA) were used in an Environmental Impact Statement that informs the public about methods used to eradicate cannabis in the United States. Direct field assistance was also given to DEA and the Government of Egypt in assessing illicit production of opium poppy and cannabis in Egypt, and in finding ways to eradicate these narcotic crops. The major constraint to adoption of recommended technologies is convincing national authorities of their safety, to both people and the environment. Legal restrictions on importing unregistered products raise barriers, as well as special testing requirements even for products produced in the country of intended use. "Real world" testing of herbicides on illicit narcotic crops is generally very difficult, besides the legal and political hurdles, due to logistic and security factors. However, such testing is critical to success since results of both efficacy and environmental fate studies are usually needed within the country of proposed use, under those "real world" conditions, for full acceptance of results and recommendations. Herbicide behavior (especially environmental) is not easily predicted solely from laboratory or temperate-zone field research, if the intended use is in the tropics. **8. List your most important non-peer reviewed publications and presentations to non-scientific organizations, and articles written about your work(NOTE: this does not replace your peer reviewed publications which are listed below)** .

PUBLICATIONS: 1998/01/01 TO 1998/09/30

1. ACOCK, M.C. and JOHNSON, E.L. 1998. Modeling the effects of nitrogen on components of coca yield. J. Plant Nutr. 21:1501-1509.
2. COLLINS, R.T. and HELLING, C.S. 1998. Glyphosate-surfactant-carrier systems for Erythroxylum sp. control. Weed Sci. Soc. Am. Abstr. 38:34.
3. DOHERTY, M.A., HELLING, C.S. and DAWSON, R. 1998. Biochemical toxicology of herbicide mixtures on Thalassiosira weisflogii. 215th Nat. Mtg., Am. Chem. Soc., Abstr. AGRO 013.
4. GISH, T.J., KUNG, K.J.S., HELLING, C.S., DOHERTY, M. and MOJASEVIC, M. 1998. Contaminant transport ... preferential flow: Visualization in 3-D. Am. Geophys. Union (AGU) Spring Mtg., Abstr. H41D-2:S120.
5. HELLING, C.S. 1998. Pesticide environmental fate in tropical regions. 1st Ann. Latin Am. Conf. Contaminated Soil and Water (Quito, Ecuador), Abstr. and Program, p. 57.
6. JOHNSON, E.L., SCHMIDT, W.F. and NORMAN, H. 1998. Flavonoids as markers for Erythroxylum taxa: E. coca var. coca and E. novogranatense var. truxillense. Biochem. Systematics Ecol. 26:743-759.
7. KUNG, K.J.S., GISH, T.J., KLADIVKO, E.J., STEENHUIS, T.S., BUBENZER, G., JAYNES, D. and HELLING, C.S. 1998. Partitioning preferential flow by ... Am. Geophys. Union (AGU) Spring Mtg., Abstr. H41D-3:S120.

8. KUNG, K.J.S., GISH, T.J., STEENHUIS, T.S., KLADIVKO, E.J. and HELLING, C.S. 1998. Partitioning ... flow by sequential application of ... tracers. Abstr. 9th Int. Congr. Pestic. Chem. 2:6D-047.
9. LYDON, J. and DARLINGTON, L. 1998. Herbicide residues in leaves of Erythroxylum coca var. coca plants treated with soil-applied tebuthiuron and hexazinone. J. Environ. Sci. Health B33:581-594.
10. MOJASEVIC, M. and HELLING, C.S. 1998. Time-zero pesticide residue data: recovery, variability and distribution. Abstr. 9th Int. Congr. Pestic. Chem. 2:7C-049.

PROGRESS: 1996/01 TO 1996/12
Cocaine, heroin, and marijuana use is a major societal problem in the USA. Control by interdiction has limited effectiveness in stemming importation of these narcotic drugs. However, a viable approach is source reduction through killing the coca, opium poppy, and cannabis crops that produce those drugs; this is achievable through use of selected herbicides. These must remain effective under a variety of conditions; be safe environmentally; and be acceptable to producer countries. Glyphosate (active ingredient in Roundup) is among the safest such herbicides, but has drawbacks, one being its reduced effectiveness against the major (for cocaine production) coca species, Erythroxylum coca. Research showed that (a) glyphosate in Roundup penetrates E. coca leaves less effectively, but (b) certain surfactants increased glyphosate efficacy, in greenhouse testing. Fundamental studies on coca plants established levels of eight leaf alkaloids, as a function of soil pH; alkaloid composition of flower parts; and identities of flavonoids in cultivated species. Ten herbicides were discovered in greenhouse tests that effectively controlled opium poppy. Direct assistance was provided cooperators on biocontrol research on coca and opium poppy. Biochemical markers were found for monitoring the impact of several herbicides. The results of this research will be used by the U.S. State Dept., U.S. Drug Enforcement Administration and collaborating scientists.

PUBLICATIONS: 1996/01 TO 1996/12
1. ACOCK, M. C., LYDON, J., JOHNSON, E., and COLLINS, R. 1996. Effects of temperature and light levels on leaf yield and cocaine content in two Erythroxylum species. Ann. Bot. 78:49-53.
2. ANDERSON, T.W., MCCARTHY, M.K., PILGERAM, A.P., WEAVER, M. B., et al. 1996. Biological control of Papaver somniferum using Fusarium oxysporum f.sp. papaver.Am. Phytopath. Soc./Mycolog. Soc. Am. Joint Mtg. 86:54.
3. DOHERTY, M.A. and SHELTON, D.R. 1996. Model for describing enhanced rates of biodegradation in soil. Ann. Mtg., Soc. Environ. Toxicol. Chem. 17:289.
4. GISH, T.J., KUNG, K.J.S., HELLING, C. S., GIMENEZ, D. and SHIRMOHAMMADI, A. 1996.Non-equilibrium field-scale pesticide transport: soil cores vs. solution samplers. Agron. 88:26.
5. GLASS, R.L. and JOHNSON, M.B. 1996. Analysis of cuscohygrine in coca leaves by high performance liquid chromatography. J. Liq. Chromatogr. 19:1777-1784.
6. KUNG, K.J. S., JU, S.H. and HELLING, C.S. 1996. Impact of funnel type preferential flow on sampling. Agron. 88:197.
7. MOJASEVIC, M., HELLING, C. S., GISH, T.J. and DOHERTY, M.A. 1996. Persistence of seven pesticides as influenced by soil moisture. J. Environ. Sci. Health B31:469-476.

CRIS SUPPLEMENTARY DATA: **Region:** 1 **Process Date:** 2000/08/14 **Progress Update:** 2000/05/16

ANNEX 140

United States Department of Agriculture,
April 2001 Colombia Coca Eradication Verification Mission Trip Report
(13 June 2001)

Redactions by the Government of the United States of America.
Document obtained by Ecuador through the U.S. Freedom of Information Act.

June 13, 2001

SUBJECT: April 2001 Colombia Coca Eradication Verification Mission Trip Report

TO: File
Alternate Crops and System Laboratory

FROM: (b)(6)

Between April 10, 2001 and May 4, 2001, I was part of the Colombian Coca Eradication Verification mission. The members of the verification team were (b)(6) and . The mission had two goals. First, verify the effectiveness of the herbicide spray solution within the spray swath. Second, evaluate the effectiveness of MDIS to replace on-the-ground-verification. The original planning for the mission took place at Patrick Air force Base between April 9, 2001 and April 11, 2001. The sites to be evaluated were selected at this time. Sites were chosen from a Satloc database containing all spray missions within the sampling period (June 1, 2000 and January 31, 2001). The selection process consisted first of creating datasets containing the missions for a department, i.e. Putumayo. The percent of samples to be sampled were roughly calculated from the Access database supplied by INL/Air Wing. This database would prove to be very useful in later analysis of the verification data. A percent of the missions were selected at random from the database of missions in the department. The process was repeated with smaller percentages selected, until the desired numbers of points were selected. Selected points were eliminated if the spray swath was either less than 100 meters or could not be distinguished from adjourning swaths. The dates of the missions were not taken into account due to limitations of Arcview. The selection continued until points were selected from all the departments where spraying occurred. The selected points with pertinent mission information were entered into an Excel spreadsheet. This spreadsheet is listed in Table 4.

Points were selected the departments of Caqueta, Causasia, Guaviare, Putumayo and Tumaco. The only departments in which spraying occurred that points were not selected were Bolivar and Cauca. Flights during this verification mission were limited because of rain and low cloud cover. Consequently, the Guaviare and Tumaco were not visited. To evaluate spray effectiveness in Causasia the mission was extended. Because of prior commitments, I was not able to extend. For this report, I utilized information collected by the other team members.

Redactions by the Government of the United States of America.
Document obtained by Ecuador through the U.S. Freedom of Information Act.

Effectiveness of Aerial Application within Swath

Eight-two sites were evaluated. Nine of the sites were dropped from the evaluation of the results. Three of the sites were repeat evaluations of the same site. Four of the sites were not randomly selected; the army landed in the sites and we were told to evaluate them. One site, site X, was not considered a site by several of the team member. One site was a half-hectare field, which was pruned immediately after by the husband and wife, who owed the field as soon as the spray plane passed over. This was not typical. Consequently it was treated as an out layer and dropped. The remaining seventy-three sites were utilized for the evaluation of effectiveness within the swath width.

Sites to be evaluated were marked by the lead helicopter. The helicopter flew slowly at tree top level. When the helicopter was fifty feet from the selected point on the spray swath, a smoke grenade was thrown to the ground. This minimized the problem of evaluators rating different fields. The four evaluators [(b)(2)] so as to have the same view. The helicopter flew in low circles around the spray swath until all evaluators had finished rating the swath. The spray swaths were rated in accordance in prior approved protocol between all parties involved. The results for this verification mission are listed in Table 3. The verification results are summarized in Table 1 along with the prior three verification missions.

The question was brought up on how to handle pruning. Of the fields evaluated, only one pruned field had fully recovered, as a result of pruning. All the other fields around it were dead, even though they had been pruned In the majority of the cases, the pruned fields still died. The condition of other fields, which had been pruned but had not died, is typical of fields, which had not received an adequate dosage of herbicide. I do not belief that these fields would have any better control if they had not been pruned. Because of this, I do not believe that pruned fields should be treated differently then non-pruned fields.

There is no definitive information as to when a field has been eradicated, taken out of production. As in the past, I have calculated eradication at several different levels: ≥ 95%, ≥90% and ≥85%. To be consistent with prior missions, I am using 85% as the lower limit of effective control. If a spray swath is ≥85% then is counted as eradicated. The data shows that simple averaging of all individual ratings masks poor application, when the results are variable. One-way to measure the variability of the data is to compare the air swath rating and ≥85% control. The differences between October 1999 and December 1999 were less than 5%. September 2000 was 7% and April 2001 was 10 percent. Those fields in the 70 to 80 % range, which should be counted as not eradicated, could be averaged into eradicated.

For the April 2001 verification mission, the data was analysised four different ways (Table 1). (1) All fields evaluated are included. (2) All fields evaluated are included except for Caucasia. (3) Only fields evaluated for November, December and January, including Caucasia were analysised. (4) Only fields evaluated for December and January, excluding Caucasia. Caucasia accounts for ten percent of the area sprayed in the eight months being evaluated. It would be difficult to justify leaving it out of the

Redactions by the Government of the United States of America.
Document obtained by Ecuador through the U.S. Freedom of Information Act.

evaluation. For the moment, leaving out the Caucasia numbers, but including all other (option 2), there is trend of decreasing of 5% for each evaluation mission (96%, 91%, 85% and 79%). If the CMP numbers are included the percent eradicated is 72% instead of 79%. *The 72% value is the statistically correct number for the April 2001 verification mission.*

Table 1. Comparison of Percent Control from the Air and Ground as wells as Percent of Spray Swaths with three Different levels of Control

Evaluation Date	AIR SWATH RATING(%)	Ground Swath Rating(%)	Overall Rating(%)	Control ≥ 95%	Control ≥90%	Control ≥85%
4/2001[a]	88	97	75	56	73	85
4/2001[b]	81	97	69	51	67	76
4/2001[c]	83	97	71	46	63	72
4/2001[d]	89	97	76	49	69	79
9/2000[e]	92	92	67	20	71	85
12/1999	94	97	78	79	88	91
10/1999	95	97	81	63	89	96

[a] Evaluation includes November, December and January, no Caucasia.
[b] Evaluation includes November , December and January, Caucasia.
[c] Evaluation of all points, Includes CMP operation in Caucasia.
[d] Evaluation of all points, does not include CMP operation in Caucasia.
[e] Evaluation does not include CMP operation in Norte de Santander.

When I first analysised the data, I was very surprised to see the poor control. The overall visual experience, in the field, was that of very good control. The question became what had happened. I started to go through all possible variables to determine the problem. One by one the variables were eliminated. OV-10 and T-65 were not different in the level of control. Aircraft speed was eliminated as a causal agent in the difference in control. The height of the aircraft was eliminated. The bearing of the aircraft when spraying was eliminated. The only variable, which accounted for difference in control, was month of application. I will start at January 2001 and work backwards. All the information by month is listed in Table 2. In January of 2001, all the spraying occurred in Putumayo. The area sprayed accounted for 45.2 percent of the total acreage sprayed during the sampling period. This area was over sampled by 9.7% because the samples represented 54.9% of the spray swaths evaluated. The percent eradicated during this period was 89%. I broke December into two groups: Caucasia and Caqueta/Putumayo. Caqueta/Putumayo account for 15.2 percent of area sprayed. The percent eradicated was 83%. The Caqueta/Putumayo was over sampled by 4.3%. Sixty percent of the area sprayed during the sampling period was in December and January; seventy percent if Caucasia is included. The control during these two periods gave the overall visual impression that the spraying during this period was very effective. Caucasia was sprayed during November 2000 and December 2000. As mentioned earlier, it accounts for 10.1 % of the area sprayed during the sampling period. The percent of the spray fields eradicated was only 40%. Caucasia was over sampled by 8.2%. These three periods account for seventy percent of all spraying during the sampling period. We did not sample in either Tumaco or Guaviare. As a result, no spray missions were evaluated

Redactions by the Government of the United States of America.
Document obtained by Ecuador through the U.S. Freedom of Information Act.

September or October. Only minimal spray swaths were evaluated in either August or November (Caucasia). June and July had very few spray missions. Together, they account for only 5.6% of the total area sprayed. Both June and July were close to being adequately sampled (1.1 and 0.7% over sampling). The question is what could account for the poor control during this period. All the fields evaluated in June were ineffective. Evaluation of incidend reports indicates extreme hostile fire. This combined with the poor weather during this period could account for the poor control. In July, there are no incidences of ground fire in the areas being evaluated, but the weather conditions were marginal. The extreme poor control in June and July severely diminished the effectiveness of the December and January spray missions. If the August, September, October and 2/3 of November had been evaluated, the numbers may have been higher. Collecting the MDIS data was a high priority, the loss of evaluation accuracy was justifiable.

For all intent and purposes the months of August, September and October need to be dropped from the calculation of spraying effectiveness. June and July have such a small impact on the spray numbers that they are not significant. *Consequently, this verification mission can only calculate the effective of the spray mission during the months of November, December and January (85% control without Caucasia, 76% with Caucasia).* I had hoped to calculate the effectiveness of the spray swaths for the year 2000. Because of the limitation of this verification trip, it is not possible to calculate the % eradication for the year 2000 with any accuracy.

MDIS

The assumption at the time of the site selection was that the MDIS swath would be rated prior to the field evaluation of the points. This was not the case. To evaluate the MDIS, first the evaluation of the verification time was studied and then the computer-generated evaluation of the MDIS was evaluated for accuracy. This procedure may have introduced bias into evaluation the accuracy of MDIS.

MDIS has several problems, as it is presently configured. (1) Because of limitations of the MDIS camera in spatial orientation, there existed problems with accurately overlaying Satloc data. The new MDIS cameral should eliminate this problem. (2) The resolution of the camera is such that it was impossible to evaluate individual swaths. (3) The imaging system cannot distinguish between chemical defoliated and handpicked fields. (4) MDIS cannot distinguish between bare fields and pruned fields. (5) MDIS cannot spot dead coca plants with grass. Consequently, MDIS images are taken at 21 to 60 days. With marginal herbicide application, control or lack of control can take a lot longer. These factors could result in inaccurate estimates of the spray effectiveness within the swath width. Increasing the resolution of the camera will eliminate these problems.

The results of (b)(6) MDIS analysis are listed in Table 5. The estimate of overall control was very impressive (78% MDIS vs. 75% for verification team). The estimate for the field analysis (73% MDIS vs. 82% for verification team) differs between MDIS and the verification team. The difference, for the field estimate, is the result of the

Redactions by the Government of the United States of America.
Document obtained by Ecuador through the U.S. Freedom of Information Act.

type of analysis. Overall control is macro (broad detail) while swath analysis is micro (focused detail). MDIS is set up to do macro type of work. It does this type of work extremely well. For MDIS to be effective in verifying the effectiveness within the spray swath, two things are necessary. First, the new MDIS camera will need to match up spatially with Satloc. Second, resolution of the camera will have to be increased to at least 0.1 meters. This would allow MDIS to pick up coca stems among dead plants; prune plants which are dead; etc.

For accurate evaluation of control within the spray swath, the Satloc path will have to be overlaid on the MDIS image. The selected point on the spray swath will have to be visually rated for percent control. In this way, MDIS could be used as a substitute for the verification team. The selection process for spray swaths to be evaluated will need to be the same as before, to insure that the sampling is statistically sound.

Some Observations

One of the important benefits of the verification trips is the collection of intelligence: how healthy are the plants, how are the plants being grown, what material is being used to grow the plants and what is the genetic background of the plants. With the elimination of conventional verification missions, this information needs to be collected by other means.

Two things, which I noticed on this trip, were not good signs. First, I have never seen so many coca nurseries full of seedlings beside eradicated fields. Second, I have never seen so many eradicated fields replanted this quickly after spraying. Obviously, the growers to not think that the spray planes will come back.

In this trip more than one major mission was crammed into a two-week verification trip. This is not the first time that this is done. The MDIS mission should have been a separate mission. As a result of the time that MDIS required there was no flexibility to adjust for weather conditions. Because of this the verification is valid only for the months of November, December and January. The use of the numbers for the year of 2000 is inappropriate.

I would make one recommendation. The best surfactant by far that I have tested is Agrotin. It would be in the best interest of the eradication program to work with the GOC to have formaldehyde removed from the formulation and substituted it at 0.25% v/v for both Cosmos Flux 411F and Cosmos IN D. Furthermore, Roundup Ultra concentration should be increased from 3.44 lb ae/A to 4.0 lb ae/ A. The mixing sheet supplied to us in 1998 indicated that the concentration was 3.53 lb ae/A. Something has happened that the concentration has decreased.

Redactions by the Government of the United States of America.
Document obtained by Ecuador through the U.S. Freedom of Information Act.

Table 2. Summarization of Spray Mission Data by Month for: Number of Missions, Hectares sprayed, Percent Sampled and Over sampling.

Month	Department Sprayed	Number of Spray Mission	Percent of spray missions	Uncorrected ha sprayed	Percent of ha sprayed	Percent sampled	Percent Control	Over/Under Sampling
June	Caqueta	31	2.7	1221	2.6	3.7	3	+1.1
July	Putumayo/Cauca	37	3.2	1440	3.0	3.7	3	+0.7
August	Caqueta/Tumaco/Cauca/Putumayo	113	9.8	4891	10.4	1.2	?	-9.4
September	Caqueta/Putumayo/Tumaco	96	8.4	4718	10.0	0	?	-10.0
Oct-Nov	Guaviare	121	10.5	1667	3.5	0	?	-3.5
Nov-Dec	Caucasia	137	11.9	4758	10.1	18.3	40	+8.2
December	Caqueta/Putumayo/Guaviare	194	16.9	7191	15.2	19.5	83	+4.3
January	Putumayo	419	36.5	21343	45.2	54.9	88.9	+9.7
Totals		**1148**	**99.9**	**47229**	**100**	**101**	**N/A**	

ANNEX 140

Redactions by the Government of the United States of America.
Document obtained by Ecuador through the U.S. Freedom of Information Act.

ANNEX 140

Table 3. Listing of Ratings from the Four Evaluators of Sites Visited by Verification Team for the April 2001 Verification of the Colombian Coca Eradication Program[1]

Plot ID	Department	(b)(6)			(b)(6)			(b)(6)			(b)(6)			Average		
		Aerial Swath Control	Ground Swath Control	Overall Control	Aerial Swath Control	Ground Swath Control	Overall Control	Aerial Swath Control	Ground Swath Control	Overall Control	Aerial Swath Control	Ground Swath Control	Overall Control	Aerial Swath Width	Ground Swath Control	Overall Control
2	Putumayo	75		40	85		90	85		60	100		98	86		72
3	Putumayo	75		15	100		20	85		60	100		30	90		31
4	Putumayo	95		50	90		25	86		60			30	90		41
9	Putumayo	95		80			0				100		90	98		57
10	Putumayo	10		10	30		20	30		40	35		50	26		30
18	Putumayo	98		90	100		35	97		96	100		80	99		75
19	Putumayo	95		30	100		80	97		97	100		90	98		74
20	Putumayo	20			30		10				50		40	33		25
24	Putumayo	99		100	100		97	90		90	100		95	97		96
27	Putumayo	99		90	10			85		80	100		80	74		83
28	Putumayo	95		70	97		97	85		80	90		85	92		83
29	Putumayo	95		95	100		100	90		95	100		100	96		98
30	Putumayo	98		98	100		100				100		100	99		99
34	Putumayo	95		90	95		40				100		95	97		75
42	Putumayo	96		80	100		20				100		95	99		65
43	Putumayo	98	98	90	100	100	100	85	85	80	100	100	80	96	96	88
44	Putumayo	95		25	50		40	85		80	40		45	68		48

[1] Points marked with gray are not eradicated at 85%

Redactions by the Government of the United States of America.
Document obtained by Ecuador through the U.S. Freedom of Information Act.

ANNEX 140

Plot ID	Department	(b)(6)				(b)(6)				(b)(6)				(b)(6)		Average			
		Aerial Swath Control	Ground Swath Control	Overall Control	Aerial Swath Control	Ground Swath Control	Overall Control	Aerial Swath Control	Ground Swath Control	Overall Control	Aerial Swath Control	Ground Swath Control	Overall Control	Aerial Swath Width	Ground Swath Control	Overall Control
45	Putumayo	98		80	95		70	88		70	95		90	94		78
46	Putumayo	95		80	95		50	90		70	80		80	90		70
47	Putumayo	98		75	100		100	98		95	100		95	99		91
48	Putumayo	99		95	100		100	98		96	100		95	99		97
49	Putumayo	98		90	100		100	95		98	100		100	98		97
50	Putumayo	98		85	92		98	97		98	95		90	96		93
52	Putumayo	95		90										95		90
53	Putumayo	85		45	100		95	90		80	100		98	94		80
54	Putumayo	98		90	90		100	90		90	100		98	95		95
57	Putumayo	98		95	90		75	90		80	100		95	95		86
60	Putumayo	85		85	30		30	30		10	20		15	41		35
62	Putumayo	100		50	100		100	95		90	100		95	99		84
63	Putumayo	98		90	100		100	98		98	100		100	99		97
64	Putumayo	90		90	50		40	90		90	40		20	68		60
65	Putumayo	94		90	90		80	90		80	90		80	91		83
67	Putumayo	98		85	100		100	99		98	98		95	99		95
68	Putumayo	98									100		100	99		100
69	Putumayo	90		90	85		87			90	100		100	91		93
70	Putumayo	75		30	90		50	100		70	85		60	88		53
71	Caqueta	95		80	100		100	90		80	90		90	94		88

Redactions by the Government of the United States of America.
Document obtained by Ecuador through the U.S. Freedom of Information Act.

Plot ID	Department	(b)(6)			(b)(6)			(b)(6)			(b)(6)			Average		
		Aerial Swath Control	Ground Swath Control	Overall Control	Aerial Swath Control	Ground Swath Control	Overall Control	Aerial Swath Control	Ground Swath Control	Overall Control	Aerial Swath Control	Ground Swath Control	Overall Control	Aerial Swath Width	Ground Swath Control	Overall Control
72	Caqueta	95		75	75		60	88		60	60		55	80		63
73	Caqueta	85		50	100		50	85		70	85		100	89		73
75	Caqueta	95		50	100		50	90		80	100		50	96		58
76	Caqueta	95		90	100		90	90		90	100		95	96		91
77	Caqueta	85		70	100		70	86		70	85		20	89		58
78	Caqueta	100	95	95	100	100	93		98	90	99	99	95	100	98	93
79	Caqueta	98		100	100		100	98		85			0	99		71
80	Caqueta	100		90	90		70	85		80	85		50	90		73
81	Caqueta	85		70	100		50	70		75	80		50	84		61
82	Caqueta	95		90	100		70	96		80	100		85	98		81
83	Caqueta	85	92	70	100	100	100		99	85	99	99	99	95	98	89
84	Caqueta	85		100	20		20	70		60	70		20	61		50
85	Caqueta				0		0	96		80	0		0	32		27
86	Caucasia				97		90	97		90	100		75	98		85
87	Caucasia				0		0	0		0	0		0	0		0
88	Caucasia				30		20	97		90	0		0	42		37
89	Caucasia				100		5	80		20	40		5	73		10
90	Caucasia				0		0	90		70	20		10	37		27
91	Caucasia				0		0	90		90	0		0	30		30
92	Caucasia				100		70	98		95	100		100	99		88

Redactions by the Government of the United States of America.
Document obtained by Ecuador through the U.S. Freedom of Information Act.

ANNEX 140

Plot ID	Department	(b)(6)			(b)(6)			(b)(6)			(b)(6)			Average		
		Aerial Swath Control	Ground Swath Control	Overall Control	Aerial Swath Control	Ground Swath Control	Overall Control	Aerial Swath Control	Ground Swath Control	Overall Control	Aerial Swath Control	Ground Swath Control	Overall Control	Aerial Swath Width	Ground Swath Control	Overall Control
93	Caucasia				100		100	99		98	100		100	100		99
94	Caucasia				100		95	90		85	95		90	95		90
95	Caucasia				0		0	0		0	0		0	0		0
96	Caucasia				95		95	98		97	98		98	97		97
97	Caucasia				98		40	90		90	85		65	91		65
98	Caucasia				0		0	80		50	0		0	27		17
99	Caucasia				98		100	0		0	0		0	33		33
120	Putumayo	90		80	88		85	98		95	100		100	94		90
121	Putumayo	85		65	95		90	70		80	80		70	83		76
122	Putumayo	98		90	99		100	99		97	100		100	99		97
123	Putumayo	95	98	90	100	100	100		99	98	90	100	100	95	99	97
124	Putumayo	95		85	100		90	99		95	90		85	96		89
125	Putumayo	99	100	95	100	100	100		98	90	80	100	100	93	100	96
147	Putumayo	95		85	98		30	97		97	80		20	93		58
148	Putumayo	98		85	97		95	97		95	100		95	98		93
150	Putumayo	98		90	100		100	98		98	100		100	99		97
151	Putumayo	95	95	80		97	30		80	80	80	97	85	88	92	69
152	Putumayo	95	98	85	80	96	85		97	96	90	99	80	88	98	87
153	Putumayo	80	90	90	90	99	70	96		90	90	98	98	87	96	87
154	Putumayo	100		90	100		100	99		98	100		100	100		97

Redactions by the Government of the United States of America.
Document obtained by Ecuador through the U.S. Freedom of Information Act.

Plot ID	Department	(b)(6)			(b)(6)			(b)(6)			(b)(6)			Average		
		Aerial Swath Control	Ground Swath Control	Overall Control	Aerial Swath Control	Ground Swath Control	Overall Control	Aerial Swath Control	Ground Swath Control	Overall Control	Aerial Swath Control	Ground Swath Control	Overall Control	Aerial Swath Width	Ground Swath Control	Overall Control
155	Putumayo	95	99	70	95	99	90	70	97	90	95	98	95	95	98	86
156	Putumayo	70		10	65		65	70		65	100		100	76		60
157	Putumayo	75		40	80		75	60		40	80		70	74		56
158	Putumayo	85		10	93		90	70		60	10		5	65		41
159	Putumayo	50		70	0		0	30		10	0		0	20		20
Average		90	96	74	80	99	66	83	94	77	78	99	66	81	97	68

Redactions by the Government of the United States of America.
Document obtained by Ecuador through the U.S. Freedom of Information Act.

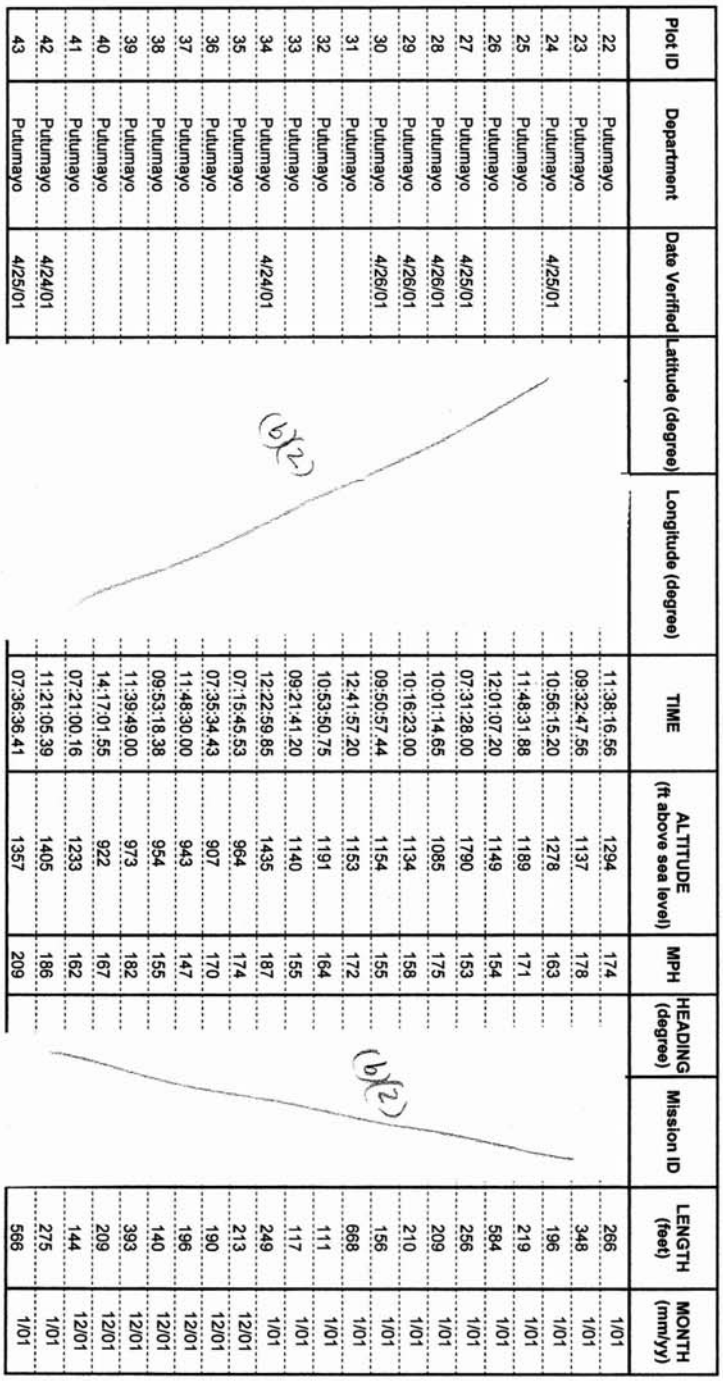
Table 4. Listing of All Sites Selected by the Verification Team for the April 2001 Verification of the Colombian Coca Eradication Program

Plot ID	Department	Date Verified	Latitude (degree)	Longitude (degree)	TIME	ALTITUDE (ft above sea level)	MPH	HEADING (degree)	Mission ID	LENGTH (feet)	MONTH (mm/yy)
1	Putumayo					1185	185			703	12/01
2	Putumayo	4/25/01			08:12:44.20	1179	220			139	12/01
3	Putumayo	4/25/01			12:48:47.59	1516	203			127	12/01
4	Putumayo	4/25/01			11:03:08.04	1237	214			190	12/01
5	Putumayo				07:20:04.00	921	171			244	12/01
6	Putumayo				11:46:57.85	966	174			237	12/01
7	Putumayo				11:39:28.36	997	176			715	12/01
8	Putumayo				07:23:59.20	1413	171			950	12/01
9	Putumayo	4/24/01			11:11:39.72	1294	172			153	1/01
10	Putumayo	4/25/01			11:47:48.07	1389	205			618	1/01
11	Putumayo				09:11:32.68	1427	205			263	1/01
12	Putumayo				07:46:21.70	1890	194			344	1/01
13	Putumayo				13:02:43.13	1319	209			178	1/01
14	Putumayo				10:38:40.46	1185	217			148	1/01
15	Putumayo				06:26:46.20	1177	215			288	1/01
16	Putumayo				07:27:22.00	918	171			141	1/01
17	Putumayo				09:28:27.78	876	158			104	1/01
18	Putumayo	4/25/01			12:19:48.00	1215	158			724	1/01
19	Putumayo	4/25/01			07:56:22.86	1260	174			211	1/01
20	Putumayo	4/24/01			13:11:57.00	1287	167			189	1/01
21	Putumayo				10:03:52.44	1202	180			141	1/01

ANNEX 140

Redactions by the Government of the United States of America.
Document obtained by Ecuador through the U.S. Freedom of Information Act.

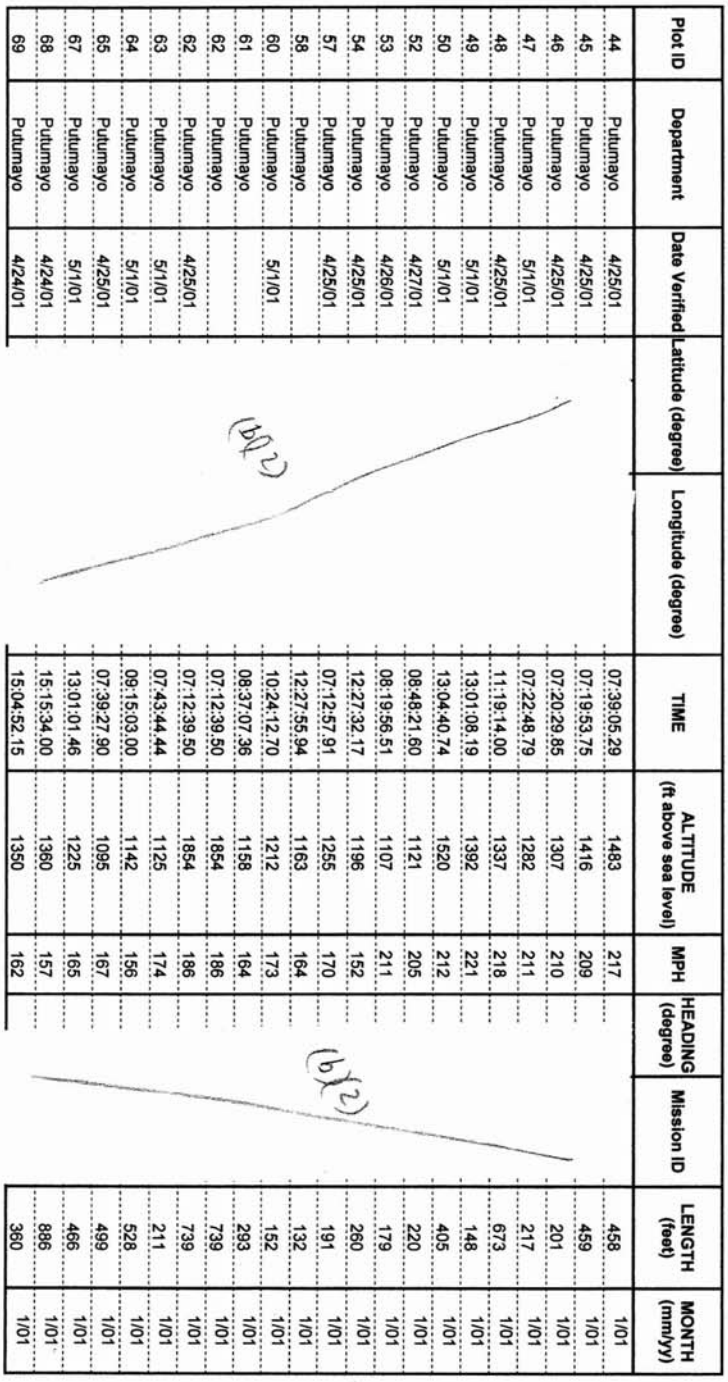
ANNEX 140



Plot ID	Department	Date Verified	Latitude (degree)	Longitude (degree)	TIME	ALTITUDE (ft above sea level)	MPH	HEADING (degree)	Mission ID	LENGTH (feet)	MONTH (mm/yy)
22	Putumayo				11:38:16.56	1294	174			266	1/01
23	Putumayo				09:32:47.56	1137	178			348	1/01
24	Putumayo	4/25/01			10:56:15.20	1278	163			196	1/01
25	Putumayo				11:48:31.88	1189	171			219	1/01
26	Putumayo				12:01:07.20	1149	154			584	1/01
27	Putumayo	4/25/01			07:31:28.00	1790	153			256	1/01
28	Putumayo	4/26/01			10:01:14.65	1085	175			209	1/01
29	Putumayo	4/26/01			10:16:23.00	1134	158			210	1/01
30	Putumayo	4/26/01			09:50:57.44	1154	155			156	1/01
31	Putumayo				12:41:57.20	1153	172			668	1/01
32	Putumayo				10:53:50.75	1191	164			111	1/01
33	Putumayo				09:21:41.20	1140	155			117	1/01
34	Putumayo	4/24/01			12:22:59.85	1435	187			249	1/01
35	Putumayo				07:15:45.53	964	174			213	12/01
36	Putumayo				07:35:34.43	907	170			190	12/01
37	Putumayo				11:48:30.00	943	147			196	12/01
38	Putumayo				09:53:18.38	954	155			140	12/01
39	Putumayo				11:39:49.00	973	182			393	12/01
40	Putumayo				14:17:01.55	922	167			209	12/01
41	Putumayo				07:21:00.16	1233	162			144	12/01
42	Putumayo	4/24/01			11:21:05.39	1405	186			275	1/01
43	Putumayo	4/25/01			07:36:36.41	1357	209			566	1/01

Redactions by the Government of the United States of America.
Document obtained by Ecuador through the U.S. Freedom of Information Act.

ANNEX 140



Plot ID	Department	Date Verified	Latitude (degree)	Longitude (degree)	TIME	ALTITUDE (ft above sea level)	MPH	HEADING (degree)	Mission ID	LENGTH (feet)	MONTH (mm/yy)
44	Putumayo	4/25/01			07:39:05.29	1483	217			458	1/01
45	Putumayo	4/25/01			07:19:53.75	1416	209			459	1/01
46	Putumayo	4/25/01			07:20:29.85	1307	210			201	1/01
47	Putumayo	5/1/01			07:22:48.79	1282	211			217	1/01
48	Putumayo	4/25/01			11:19:14.00	1337	218			673	1/01
49	Putumayo	5/1/01			13:01:08.19	1392	221			148	1/01
50	Putumayo	5/1/01			13:04:40.74	1520	212			405	1/01
52	Putumayo	4/27/01			08:48:21.60	1121	205			220	1/01
53	Putumayo	4/26/01			08:19:56.51	1107	211			179	1/01
54	Putumayo	4/25/01			12:27:32.17	1196	152			260	1/01
57	Putumayo	4/25/01			07:12:57.91	1255	170			191	1/01
58	Putumayo				12:27:55.94	1163	164			132	1/01
60	Putumayo	5/1/01			10:24:12.70	1212	173			152	1/01
61	Putumayo				08:37:07.36	1158	164			293	1/01
62	Putumayo				07:12:39.50	1854	186			739	1/01
62	Putumayo	4/25/01			07:12:39.50	1854	186			739	1/01
63	Putumayo	5/1/01			07:43:44.44	1125	174			211	1/01
64	Putumayo	5/1/01			09:15:03.00	1142	156			528	1/01
65	Putumayo	4/25/01			07:39:27.90	1095	167			499	1/01
67	Putumayo	5/1/01			13:01:01.46	1225	165			466	1/01
68	Putumayo	4/24/01			15:15:34.00	1360	157			886	1/01
69	Putumayo	4/24/01			15:04:52.15	1350	162			360	1/01

Redactions by the Government of the United States of America.
Document obtained by Ecuador through the U.S. Freedom of Information Act.

ANNEX 140

Plot ID	Department	Date Verified	Latitude (degree)	Longitude (degree)	TIME	ALTITUDE (ft above sea level)	MPH	HEADING (degree)	Mission ID	LENGTH (feet)	MONTH (mm/yy)
70	Putumayo	4/25/01			12:39:29.76	1784	154			313	1/01
71	Caqueta	4/24/01			14:39:01.00	821	205			158	7/00
72	Caqueta	4/24/01			15:16:48.04	906	215			153	6/00
73	Caqueta	4/24/01			10:07:46.49	861	166			175	12/01
75	Caqueta	4/23/01			07:59:15.40	857	157			172	12/01
76	Caqueta	4/24/01			09:57:33.20	993	228			122	12/01
77	Caqueta	4/24/01			09:55:46.00	902	162			213	12/01
78	Caqueta	4/24/01			07:31:40.71	958	199			328	12/01
79	Caqueta	4/24/01			11:08:40.69	904	202			152	12/01
80	Caqueta	4/24/01			07:27:44.66	936	221			209	12/01
81	Caqueta	4/24/01			07:42:27.82	903	221			113	12/01
82	Caqueta	4/24/01			09:04:12.10	870	205			119	12/01
83	Caqueta	4/23/01			09:23:55.65	996	207			124	12/01
84	Caqueta	4/24/01			11:38:09.24	945	208			151	12/01
85	Caucasia	5/3/01			10:56:39.00	1370	201			275	11/00
86	Caucasia	5/3/01			09:31:59.38	2058	170			428	11/00
87	Caucasia	5/3/01			10:28:40.22	1753	172			257	11/00
88	Caucasia	5/3/01			08:44:19.79	1367	146			141	11/00
89	Caucasia	5/3/01			07:21:36.23	1340	183			210	11/00
90	Caucasia	5/3/01			11:06:12.99	1897	162			139	12/01
91	Caucasia	5/3/01			11:52:34.20	1061	176			230	12/01
92	Caucasia	5/3/01			09:10:48.65	2614	129			261	12/01

(b)(2)

(b)(2)

Redactions by the Government of the United States of America.
Document obtained by Ecuador through the U.S. Freedom of Information Act.

ANNEX 140

Plot ID	Department	Date Verified	Latitude (degree)	Longitude (degree)	TIME	ALTITUDE (ft above sea level)	MPH	HEADING (degree)	Mission ID	LENGTH (feet)	MONTH (mm/yy)
93	Caucasia	5/3/01			12:15:29.86	3272	166			145	12/01
94	Caucasia	5/3/01			07:20:30.75	2371	192			320	12/01
95	Caucasia	5/3/01			09:45:55.00	954	186			100	12/01
96	Caucasia	5/3/01			11:53:04.99	2085	164			356	12/01
97	Caucasia	5/3/01			07:29:53.80	1568	160			206	12/01
98	Caucasia	5/3/01			10:29:15.79	1996	172			247	12/01
99	Caucasia	5/3/01			09:43:15.39	663	180			195	12/01
100	Guaviare				07:37:44.19	881	207			103	11/00
101	Guaviare				06:43:16.44	883	213			411	11/00
102	Guaviare				06:38:23.51	942	201			133	11/00
103	Guaviare				06:42:53.63	906	197			646	11/00
104	Guaviare				06:47:23.39	902	217			204	11/00
105	Guaviare				10:40:21.58	1060	204			182	11/00
106	Guaviare				07:15:55.26	1177	221			196	11/00
107	Guaviare				07:30:52.50	999	212			211	11/00
108	Guaviare				07:27:41.95	1159	210			204	11/00
109	Guaviare				10:05:00.20	951	219			219	11/00
110	Guaviare				10:12:26.31	956	196			213	11/00
111	Guaviare				10:10:35.94	874	212			289	10/00
112	Guaviare				10:14:54.81	899	212			285	10/00
113	Guaviare				11:04:08.20	904	209			319	10/00
114	Guaviare				11:00:15.00	897	208			156	10/00

(b)(2)

(b)(2)

Redactions by the Government of the United States of America.
Document obtained by Ecuador through the U.S. Freedom of Information Act.

ANNEX 140

Plot ID	Department	Date Verified	Latitude (degree)	Longitude (degree)	TIME	ALTITUDE (ft above sea level)	MPH	HEADING (degree)	Mission ID	LENGTH (feet)	MONTH (mm/yy)
115	Guaviare				09:33:07.85	764	215			146	10/00
116	Guaviare				09:39:30.96	758	192			155	10/00
117	Guaviare				12:18:17.31	893	209			348	12/01
118	Guaviare				12:18:32.25	843	209			233	12/01
119	Guaviare				07:41:52.08	867	207			208	12/01
120	Putumayo	4/29/01			08:42:09.31	951	211			209	7/00
121	Putumayo	4/29/01			11:47:36.00	989	211			188	1/01
122	Putumayo	4/29/01			08:01:47.83	934	201			256	1/01
123	Putumayo	4/29/01			08:05:51.95	918	202			102	1/01
124	Putumayo	4/29/01			08:08:35.96	941	205			125	1/01
125	Putumayo	4/29/01			08:12:30.00	906	212			396	1/01
126	Putumayo				09:29:22.88	433	192			156	9/00
127	Putumayo				09:48:58.00	391	185			110	9/00
128	Putumayo				12:03:34.24	409	178			554	9/00
129	Putumayo				13:22:20.74	707	165			492	9/00
130	Putumayo				13:49:19.00	428	161			128	9/00
131	Putumayo				12:58:36.91	424	151			277	9/00
132	Putumayo				12:51:46.67	365	168			193	9/00
133	Putumayo				12:01:00.75	390	144			209	9/00
134	Putumayo				12:09:45.74	385	168			146	9/00
135	Putumayo				13:18:56.89	618	167			221	9/00
136	Putumayo				14:35:42.13	428	170			154	9/00

(b)(2)

(b)(2)

Redactions by the Government of the United States of America.
Document obtained by Ecuador through the U.S. Freedom of Information Act.

ANNEX 140

Plot ID	Department	Date Verified	Latitude (degree)	Longitude (degree)	TIME	ALTITUDE (ft above sea level)	MPH	HEADING (degree)	Mission ID	LENGTH (feet)	MONTH (mm/yy)
137	Putumayo				13:16:56.25	705	156			295	8/00
138	Putumayo				14:34:30.35	564	141			369	8/00
139	Putumayo				13:46:38.82	418	150			333	8/00
140	Putumayo				13:46:52.81	381	137			412	8/00
141	Putumayo				11:42:46.70	386	170			141	8/00
142	Putumayo				10:49:17.70	389	152			122	8/00
143	Putumayo				12:41:43.24	294	173			152	8/00
144	Putumayo				37:22.2	1671	177			1249	1/01
145	Putumayo				18:55.2	1274	178			813	1/01
146	Putumayo				22:35.2	1698	195			400	1/01
147	Putumayo	5/1/01			17:45.5	1762	216			336	1/01
148	Putumayo	5/1/01			19:34.0	1461	206			729	1/01
149	Putumayo				36:31.9	1289	213			769	1/01
150	Putumayo	5/1/01			35:15.7	1575	217			514	1/01
151	Putumayo	5/1/01			21:43.8	1571	209			1024	1/01
152	Putumayo	5/1/01			18:38.4	1436	221			275	1/01
153	Putumayo	5/1/01			35:36.2	1363	221			578	1/01
154	Putumayo	5/1/01			56:50.9	1307	197			1168	12/01
155	Putumayo	5/1/01			05:20.3	1284	210			269	12/01
156	Putumayo	4/29/01			51:14.1	990	199			217	8/00
157	Putumayo	4/29/01			41:38.0	957	210			382	7/00
158	Putumayo	4/29/01			16:58.5	956	206				6/00

(b)(2)

(b)(2)

Redactions by the Government of the United States of America.
Document obtained by Ecuador through the U.S. Freedom of Information Act.

Plot ID	Department	Date Verified	Latitude (degree)	Longitude (degree)	TIME	ALTITUDE (ft above sea level)	MPH	HEADING (degree)	Mission ID	LENGTH (feet)	MONTH (mm/yy)
159	Putumayo	4/29/01	(b)(2)		14:50.8	1072	226	(b)(2)			6/00

Redactions by the Government of the United States of America.
Document obtained by Ecuador through the U.S. Freedom of Information Act.

ANNEX 140

Table 5. (b)(6) **Analysis of MDIS Data**

Area A (Alpha)		
Spray Timeline: From 18 - 30 January 2001		
Imagery Captured: 10 March 2001		
*All statistic totals are in hectares		
Total ground area coverage (**TGAC**) for Area A	**2548.168**	
Image Capture Percentage (In Hectares)		
20% of Area A (**TGAC**)	**509.634**	
Valid imaged area for analysis	**578.164**	
Percentage of (**TGAC**) captured on 10 March 2001	22.69%	
Field Analysis (In Hectares)		
Total Field Sum	**964.072**	
Eradicated Fields	**700.101**	**73%**
(C.S. 1) Fields	**0.000**	**0%**
Live Coca Fields	**263.971**	**27%**
Live Coca Remaining (In Hectares)		
Total Fields	**263.971**	
Live Coca Fields remaining < 1.0	**71.717**	**27%**
Live Coca Fields remaining > 1.0	**192.254**	**73%**
Overall Effectiveness (In Hectares)		
Total field sum > 1.0	**892.355**	
Eradicated Field Count	**700.101**	**78%**
(C.S. 1) Fields	**0.000**	**0%**
Live Coca Fields	**192.254**	**22%**
Over all effectiveness	**700.101**	**78%**

Redactions by the Government of the United States of America.
Document obtained by Ecuador through the U.S. Freedom of Information Act.

ANNEX 141

Ronald T. Collins & Charles S. Helling,
Surfactant-Enhanced Control of Two Erythroxylum Species by Glyphosate,
Weed Technology, Vol. 16 (2002)

Weed Technology. 2002. Volume 16:851–859

Commentary

Surfactant-Enhanced Control of Two *Erythroxylum* Species by Glyphosate[1]

RONALD T. COLLINS and CHARLES S. HELLING[2]

Abstract: Glyphosate is the only herbicide used for controlling illicit coca (*Erythroxylum coca* and *E. novogranatense*), a source of cocaine. Because commercially available formulations of glyphosate were inconsistent in controlling coca, research was conducted in a large-scale aerial eradication program, greenhouse (in Maryland) and field (Hawaii), to develop more effective control systems. Sixteen surfactants (cationic, nonionic, or mixed) were tested with two commercial glyphosate herbicide formulations, in aqueous or oil-based carrier systems, for coca control. Ultimately, two glyphosate–surfactant systems (COC/OSI-U [a mixture of crop-oil concentrate, Agri-Dex® and organosilicone, Silwet L-77®] and CAT/ANA [cationic surfactant/anionic surfactant, Optima®]) were found that increased glyphosate phytotoxicity fourfold: 1.1 kg ae/ha of glyphosate + surfactant was equivalent to 4.4 kg ae/ha glyphosate without added surfactant, for both species. In consequence, the glyphosate mixture used in Colombia for coca eradication was modified with substantially improved results.

Nomenclature: Glyphosate; coca, selected taxa of the genus *Erythroxylum*, especially *E. coca* var. *coca* Lam, *E. novogranatense* var. *novogranatense* (Morris) Hieron, *E. coca* var. *ipadu* Plowman, and *E. novogranatense* var. *truxillense* (Rusby) Plowman.

Additional index words: Adjuvants, coca control, herbicide carrier system, herbicide efficacy, narcotic plants, surfactants.

Abbreviations: ANA, anionic surfactant; CAT, cationic surfactant; COC, crop-oil concentrate; ECC, *E. coca* var. *coca*; ECI, *E. coca* var. *ipadu*; ENN, *E. novogranatense* var. *novogranatense*; ENT, *E. novogranatense* var. *truxillense*; Gly, glyphosate (isopropylamine salt); MSO, methylated seed oil; NIS, nonionic surfactant; OSI, organosilicone surfactant; VO, vegetable oil.

INTRODUCTION

Illicit drug use was estimated to cost the U.S. society $143 billion in 1998, and the projected loss for 2000 was over $160 billion (ONDCP 2001). Cocaine remains a major substance of abuse. One facet of U.S. and international strategy to solve this immense problem is to break the supply source. The U.S. supply-reduction efforts place major emphasis on eliminating illegal cultivation of the coca plant and processing of its leaves to extract cocaine.

Erythroxylum coca var. *coca* (ECC) is the primary coca species used for production of cocaine (Plowman 1979). But three other taxa besides ECC produce cocaine in sufficient quantities to be considered for commercial production: *E. coca* var. *ipadu* (ECI), *E. novogranatense* var. *novogranatense* (ENN), and *E. novogranatense* var. *truxillense* (ENT). Their taxonomy (Plowman 1979) and leaf surface morphology (McWhorter and Ouzts 1994) have been documented. In more recent years, progress has been achieved in describing coca alkaloid (Johnson and Emche 1994) and flavonoid (Johnson et al. 1997, 1998) composition, the latter offering potential for chemotaxonomic identification of individual taxa.

Coca is produced almost entirely in three Andean countries, Peru, Bolivia, and Colombia. The net area (i.e., adjusted for eradication) under illicit coca production estimated in 2000 was 184,900 ha; 136,200 ha of this was in Colombia, which since 1997 supplanted Peru as the leading coca producer (Anonymous 2002). Environmentally sound eradication of coca is indispensable for successful cocaine supply reduction; as a goal, this may be linked with alternative cropping or other development plans, but the barriers to successful voluntary crop substitution (especially in Colombia) remain for-

[1] Received for publication October 4, 2001, and in revised form April 29, 2002.

[2] Agronomist and Soil Scientist, Alternate Crops and Systems Laboratory, Agricultural Research Service, United States Department of Agriculture, BARC-W, 10300 Baltimore Avenue, Beltsville, MD 20705. Corresponding author's E-mail: rcollins@asrr.arsusda.gov.

midable. Approximately 84,250 ha of the Colombian coca was sprayed (with glyphosate) in 2001, in efforts to reduce the coca leaf and cocaine supply (Anonymous 2002).

Although herbicides are a logical tool for suppressing coca and other illicit narcotic crops, there are other approaches that, in theory, can be used. Manual eradication of coca has been done, as in Peru, but it is extremely labor-intensive, is not always effective, and exposes the worker to substantial risk in areas where growers oppose eradication. Biocontrol of coca received intensive research focus from the Agricultural Research Service (ARS) and collaborators throughout the 1990s. Although disclosure was originally restricted because of security concerns, recent publications now describe the use of a selective, naturally occurring soil pathogen to induce coca wilt (Bailey et al. 1997, 1998; Hebbar et al. 1998; Sands et al. 1997). Mycoherbicides remain unimplemented as tools for coca eradication, pending additional testing and host government approval.

A narcotics research program has existed within ARS, United States Department of Agriculture (USDA), mainly at Beltsville, MD, since 1972. From the late 1980s until ca. 1994, by ARS policy, research on narcotic crop eradication was considered especially sensitive; the extensive research on herbicide efficacy was generally published only in internal technical reports. Accordingly, most background research is necessarily cited as personal communications.

This report focuses only on glyphosate. As a nonselective herbicide, glyphosate's worldwide uses have included many noncropland and forestry applications. For this reason, and because of its minimal environmental impact, including on humans (Williams et al. 2000), glyphosate represented a logical candidate for possible coca control.

In 1985, ARS examined methods to control coca in a small-scale field study in Colombia, South America (Anonymous 1990); Gly/CAT (glyphosate/cationic surfactant, Roundup Original®)[3], at rates of 2.2 and 4.5 kg ae/ha, was ineffective in these early experiments. In 1987, Gly/CAT was reevaluated for coca control in Peru, but again it was found to be ineffective (Anonymous 1990). In 1989, a renewed, aggressive program was begun by ARS, USDA to evaluate foliar-applied herbicides for control of coca. Ultimately, systems were found in which Gly/CAT proved effective in controlling coca (R. W. Bovey, personal communication).

[3] The coding, nomenclature, and sources of supply for herbicides and adjuvants are found in Table 1.

In 1993, ARS assisted the U.S. Department of State and Government of Panama in testing Gly/CAT on illicit coca discovered in Panama (Helling 1993). This was the first large-scale aerial testing or eradication ever done with Gly/CAT against coca. Gly/CAT at 4.5 kg/ha gave acceptable control (90 to 95% 3 mo after application) in fields that had not received rainfall within an estimated 8 to 12 h after application, but treatments failed where rainfall occurred earlier. It was determined that the plants were ENN (Helling 1993), which by greenhouse (R. T. Collins, personal communication; Ferreira et al. 1997) and field (C. G. McWhorter, personal communication) studies proved easier to control by glyphosate than did the ECC plants. A recent study (Ferreira and Reddy 2000) confirms that [^{14}C]glyphosate is absorbed and translocated faster and more completely in ENN than in ECC, at least for mature plants.

Largely because of the Panama test results, the Government of Colombia began using Gly/CAT in 1994 for their coca eradication program. Since 1996, most of our foliar-applied herbicide research focused on improving glyphosate performance.

Assuming that product delivery to target is not an issue, still at least four potential problems confront successful coca control by Gly/CAT application: species sensitivity differences, rainfall, plant pruning, and defoliation. Field observations of Gly/CAT (applied in water at 65 and 94 L/ha, respectively) in Panama (Helling 1993) and Hawaii (R. W. Bovey, unpublished data) confirmed that rainfall after application was an important factor limiting glyphosate's effectiveness. Furthermore, growers of illicit coca have used at least two techniques to reduce the herbicide effect, i.e., hand-defoliation or pruning (to ca. 10- to 15-cm height) of treated plants shortly after application (C. S. Helling, personal communication).

The logical approach, to solve the problems of Gly/CAT application on coca, was to develop an adjuvant system that increased the speed of glyphosate penetration and uptake. As an example, surfactant CAT-I (Frigate®) at 0.5% (v/v) greatly accelerated uptake, translocation, and distribution of [^{14}C]glyphosate isopropylamine salt by several grassy species and improved their control (Ku et al. 1989). Surfactants have been widely studied to improve Gly/CAT performance, but general predictions of effect by species, chemical, and other variables (Franz et al. 1997) seem highly complicated. In general, tertiary polyoxyethylene alkylamine surfactants are thought to increase glyphosate efficacy by enhancing spray droplet retention on foliage (de Ruiter et al. 1990) and foliar

absorption (Gaskin and Holloway 1992; Sherrick et al. 1986). A polyoxyethene (10) alkylamine surfactant was thought to enhance hydration of the leaf cuticle, thereby facilitating transfer of polar glyphosate through the nonpolar barrier (Coret and Chamel 1993). Similarly, a polyethoxyethylene tallow amine surfactant lessened the negative impact of water stress on glyphosate efficacy by increasing herbicide absorption but could not overcome the reduced translocation caused by this stress (de Ruiter and Meinen 1998). In some cases, additional nonionic surfactant (NIS) added to a commercial glyphosate product actually reduced the absorption of the herbicide in four test weed species (Norsworthy et al. 2001).

This paper reports the results of experiments conducted in three phases, designed first to evaluate a large number of adjuvants in greenhouse studies and then to select the most promising systems for detailed greenhouse and field research. Given the limited resources, as wide a variety of adjuvant types as possible was studied, but which certainly included CAT-M (the surfactant used in the original commercial glyphosate, MON 0818) and other alkylamine-type products.

To be considered successful, the surfactant–glyphosate system needed to meet the following criteria: (1) it must be effective on both ECC and ENN, (2) it must work equally well on leaves of varying ages (within the approximate range of 60 to 120 d), (3) it must provide excellent control of coca under natural field conditions, and (4) the surfactant system components must be readily commercially available. If the above criteria are met, the research will have resulted in the successful development of a glyphosate herbicide system to control illicit coca. As described subsequently, these criteria were met.

MATERIALS AND METHODS

In phase 1, a representative selection of commercially available surfactants was evaluated to determine their effect on Gly/N (Rodeo®) activity against ECC. In phase 2, the best surfactants from phase 1 were evaluated at four surfactant concentrations and two glyphosate rates. Several surfactants, not available during phase 1, also were added to phase 2 testing. For phase 3, the best surfactants from phase 2 were applied with 1.1, 2.2, and 4.4 kg ae/ha Gly/N in field experiments in Hawaii. phase 3 testing included both ECC and ENN coca species.

There was an urgent requirement for rapid feedback from these greenhouse and small–field-plot experiments because initial monitoring of the ongoing Colombia eradication program had shown lower than the desired coca control. To achieve speed, the first replicates of the next phase (as with phases 1 and 2) were begun even before complete results from the preceding testing were available. Although this at times led to seemingly contradictory evidence, it did not alter the final results and conclusions.

Phase 1: Initial Surfactant Selection. The initial surfactant evaluation was conducted in a greenhouse at the USDA Beltsville Agricultural Research Center in 1995. Two-year-old coca plants (grown from seed), ca. 76 cm tall, were used. Most coca leaves were 6 mo old at the time of treatment, but the plants had never been pruned or deleafed. The plants were grown in 15-cm-diam pots, in a greenhouse potting mixture (loam soil + Pro-Mix®[4] [1:1 by wt], pH $\approx$ 5.5). No supplemental lighting was used; maximum light was ca. 900 μmol/m^2/s (summer [shading used]) and 600 μmol/m^2/s (winter). Temperature ranges were from 41 to 21 C (summer) and from 32 to 18 C (winter).

Two commercial formulations of glyphosate were used in the experiment: Gly/CAT and Gly/N. Both Gly/CAT and Gly/N were applied at 0.6 kg ae/ha. Gly/CAT (without additional surfactant) was included in the experiment as a standard; it was applied in water only. The Gly/N tank mixture contained surfactant(s) with either an aqueous (H_2O) or a nonaqueous (oil[5]) carrier. These herbicide solutions were applied at 47 L/ha.

Thirteen surfactants and two additives were evaluated in phase 1. Eight surfactants were used with the aqueous system: CAT-M, COC-H1 (crop-oil concentrate, Agri-Dex®), COC/OSI-U (AL-77: COC-H1 + organosilicone surfactant [OSI, Silwet L-77®]), MSO (methylated seed oil), MSO/OSI-H1 (Dyne-Amic®), NIS-L (X-77®), NIS-M (Sterox NJ®), and OSI; two additives, vinegar and sucrose (as a postherbicide treatment), were also included. Five surfactants were used with the nonaqueous system: COC-B (JLB Oil Plus®), COC-H2 (Penetrator®), NIS-B1 (Cide-Kick II®), NIS-B2 (Improved Cide-Kick II®), and VO-B (vegetable oil, Improved JLB Oil Plus®). The surfactant or vinegar concentration was always 0.5% (v/v). The concentration of sucrose (sugar) was 70 g/L. The sugar–water solution was applied at a rate of 187 L/ha 15 min after the glyphosate application.

To ensure a stable and uniform mixture of glyphosate in the nonaqueous carrier system, special steps were taken: (1) emulsifier #1 (1% [v/v]) was added to Gly/N and thoroughly blended; (2) emulsifier #2 (1% [v/v]) was

[4] Pro-Mix BX®, a mixture of sphagnum peat moss (75 to 85%, v/v), perlite, vermiculite, dolomitic and calcitic limestone, macro- and micronutrients, and a wetting agent; Premier Horticulture, 326 Main Street, Red Hill, PA 18076.

[5] Orchex 692®, a C_{21} paraffinic oil.

added to a C-21 paraffinic oil and blended; (3) finally, these two solutions were mixed together to form a stable emulsion.

The herbicide treatments were made in an automated spray chamber.[6] The herbicide solution was applied with a TeeJet 8001E flat-fan nozzle[7] at 276 kPa. The speed of the spray head assembly during application was 6.4 km/h.

Treated plants were visually rated for growth, as a percentage of untreated plants, 6 mo after application. A dead plant was evaluated as 0% growth of control; a healthy plant with no symptoms of herbicide effect was evaluated as 100% growth of control. The percent control was then calculated by subtracting percent growth from 100%. This procedure was used for phases 1, 2, and 3 testing, except that phase 3 field ratings were taken 4 mo after treatment.

Phase 1 used a completely randomized design. Each treatment was replicated three times, one plant per replication. Each experiment was repeated. The data were analyzed by the SAS Proc Mix program (SAS 1997), with the replicated experiments included as a variable in the random statement. The experiments were not significantly different (α was set at the 5% level), so results were pooled in the data presentations. This pooling was the case for all three phases.

Phase 2: Evaluation of Selected Surfactants. Phase 2 consisted of two greenhouse experiments, one dealing exclusively with cationic surfactants and the other with noncationic surfactants. It was conducted at Beltsville, MD, in 1995, using 2-yr-old ECC plants (ca. 70 cm tall). Most leaves were 5 to 6 mo old. Other growing conditions were as described for phase 1.

Gly/N was applied at 0.6 kg ae/ha for both cationic and noncationic experiments. The three cationic surfactants were CAT/anionic surfactant (ANA) (Optima®), CAT-I, and CAT-M. The noncationic surfactants were COC/OSI-U, MSO/OSI-H2 (Aero Dyne-Amic®), and NIS-L. Concentrations of surfactants evaluated were 0.5, 1.0, 2.0, and 4.0% (v/v).

Each treatment in phase 2 was replicated three times, and each experiment, twice. A treatment replication consisted of one plant. Statistical analysis was as in phase 1.

Phase 3: Field Evaluation of Surfactants. During 1996 to 1997, phase 3 was conducted in Hawaii, on Halii sandy clay loam, a Typic Gibbshumox soil. Mean annual rainfall at the site is ca. 2,500 mm; mean air temperature is 20.5 C. Both soil and meteorological conditions at the field research site resemble those encountered in typical locations where illicit coca is grown (Helling 1997).

In phase 3, the most effective (in increasing coca control by glyphosate) cationic and noncationic adjuvants from phase 2, plus surfactants in nonaqueous carriers from phase 1, were evaluated for coca control in systems with 1.1 kg ae glyphosate/ha. The most efficacious of these were further evaluated at glyphosate rates of 2.2 and 4.4 kg ae/ha. In all field testing, the surfactant concentration was 2% (v/v). Both ECC and ENN coca were used in phase 3. The plants, 2 yr old (ca. 120 cm tall) at application, had been pruned to ca. 75-cm height 90 d before glyphosate treatment. For the first full experiment, coca was grown in 1-m rows, with 46-cm interplant spacing; crop density was 21,740 plants/ha. In the repeat experiment, density was increased to 44,445 plants/ha by reducing row spacing to 0.75 m and plant spacing to 30 cm.

Carrier volume was 47 L/ha, applied to the plants with a two-nozzle hand-held boom. Other conditions of spraying were nozzle type, TJ80005; nozzle separation, 51 cm; nozzle height, 46 cm above mean plant height; pressure, 276 kPa; and boom speed, 4.8 km/h. To protect nontarget plants, a plastic shield (1.5 m high, 1.1 m wide, and 1.2 to 1.8 m long) was placed around the target plants at the time of herbicide application.

Each treatment in phase 3 was replicated three times; each replication consisted of five plants. Each experiment was repeated but with the changes described above (there were two experiments). Statistical analysis was as previously described for phases 1 and 2.

RESULTS AND DISCUSSION

Phase I: Initial Surfactant Selection. In phase 1, control was significantly different among the glyphosate–adjuvant systems evaluated. The results of the experiment and the statistical relationships among treatments are listed in Table 2. Five treatments were statistically similar to that with the highest percent control, NIS-L. These six most effective treatments were NIS-L (84%), COC/OSI-U (75%), NIS-B1 (70%), COC-B (65%), no surfactant or oil carrier (64%), and NIS-B2 (62%). The coca control for each of the remaining 11 treatments was statistically different from the treatment with the highest control. The use of glyphosate emulsified in oil was extremely effective in controlling ECC: four of the six best treatments (NIS-B1, COC-B, no surfactant, and NIS-B2) used an oil carrier.

[6] Model #RC-5000-100EP; Mandel Scientific Co., 2 Admiral Place, Guelph, ON N1TN4.

[7] TeeJet 8001E and TJ 80005 nozzle tips; Spraying Systems Co., P.O. Box 7900, Wheaton, IL 60189-7900.

Table 1. Herbicide–adjuvant systems: their coding, nomenclature, and sources of supply.

Code	Name		Composition	Source
	Common name	Trade name		
Herbicides				
Gly	Glyphosate	—	Glyphosate, isopropylamine salt	—
Gly/CAT	(Glyphosate)	Roundup Original®	Gly + ethoxylated tallow amines	Monsanto Co., 800 North Lindbergh Boulevard, St. Louis, MO 63167
Gly/N	(Glyphosate)	Rodeo®	Gly, w/o surfactants	Monsanto Co.
Adjuvants, generic and commercial				
ANA	Anionic surfactants	—	—	—
CAT	Cationic surfactants	—	—	—
CAT/ANA	—	Optima®	Polyethoxylated alkyl amines [C_8–C_{18}] + alkyl polyoxyethylene glycols + organic acids	Helena Chemical Co., 6075 Poplar Avenue, Memphis, TN 38119-4702
CAT-I	—	Frigate®	Mixture of ethoxylated long-chain fatty amines	ISK Biosciences Corp. (now ISK Biocides, Inc.), 416 E. Brooks Road, Memphis, TN 38109
CAT-M	—	MON 0818	Ethylene glycol + ethoxylated tallow amines	Monsanto Co.
COC	Crop-oil concentrate	—	—	—
COC-B	—	JLB Oil Plus®	Petroleum process oil + D-limonene emulsifiers	Brewer International, P.O. Box 6006, Vero Beach, FL 32961-6006
COC-H1	—	Agri-Dex®	Heavy-range paraffin-based petroleum oil + polyethoxylated derivatives thereof + sorbitan ester-based emulsifiers	Helena Chemical Co.
COC-H2	—	Penetrator®	Light-range paraffin-base petroleum oil + polyol fatty acid esters + polyethoxylated derivatives	Helena Chemical Co.
MSO	Methylated seed oil	Sun-It II®	Methylated seed oil	American Cyanamid Co. (now BASF), One Campus Drive, Parsippany, NJ 07054-4492
MSO/OSI-H1	—	Dyne-Amic®	Polyalkyleneoxide-modified polydimethylsiloxane + alkyl polyoxyethylene glycols + methylated soybean oil	Helena Chemical Co.
MSO/OSI-H2	—	Aero Dyne-Amic®	Ethoxylated alkyl phosphate esters + polyalkyleneoxide-modified polydimethylsiloxane + alkyl polyoxyethylene glycols + methylated soybean oil	Helena Chemical Co.
NIS	Nonionic surfactants	—	—	—
NIS-B1	—	Cide-Kick II®	D-Limonene + nonylphenol polyethyleneglycol ether	Brewer International
NIS-B2	—	Improved Cide-Kick II®	D,L-Limonene + terpene hydrocarbon + nonylphenol polyethyleneglycol ether	Brewer Internationsl
NIS-L	—	X-77®	Alkylarylpolyoxyethylene glycols + free fatty acids + isopropanol	Loveland Industries, Inc., P.O. Box 1289, Greeley, CO 80632-1289
NIS-M	Nonoxynol	Sterox NJ®	Nonoxyl (9–10 POE)	Monsanto Co.
OSI	Organosilicone surfactant	Silwet L-77®	Polyalkyleneoxide-modified heptamethyltrisiloxane	Witco Corp., One American Lane, Greenwich, CT 06831-2559
VO	Vegetable oil	—	—	—
VO-B	Vegetable oil	Improved JLB Oil Plus®	Natural vegetable oil + D-limonene emulsifiers	Brewer International
—	(Emulsifier #1)	Alfonic® 1012–5	C_{10}–C_{12} ethoxylated alcohols	Vista Chemical Co. (now Sasol Chemical Industries), 15990 North Barker's Landing Road, P.O. Box 19029, Houston, TX 77224
—	(Emulsifier #2)	Alfonic® 1012–3	Ethoxylated alcohol	Vista Chemical Co.
—	Oil	Orchex 692®	Paraffinic oil	Exxon Company, USA, P.O. Box 2180, Houston, TX 77252-2180
—	Sugar	—	Sucrose, 0.5% (v/v) in water	—
—	Vinegar	—	Vinegar (acetic acid), 0.5% (v/v) in water	—
Adjuvants, custom mixtures (this study)				
COC/OCI-U	—	"AL-77"	Agri-Dex + Silwet L-77 (1:1)	—

ANNEX 141

Table 2. Glyphosate control of *Erythroxylum coca* var. *coca* as influenced by surfactants (0.5% v/v) and formulation: phase 1 evaluation of surfactant systems. Treatments are ranked in decreasing order of efficacy, at the 0.6-kg ae/ha glyphosate rate.

Glyphosate formulation	Treatment[a]	Control[b]
		%
Gly/N[c]	NIS-L	84 a
Gly/N[c]	COC/OSI-U	75 ab
Gly/N[d]	NIS-B1	70 abc
Gly/N[d]	COC-B	65 abc
Gly/N[d]	None	64 abc
Gly/N[d]	NIS-B2	62 abc
Gly/N[d]	VO	60 bc
Gly/N[d]	COC-H2	58 bc
Gly/CAT	Vinegar	55 bc
Gly/N[c]	MSO	54 bc
Gly/N[c]	COC-H1	51 bc
Gly/N[c]	MSO/OSI-H1	49 cd
Gly/CAT[c]	None	48 cd
Gly/N[c]	OSI	47 cd
Gly/N[c]	CAT-M	33 d
Gly/CAT[c]	Sucrose[e]	31 d
Gly/N[c]	NIS-M	29 d

[a] Surfactant concentration was 0.5% v/v.

[b] Means within a column not followed by the same letter are significantly different (P = 0.05).

[c] Carrier is water.

[d] Carrier is oil.

[e] Sucrose solution (70 g/L) was sprayed onto plants 15 min after glyphosate treatment.

Table 3. Control of *Erythroxylum coca* var. *coca* by Gly/N at 0.6 kg ae/ha in aqueous carrier, as influenced by surfactant concentration: phase 2 evaluation of selected surfactants.

Formulation	Surfactant	Concentration	Control
		% v/v	%
Cationic	CAT-I	0.5	57
	CAT-I	1	60
	CAT-I	2	75
	CAT-I	4	70
	CAT-M	0.5	65
	CAT-M	1	57
	CAT-M	2	62
	CAT-M	4	80
	CAT/ANA	0.5	57
	CAT/ANA	1	53
	CAT/ANA	2	70
	CAT/ANA	4	55
Noncationic			
	MSO/OSI-H2	0.5	55
	MSO/OSI-H2	1	76
	MSO/OSI-H2	2	72
	MSO/OSI-H2	4	60
	COC/OSI-U	0.5	54
	COC/OSI-U	1	67
	COC/OSI-U	2	53
	COC/OSI-U	4	56
	NIS-L	0.5	76
	NIS-L	1	88
	NIS-L	2	79
	NIS-L	4	74

Sucrose and vinegar are not normally considered as additives. But reports from Colombia stated that (1) vinegar increased the activity of glyphosate in controlling coca, and (2) coca growers were applying sugar water to coca plants shortly after glyphosate application to negate its activity (C. S. Helling, personal communication). The phase 1 experiment showed that coca control by Gly/CAT was not significantly increased with (55%) vs. without (48%), vinegar (Table 2). Second, spraying sugar water onto plants treated 15 min earlier with glyphosate did not significantly decrease Gly/CAT control of coca: unsprayed (48%) vs. sprayed (31%). The spray volume dose of the sugar water, although four times that of glyphosate, was insufficient to cause runoff.

As a result of phase 1, three surfactants used with aqueous carriers were further evaluated in phase 2: NIS-L, COC/OSI-U, and CAT-M. CAT-M was included (although not among the six best surfactants) because it is used in Gly/CAT at ca. 7 to 8 wt% (Franz et al. 1997). The MSO/OSI-H1–glyphosate system was not included in the phase 2 test as a result of its poor control of coca. Surfactant MSO/OSI-H2 was added to phase 2 instead. OSI by itself did not increase the percent control of ECC; when added to a surfactant that increases penetration, there was a synergistic effect. Thus, when COC-H1 (51% control) is combined with OSI (47% control), the new adjuvant mixture COC/OSI-U is formed; glyphosate in this tertiary COC/OSI-U system gave superior coca control (75%) to that obtained from the corresponding binary systems. The higher OSI concentration in MSO/OSI-H2 is similar to that in COC/OSI-U. One goal of the phase 2 research was therefore to determine if increased organosilicone content enhances coca injury and death.

Phase 2: Evaluation of Selected Surfactants[8]. *Cationic surfactants.* Two additional cationic surfactants (CAT-I and CAT/ANA) were included in phase 2; they had been unavailable for research in phase 1. Percent control as affected by surfactant ($P > 0.09$), surfactant rate ($P > 0.07$), or the interaction between surfactant and surfactant rate ($P > 0.39$) was not significantly different among treatments. Concentration-pooled efficacy ratings for the three cationic surfactants were CAT-I (61%), CAT-M (58%), and CAT/ANA (53%) (Table 3). The overall control efficacies for the four surfactant rates—0.05, 1, 2, and 4% v/v—were 54, 52, 61, and 62%, respectively.

All three cationic surfactants were selected for further

[8] Because of limited plant resources, further evaluation of glyphosate in an oil carrier was deferred until phase 3 field testing.

Table 4. Control of *Erythroxylum coca* var. *coca* (ECC) and *E. novogranatense* var. *novogranatense* (ENN) by glyphosate at 1.1 kg ae/ha, as influenced by surfactant–carrier combinations: phase 3 Hawaii field evaluation.

Surfactant[a]	Carrier	Control[b]		
		ECC/ENN	ECC	ENN
		%		
COC/OSI-U	Water	91 a	98 a	84 ab
CAT/ANA	Water	90 ab	98 a	81 abc
NIS-L	Water	84 abc	67 bc	100 a
CAT-M	Water	82 abc	85 ab	78 abc
MSO/OSI-H2	Water	80 abcd	91 ab	69 bc
Gly/N	Water	76 abcd	88 ab	65 bc
Gly/CAT[c]	Water	71 bcde	52 c	89 a
COC-H1	Water	67 de	33 c	100 a
CAT-I	Water	54 ef	33 c	76 abc
None[d]	Oil	47 f	85 ab	8 d
NIS-B1	Oil	45 f	56 c	33 c
COC-H2	Oil	45 f	58 c	32 c

[a] Surfactant concentration was 2% v/v.

[b] Means within a column not followed by the same letter are significantly different ($P = 0.05$).

[c] Gly/CAT treatment contained no additional surfactant besides those in the original formulation.

[d] Gly/N was used without surfactants.

evaluation in phase 3 field testing. Although surfactant concentration was not a significant ($P \leq 0.05$) overall factor that affected coca control by glyphosate, within individual surfactant tests there were differences between rates. The lowest rate (based on all tested surfactants) common to all three cationic surfactants was 2%.

Noncationic surfactants. The percent coca control for the noncationic surfactant–glyphosate systems (Table 3) was significantly different ($P > 0.001$) among treatments. NIS-L (79%) gave better control than both MSO/OSI-H2 (66%) and COC/OSI-U (58%). Neither surfactant rate ($P > 0.09$) nor the interaction between surfactants and surfactant rates ($P > 0.95$) was significantly different for percent control. All three noncationic surfactants were selected for field evaluation. The noncationic surfactants were subsequently applied in phase 3 at the same rate as were the cationic surfactants, 2% v/v.

Phase 3: Field Evaluation of Selected Surfactants. The results of the 1.1 kg/ha glyphosate evaluations are listed in Table 4. Control was not different for species (ECC = 70% and ENN = 68%). Surfactant ($P > 0.0001$) and surfactant-by-species interactions ($P > 0.0001$) were different.

The overall mean coca control for the 12 glyphosate–adjuvant systems tested in phase 3 is listed in Table 4 in the ECC/ENN column. Five treatments (CAT/ANA [90%], NIS-L [84%], CAT-M [82%], MSO/OSI-H2 [80%], and Gly/N w/o surfactant [76%]) were not different from that with the highest coca control, COC/OSI-U (91%).

The percent control means for the surfactant-by-species interaction are listed in the individual ECC and ENN columns (Table 4). COC/OSI-U, CAT/ANA, and CAT-M control were not significantly different between species. COC/OSO-U and CAT/ANA were further evaluated in the 2.2- or 4.4-kg/ha experiment. CAT-M was dropped for two reasons: (1) it controlled less ECC, and (2) it is not commercially available. Treatments NIS-L, MSO/OSI-H2, Gly/N, Gly/CAT, and COC-H1 gave inconsistent control (Table 4) depending on the species. NIS-L and Gly/CAT were further evaluated in the 2.2- and 4.4-kg/ha experiments. NIS-L was selected to include an NIS; Gly/CAT was included because it was the commercial glyphosate formulation. Of the remaining treatments shown in Table 4, only NIS-B1 was used; it was included as a representative of treatments with oil carriers.

The results from the 2.2- and 4.4-kg/ha glyphosate experiments showed that coca control was different for herbicide rates ($P > 0.001$) and for surfactants ($P > 0.0001$) but not for species ($P > 0.07$). Percent control of ENN and ECC coca, pooled for surfactant and herbicide rate, was 96 and 93%, respectively. The glyphosate rate giving the best control was 4.4 kg/ha (97%), whereas the 2.2-kg/ha rate controlled 92%, averaged over all systems. COC/OSI-U (100%), CAT/ANA (96%), and NIS-L (96%) were not different from each other; CAT/ANA, NIS/L, Gly/CAT w/o surfactant (90%), and NIS-B1 (91%) were not different from each other (Table 5, surfactant percent control column).

Control was not different for the species by surfactants interaction ($P > 0.35$), but it was different for the interaction between species and herbicide rate ($P > 0.0001$). There was no difference between the ENN–2.2 kg/ha (96%), ENN–4.4 kg/ha (95%), and ECC–4.4 kg/ha (99%) treatments; ECC–2.2 kg/ha (87%) control was significantly lower than that of the other treatments. The interaction between surfactant and herbicide rate was different ($P > 0.03$; Table 5). The two interactions with different percent control were NIS-B1 (87%) and Gly/CAT (with no additional surfactant) (83%).

The percent control for the interaction between surfactant, herbicide rate, and species was different ($P > 0.02$). Of the 20 possible interactions (data in the last four columns of Table 5), only four had lower control: ECC–2.2 kg/ha–Gly/CAT, ECC–2.2 kg/ha–NIS-B1, ENN–2.2 kg/ha–Gly/CAT, and ENN–4.4 kg/ha–NIS-B1. All the remaining treatments gave excellent control (93

Table 5. Control of *Erythroxylum coca* var. *coca* (ECC) and *E. novogranatense* var. *novogranatense* (ENN) by glyphosate at 2.2 and 4.4 kg ae/ha, as influenced by surfactant–carrier combinations and herbicide rate: phase 3 Hawaii field evaluation.

	Control[b] at 2.2 or 4.4 kg ae glyphosate/ha						
				Coca species			
	Surfactants, independent of coca species			ECC		ENN	
Surfactant[a]	All rates	2.2	4.4	2.2	4.4	2.2	4.4
	%						
COC/OSI-U	100 a	99 a	100 a	99 a	99 a	100 a	100 a
CAT/ANA	96 ab	95 ab	97 a	91 ab	100 a	99 a	93 a
NIS-L	96 ab	95 ab	97 a	93 a	98 a	97 a	97 a
None[c]	90 b	83 b	97 a	77 b	94 a	90 b	99 a
NIS-B1[d]	91 b	87 b	94 ab	77 b	100 a	97 a	88 b

[a] Surfactant concentration was 2% v/v.

[b] Means within a column not followed by the same letter are significantly different ($P = 0.05$).

[c] Herbicide used was Gly/CAT; all other treatments used Gly/N.

[d] Carrier is oil; all others are water.

to 100%) of ECC and ENN. Just as with the percent control data pooled for surfactants, and with the interaction between surfactant and herbicide rates, Gly/CAT and NIS-B1 systems had the poorest control. Poor control was consistent with findings from the three-way interactions mentioned above.

Testing of glyphosate–adjuvant applied in an oil carrier was conducted in phases 1 and 3 in comparison with water-as-carrier systems. Glyphosate in water proved more efficacious.

In the three experimental phases, no single surfactant was superior to all the others. Selection of a preferred system was therefore based on consideration of various factors related to the adjuvants tested. Gly/CAT (w/o additional surfactant) and NIS-B1 were eliminated because coca control in phase 3 experiments, at 2.2 and 4.4 kg/ha glyphosate, proved unsatisfactory. The elimination of Gly/CAT was very important because, at the time our research began, this was the only commercial formulation of glyphosate available and apparently suitable for coca eradication. Gly/CAT was, in fact, the product initially used against coca in Colombia.

The remaining three field-tested surfactants (COC/OSI-U, CAT/ANA, and NIS-L) gave better control than did the commercial glyphosate formulation. Because a desirable glyphosate–surfactant system must be equally effective against both ECC and ENN species, these three systems (at both 2.2- and 4.4-kg/ha rates) fulfilled this criterion. But in the 1.1-kg/ha experiment, only surfactants COC/OSI-U and CAT/ANA controlled both ECC and ENN. Considering herbicidal performance at the suboptimal rate (1.1 kg/ha) is relevant because in the actual spray application of glyphosate relatively high above coca fields, coca within the spray swath may not receive the full target dose. Consequently, of all the tested surfactants, COC/OSI-U and CAT/ANA were superior. These adjuvants, or their equivalent, are now recommended as additives to glyphosate for coca eradication in Colombia or elsewhere.

The greenhouse experiments were useful for predicting which herbicide–adjuvant treatments would fail. Only the field research demonstrated conclusively those that would work. Field-grown coca responded rather differently from those plants grown in the greenhouse. Three examples can be cited. Whereas NIS-L was the best noncationic surfactant in greenhouse studies on ECC, in the field it did not control ECC as well. COS/OSI-U + glyphosate was only marginally effective in the greenhouse but gave exceptional control in the field. Glyphosate with CAT-I controlled ECC in a similar way as did glyphosate with the other two cationic surfactants in the greenhouse. But in the field, CAT-I provided poorer control than did the other surfactants. Whether associated with environmental variables or plant characteristics, the variability in testing results were a reminder that the most accurate way to predict surfactant performance is to incorporate field evaluations in the research scheme.

In this research the best glyphosate–surfactant systems for ECC and ENN control were COC/OSI-U and CAT/ANA. The chemistry of these two surfactants is so different that it appears impossible to predict which surfactant properties are necessary for improving glyphosate control of both ECC and ENN. It seems likely, however, that systems that (1) increase glyphosate penetration through the epicuticular wax of coca leaves, and then (2) facilitate subsequent translocation will optimize the herbicide's performance. McWhorter and Ouzts (1994) found that water droplets containing 0.1% OSI Silwet L-77 did spread better on coca leaves than did water with

a COC (Agri-Dex) or NIS-M adjuvant. But enhanced spray droplet distribution was certainly not the major discriminating factor for the glyphosate–adjuvant systems in our study. If this characteristic was important, then oil carrier systems should have surpassed water-based mixtures because spread coefficients on coca leaves were much higher for nearly all nonaqueous carriers (McWhorter and Ouzts 1994).

In the evolving process of optimizing herbicide performance through spray system modification, it is important to recognize that adjuvants may function differently with newer or modified commercial formulations of the herbicide. Nevertheless, in the series of experiments described herein, we have shown substantial improvement in coca control by the addition of selected surfactants to a commercial glyphosate formulation.

The technological improvements developed through this research were integrated in the Colombia coca eradication program. We recommended adding a Colombia-manufactured agricultural adjuvant with properties similar to one of the most effective surfactants tested in this research. Largely, as a result of the modified spray tank mixture, the mean swath control of coca increased from ca. 70% in 1997 to ca. 90% or higher thereafter.

ACKNOWLEDGMENTS

This research could not have been completed without the assistance of Rembert Shaw in phases 1 and 2, and John Iwan in phase 3. We also acknowledge the method suggested by Dr. Chester G. McWhorter (ARS, USDA, retired) for preparing glyphosate formulations in nonaqueous carrier systems. Mention of commercial or proprietary products is for the reader's convenience and does not constitute endorsement by the ARS, USDA over other suitable products.

LITERATURE CITED

Anonymous. 1990. U.S. Department of State, Bureau of International Narcotics Matters. Environmental Assessment of the Use of Herbicides to Eradicate Illicit Coca Overseas (Revised). September 7, 1990. Washington, DC: U.S. Department of State, International Narcotics Matters. 134 p.

Anonymous. 2002. U.S. Department of State, Bureau of International Narcotics Law Enforcement Affairs (INL). International Narcotics Control Strategy Report: March 2002. Washington, DC: U.S. Department of State, International Narcotics Law Enforcement Affairs: Web page: http://www.state.gov/g/inl/rls/nrcrpt/2001. Accessed: March 6, 2002.

Bailey, B. A., K. P. Hebbar, M. Strem, L. C. Darlington, and R. D. Lumsden. 1997. An alginate prill formulation of *Fusarium oxysporum* Schlechtend: Fr. f. sp. *erythroxyli* for biocontrol of *Erythroxylum coca* var. *coca*. Biocontrol Sci. Technol. 7:423–435.

Bailey, B. A., K. P. Hebbar, M. Strem, R. D. Lumsden, L. C. Darlington, W. J. Connick Jr., and D. J. Daigle. 1998. Formulations of *Fusarium oxysporum* f. sp. *erythroxyli* for biocontrol of *Erythroxylum coca* var. *coca*. Weed Sci. 46:682–689.

Coret, J. M. and A. R. Chamel. 1993. Influence of some nonionic surfactants on water sorption by isolated tomato fruit cuticles in relation to cuticular penetration of glyphosate. Pestic. Sci. 38:27–32.

de Ruiter, H. and E. Meinen. 1998. Influence of water stress and surfactant on the efficacy, absorption, and translocation of glyphosate. Weed Sci. 46:289–296.

de Ruiter, H., A.J.M. Uffing, E. Meinen, and A. Prins. 1990. Influence of surfactants and plant species on the retention of spray solutions. Weed Sci. 38:567–572.

Ferreira, J.F.S. and K. N. Reddy. 2000. Absorption and translocation of glyphosate in *Erythroxylum coca* and *E. novogranatense*. Weed Sci. 48:193–199.

Ferreira, J.F.S., R. J. Smeda, and S. O. Duke. 1997. Control of coca plants (*Erythroxylum coca* and *E. novogranatense*) with glyphosate. Weed Sci. 45:551–556.

Franz, J. E., M. K. Mao, and J. A. Sikorski. 1997. Glyphosate: A Unique Global Herbicide. ACS Monograph 189. Washington, DC: American Chemical Society. 653 p.

Gaskin, R. E. and P. J. Holloway. 1992. Some physicochemical factors influencing foliar uptake enhancement of glyphosate-mono(isopropylammonium) by polyoxyethylene surfactants. Pestic. Sci. 34:195–206.

Hebbar, K. P., R. D. Lumsden, J. A. Lewis, S. M. Poch, and B. A. Bailey. 1998. Formulation of mycoherbicidal strains of *Fusarium oxysporum*. Weed Sci. 46:501–507.

Helling, C. S. 1993. Coca Eradication in Panama: Final Technical Rep. Beltsville, MD: U.S. Department of Agriculture, Agricultural Research Service. 42 p.

Helling, C. S. 1997. Environmental fate of herbicides in Hawaii, Peru and Panama. *In* Environmental Behavior of Crop Protection Chemicals, STI/PUB/1003. Vienna: International Atomic Energy Agency. pp. 389–406.

Johnson, E. L. and S. D. Emche. 1994. Variation of alkaloid content in *Erythroxylum coca* leaves from leaf bud to leaf drop. Ann. Bot. 73:645–650.

Johnson, E. L., W. L. Schmidt, and H. A. Norman. 1997. Leaf flavonoids as chemotaxonomic markers for two *Erythroxylum* taxa. Z. Naturforsch. 52c:577–585.

Johnson, E. L., W. L. Schmidt, and H. A. Norman. 1998. Flavonoids as markers for *Erythroxylum* taxa: *E. coca* var. *ipadu* and *E. novogranatense* var. *truxillense*. Biochem. Syst. Ecol. 26:743–759.

Ku, H. S., G. J. Misich, L. E. Limpel, and D. C. Findak. 1989. Enhancement of glyphosate activity by a fatty amine ethoxylate adjuvant: a physiological investigation. *In* P.N.P. Chow, C. A. Grant, and A. M. Hinshalwood, eds. Adjuvants and Agrochemicals. Vol. I. Mode of Action and Physiological Activity. Boca Raton, FL: CRC Press. pp. 167–174.

McWhorter, C. G. and C. Ouzts. 1994. Leaf surface morphology of *Erythroxylum* sp. and droplet spread. Weed Sci. 42:18–26.

Norsworthy, J. K., N. R. Burgos, and L. R. Oliver. 2001. Differences in weed tolerance to glyphosate involve different mechanism. Weed Technol. 15: 725–731.

[ONDCP] Office of National Drug Control Policy. 2001. The Economic Costs of Drug Abuse in the United States, 1992–1998. Publ. No. NCJ-190636. Washington, DC: Executive Office of the President. 104 p.

Plowman, T. 1979. The identity of Amazonian and Trujillo coca. Bot. Mus. Leafl. 27:45–68.

Sands, D. C., E. J. Ford, R. V. Miller, B. K. Sally, M. McCarthy, T. W. Anderson, M. B. Weaver, C. T. Morgan, and L. C. Darlington. 1997. Characterization of a vascular wilt of *Erythroxylum coca* caused by *Fusarium oxysporum* f. sp. *erythroxyli* forma specialis nova. Plant Dis. 81: 501–504.

[SAS] Statistical Analysis Systems. 1997. SAS/STAT Software; Changes and Enhancements Through Release 6.12. Cary, NC: Statistical Analysis Systems Institute. pp. 571–702.

Sherrick, S. L., H. A. Holt, and F. D. Hess. 1986. Effects of adjuvants and environment during plant development on glyphosate absorption and translocation in field bindweed (*Convolvulus arvensis*). Weed Sci. 34: 811–816.

Williams, G. M., R. Kroes, and I. C. Munroe. 2000. Safety evaluation and risk assessment of the herbicide Roundup and its active ingredient, glyphosate, for humans. Regul. Toxicol. Pharmacol. 31:117–165.

ANNEX 142

United States Environmental Protection Agency,
GLYPHOSATE – 2nd Report of the
Hazard Identification Assessment Review Committee (22 Jan. 2002)

OPP OFFICIAL RECORD
HEALTH EFFECTS DIVISION
SCIENTIFIC DATA REVIEWS
EPA SERIES 361

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

TXR: **0050428**

OFFICE OF
PREVENTION, PESTICIDES AND
TOXIC SUBSTANCES

DATE: **1/22/02**

MEMORANDUM

SUBJECT: *GLYPHOSATE* - 2nd Report of the Hazard Identification Assessment Review Committee.

FROM: William Dykstra, Toxicologist.
Registration Action Branch 1
Health Effects Division (7509C)

THROUGH: Jess Rowland, Co-Chair
and
Elizabeth Doyle, Co-Chair
Hazard Identification Assessment Review Committee
Health Effects Division (7509C)

TO: William Donovan, Risk Assessor
Registration Action Branch 1
Health Effects Division (7509C)

PC Code: 417300

On November 20, 2001, the Health Effects Division (HED) Hazard Identification Assessment Review Committee (HIARC) reviewed the recommendations of the toxicology reviewer for GLYPHOSATE with regard to the acute and chronic Reference Doses (RfDs) and the toxicological endpoint selection for use as appropriate in occupational/residential exposure risk assessments. Glyphosate was previously assessed by the HIARC on March 26, 1998. The potential for increased susceptibility of infants and children from exposure to GLYPHOSATE was also evaluated as required by the Food Quality Protection Act (FQPA) of 1996. The purpose of this meeting was to select toxicity endpoints for incidental oral exposures and re-evaluate the endpoints selected for occupational/residential exposures based on the redefined exposure periods. The conclusions drawn at this meeting are presented in this report.

Recycled/Recyclable
Printed with Soy/Canola ink on paper that contains at least 50% recycled fiber

ANNEX 142

Committee Members in Attendance

Members present were: Jess Rowland, William Burnam, Pam Hurley, David Nixon, Paula Deschamp, Susan Makris, and Virginia Fornillo

Member(s) in absentia: Ayaad Assaad, Beth Doyle, Elizabeth Mendez, John Liccione, Jonathan Chen, and Brenda Tarplee

Data evaluation prepared by: William Dykstra, RAB1

Also in attendance were: Karen Whitby, Jeff Herndon, Troy Swackhammer, Dana Vogel, and William Donovan (all of RAB1)

Data Evaluation / Report Presentation

William Dykstra
Toxicologist

1. INTRODUCTION

On November 20, 2001, the Health Effects Division (HED) Hazard Identification Assessment Review Committee (HIARC) reviewed the recommendations of the toxicology reviewer for Glyphosate with regard to the acute and chronic Reference Doses (RfDs) and the toxicological endpoint selection for use as appropriate in occupational/residential exposure risk assessments. A previous evaluation of glyphosate occurred on March 26, 1998. The potential for increased susceptibility of infants and children from exposure to GLYPHOSATE was also evaluated as required by the Food Quality Protection Act (FQPA) of 1996. The purpose of this meeting was to select toxicity endpoints for incidental oral exposures and re-evaluate the endpoints selected for occupational/residential exposures based on the redefined exposure periods.

2. HAZARD IDENTIFICATION

2.1 Acute Reference Dose (RfD)

Study Selected: None §None

MRID No.: None

Executive Summary: None

Dose and Endpoint for Establishing RfD: Not Applicable

Uncertainty Factor (UF): None

Comments about Study/Endpoint/Uncertainty Factor: A review of the toxicology database, including the rat and rabbit developmental studies did not provide an appropriate endpoint attributable to a single dose (exposure) that could be used for acute dietary risk purposes. Additionally, there were no data requirements for acute or subchronic rat neurotoxicity studies since there was no evidence of neurotoxicity in any of the toxicology studies at very high doses and glyphosate lacks a leaving group. Therefore, it would not seem likely to inhibit esterases, which is the presumptive neurotoxic mechanism of concern for all organophosphates.

2.2 Chronic Reference Dose (RfD)

Study Selected: Rabbit Developmental Toxicity Study §83-3(b)

MRID No.: 00046363

Executive Summary: Groups of 16/dose Dutch Belted rabbits were dosed with technical glyphosate at doses of 0, 75, 175, or 350 mg/kg/day between gestation days 6 to 27. Maternal

effects were seen at only the high dose and consisted of diarrhea, nasal discharge and death [10/16]. Developmental effects were not seen at any dose tested. **The NOAEL for maternal toxicity was 175 mg/kg/day and LOAEL for maternal toxicity was 350 mg/kg/day based on clinical signs and mortality. The developmental NOAEL was 350 mg/kg/day (HDT).**

Dose and Endpoint for Establishing RfD: Maternal NOAEL of 175 mg/kg/day based on death, diarrhea, and nasal discharge at the LOAEL of 350 mg/kg/day (LOAEL).

Uncertainty Factor(s): 100 (10x for interspecies differences and 10x for intra species variations)

Chronic RfD = $\frac{\text{175 mg/kg/day (NOAEL)}}{\text{100 (UF)}}$ = **1.75 mg/kg/day**

Comments about Study/Endpoint/Uncertainty Factor: Systemic toxicity manifested most commonly as clinical signs, decreases in body weight and/or body weight at or above the Limit Dose in the subchronic and chronic oral toxicity studies (1-year dog, 2-year mouse, 2-year chronic/ carcinogenic rat, and 2-generation rat reproduction), The NOAELs were reported to be following: the 1-year dog study -NOAEL = 500 mg/kg/day, the 2-year mouse carcinogenicity study -NOAEL = 750 mg/kg/day, 2-year chronic/carcinogenicity rat study -NOAEL = 400 mg/kg/day, and the 2-generation rat reproduction study - NOAEL = 500 mg/kg/day.

The NOAEL selected for establishing the chronic RfD (175 mg/kg/day) was observed to be lower than the NOAELs established in the long-term studies. Rabbits appearing to be the most sensitive of the species tested. Though a developmental toxicity study was selected, the HIARC noted that the RfD is applicable to all population group since the endpoints of concern are maternal toxicity (not *in utero* effects), and these can occur in both males and females. The NOAEL selected however would be protective of the other toxicity seen since they occurred at higher doses.

The HIARC did not apply an additional safety factor for the use of short term study for long term risk assessment because the weight of evidence shows toxicity at much higher doses in the other species and thus would provide adequate protection for long-term risk assessment.

2.3 Occupational/Residential Exposure

2.3.1 Short-Term (1 Day - 1 Month) and Intermediate-Term (1-6 Months) Incidental Oral Exposure

Study Selected: Rabbit Developmental Toxicity Study §83-3(b)

MRID No.: 00046363

Executive Summary: see chronic RfD (Section 2.2)

Dose and Endpoint for Risk Assessment: Maternal NOAEL of 175 mg/kg/day based on death, diarrhea, and nasal discharge at the LOAEL of 350 mg/kg/day (LOAEL).

Comments about Study/Endpoint: The systemic toxicity is appropriate for the population subgroup (infants and children) and duration of concern.

2.3.2 Dermal Absorption

Dermal Absorption Factor: An upper bound dermal absorption factor of 35% was extrapolated based on the ratio of the LOAEL of 350 mg/kg/day in the developmental toxicity study in rabbits and the systemic NOAEL of 1000 mg/kg/day (assumed to be a LOAEL) in the 21 day dermal toxicity study in rabbits.

2.3.3 Short-Term (1-Day to 1 Month) Intermediate-Term (1- 6 Months) , and Long-Term (> 6 Month) Dermal Exposure

Study Selected: None §None

MRID No.: None

Executive Summary: None

Dose and Endpoint for Risk Assessment: Not applicable

Comments about Study/Endpoint: No hazard was identified via the dermal route. In a dermal toxicity study in rabbits (MRID 00098460), repeated dermal applications of technical glyphosate were made at 0, 100, 1000 or 5000 mg/kg/day, 6 hours/day, 5 days/week for three consecutive weeks to male and female New Zealand rabbits. The systemic NOAEL was 1000 mg/kg/day and the LOAEL was 5000 mg/kg/day based on decreased food consumption in females (MRID 00098460). In addition, there is no concern for developmental or reproductive toxicity. Therefore, quantification of dermal risk is not required.

2.3.4 Short-Term (1-Day to 1 Month) Intermediate-Term (1- 6 Months) , and Long-Term (> 6 Month) Inhalation Exposure

Study Selected: None §None

MRID No.: None

Executive Summary: None

Dose/Endpoint for Risk Assessment: Not Applicable

Comments about Study/Endpoint: No hazard was identified via the inhalation route. In a rat subchronic inhalation study (MRID 00137704), male and female Sprague-Dawley rats were exposed by whole body inhalation to analytical concentrations of 0, 0.05, 0.16, or 0.36 mg/L of a 33-1/3% concentration of isopropylamine salt of glyphosate for 6 hrs/day, 5 days/week for 4 weeks. No treatment related effects were noted. **The systemic NOAEL was 0.36 mg/L (HDT).** Additionally, based on the low toxicity of the formulation products (Toxicity Category III or IV) and the physical characteristics of the technical product (wetcake), there is minimal concern for potential inhalation exposure or risk and, therefore, the acute inhalation study was waived for technical glyphosate. In addition, there is no concern for developmental or reproductive toxicity. Therefore, quantification of inhalation risk is not required.

2.3.5 Margins of Exposure for Occupational/Residential Risk Assessments

The acceptable MOEs for residential exposure will be determined by the FQPA Safety Factor Committee. No hazard was identified via the dermal or inhalation routes and quantification of risk is not required.

2.4 Recommendation for Aggregate Exposure Risk Assessments

Aggregate risk assessment is not required since no hazard was identified and quantification of risk is not required for short, intermediate or long term exposures via the dermal and inhalation routes.

3 CLASSIFICATION OF CARCINOGENIC POTENTIAL

3.1 Combined Chronic Toxicity/Carcinogenicity Study in Rats

Executive Summary : Randomized groups of 60/sex/dose Sprague-Dawley rats were fed glyphosate at dietary levels of 0, 2000, 8000, or 20,000 ppm [male: 0, 89, 362, or 940 mg/kg/day; female: 0, 113, 457, or 1183 mg/kg/day]. The NOAEL was 8000 ppm [362 mg/kg/day for males and 457 mg/kg/day for females] and the LOAEL was 20,000 ppm [940 mg/kg/day for males and 1183 mg/kg/day for females] based on decreased weight gain in females, decreased urinary pH in males, increased incidence of cataracts and lens abnormalities in males, and increased absolute and relative liver weight in males. The carcinogenic potential was negative.

MRID No. 41643801

Discussion of Tumor Data: The study showed a slightly increased incidence of pancreatic islet cell adenomas in the low and high dose males; hepatocellular adenomas in the low and high dose males; and thyroid C-cell adenomas in the mid and high dose males and females. The Agency concluded that these adenomas were not treatment-related and glyphosate was not considered to be carcinogenic in this study. The pancreatic islet cell adenomas did not display a positive dose-trend in their occurrence; there was no progression to carcinoma and the incidence of pancreatic hyperplasia was not dose-related. The hepatocellular adenomas were not statistically significant by pair-wise comparison; the incidence was within the range of historical controls; there was no progression to carcinoma and the hyperplasia was not compound-related. The C-cell adenomas were statistically significant by pair-wise comparison and were not dose-related; there was no progression to carcinoma and there was no significant dose-related increase in severity or incidence of hyperplasia in either sex.

Adequacy of the Dose Levels Tested: The highest dose tested was the limit dose of 20,000 ppm in both sexes.

3.2 Carcinogenicity Study in Mice

Executive Summary: Randomized groups of 50/sex/dose CD-1 mice were fed glyphosate in the diet for 2 years at doses of 0, 1000, 5000, or 30,000 ppm [0, 150, 750, or 4500 mg/kg/day]. The systemic NOAEL was 5000 ppm and the LOAEL was 30,000 ppm based on decreased weight gain in both sexes, hepatocyte necrosis and interstitial nephritis in males and increased incidence of proximal tubule epithelial basophilia and hypertrophy in the kidney of females. The carcinogenic potential was negative.

MRID No. 00130406, 00150564

Discussion of Tumor Data The incidence in males of renal tubular adenomas, a rare tumor, was 1, 0, 1, and 3 in the control, low, mid, and high dose groups, respectively. Although the trend was significant, there was no statistical significance by pairwise comparison of the control and high dose group. The incidence at the high dose exceeded the occurrence of historical controls from the testing laboratory. The non-neoplastic findings in the male kidney did not occur in a increased dose-related manner and the tumorigenic findings in the kidney were considered to occur by chance rather than as a result of treatment.

Adequacy of the Dose Levels Tested: The highest dose tested [30,000 ppm] exceeded the limit dose of 7000 ppm for both sexes of mice.

3.3 Classification of Carcinogenic Potential

On June 26, 1991, HED's Cancer Peer Review Committee classified glyphosate as a "Group E " chemical [evidence of non-carcinogenicity for humans) based on the lack of convincing carcinogenicity evidence in adequate studies in two animal species (CPRC Report dated October 30, 1991).

4 MUTAGENICITY

In a bacterial gene mutation assay (MRID 00078620), glyphosate technical was negative for mutagenic activity up to cytotoxicity or 1,000 ug/plate, both in the presence or absence of metabolic activation with S-9, in *Salmonella typhimurium* strains TA 98, TA 100, TA 1535, or TA 1537.

In an in vivo cytogenetics assay (MRID 00132683), glyphosate technical was not clastogenic up to 1,000 mg/kg in bone marrow of both sexes of Sprague-Dawley rats.

In a recombinant assay and a reverse mutation assay (MRID 00078619), glyphosate technical was negative for mutangenicity up to 2,000 ug/disk in the rec-assay with *B. subtilis* H176 (rec+) and M45 (rec-). Glyphosate technical was also negative for mutagenicity both with and without S-9 up to 5,000 ug/plate (or cytotoxicity) with *E. coli* WP2hcrA and *S. typhimurium* TA98, TA100, TA1535, TA1537, and TA1538.

In a HGPRT/Chinese hamster cell assay (MRID 00132681), glyphosate technical was not mutagenic, both with and without S-9, up to the limits of cytotoxicity against standard reference mutagens.

5 FQPA CONSIDERATIONS

5.1 Adequacy of the Data Base

The glyphosate data base is adequate for an FQPA evaluation. Acceptable developmental toxicity studies in rats and rabbits and a 2-generation rat reproduction study are available.

5.2 Neurotoxicity Data

There were no data requirements for acute or subchronic rat neurotoxicity studies since there was no evidence of neurotoxicity in any of the toxicology studies at very high doses and glyphosate lacks a leaving group. Therefore, it would not seem likely to inhibit esterases, which is the presumptive neurotoxic mechanism of concern for all organophosphates.

5.3 Developmental Toxicity

In a prenatal developmental toxicity study (MRID 00046362) , pregnant Sprague-Dawley rats received oral administration of glyphosate (98.7%) in 0.5% aqueous methocel at 0, 300, 1000 or 3500 mg/kg/day during gestation days 6 through 19. **For maternal toxicity, the NOAEL was 1000 mg/kg/day and the LOAEL was 3500 mg/kg/day based on diarrhea, decreased mean body weight gain, breathing rattles, inactivity, red matter around the nose and mouth, and on forelimbs and dorsal head, decreases in total implantations/dam and unviable fetuses/dam, and death (24% of the group). For developmental toxicity, the NOAEL was 1000 mg/kg/day and the LOAEL was 3500 mg/kg/day based on increased number of litters and fetuses with unossified sternebrae, and decreased mean fetal body weights.**

In a prenatal developmental toxicity study (MRID 00046363), pregnant New Zealand white rabbits received oral administration of glyphosate (98.7%) in 0.5% aqueous methocel at 0, 75, 175 or 350 mg/kg/day during gestation days 6 through 27. **For maternal toxicity, the NOAEL was 175 mg/kg/day and the LOAEL was 350 mg/kg/day based on diarrhea, nasal discharge, and death (62.5% of does died by gestation day 21). Developmental toxicity was not observed at any dose tested. For developmental toxicity, the NOAEL was ≥ 350 mg/kg/day (HDT) .**

5.4 Reproductive Toxicity

In a three-generation reproduction study (MRID 00105995), Sprague-Dawley rats received diets containing glyphosate at 0, 3, 10 or 30 mg/kg/day for three generations. For parental systemic toxicity, the NOAEL was 30 mg/kg/day (highest dose tested). The only effect observed was an increased incidence of focal tubular dilation of the kidney (both unilateral and bilateral combined) in the high-dose male F_{3b} pups. However, this effect (focal tubular dilation of the kidneys) was not observed at the 1500 mg/kg/day level in a 2-generation rat reproduction study discussed below. Therefore, the OPP Developmental Peer Review Committee concluded that the effect seen in the three generation study was a spurious rather than glyphosate-related effect. No reproductive or offspring toxicity was observed; NOAELs were ≥30 mg/kg/day.

In a two-generation reproduction study (MRID 41621501), Sprague-Dawley rats received diets containing glyphosate at 0, 2000, 10,000 or 30,000 ppm for two generations. Treatment-related effects observed at 30,000 ppm included soft stools, very frequent, in the F_o and F_1 males and females, decreased food consumption and body weight gain of the F_o and F_1 males and females during the growth (premating) period, and decreased body weight gain of the F_{1a}, F_{2a} and F_{2b} male and female pups during the second and third weeks of lactation. Focal tubular dilation of the kidneys, observed in the 3-generation study, was not observed at any dose level in this study. **Based on the above findings, the parental and developmental (pup) NOAEL's are 500 mg/kg/day and the parental and developmental (pup) LOAEL's are 1500 mg/kg/day. The reproductive toxicity NOAEL is ≥1500 mg/kg/day.**

5.5. Additional information from the literature

No studies were available

5.6 Determination of Susceptibility

The data provided no indication of increased susceptibility of rats or rabbits to *in utero* and/or postnatal exposure to glyphosate. In the prenatal developmental toxicity study in rats, developmental toxicity was seen in the presence of maternal toxicity at the highest dose tested. No developmental toxicity was seen in the rabbits. In reproductions toxicity studies, effects in the offspring were observed only at or above treatment levels which resulted in evidence of parental toxicity.

5.7 Recommendation for a Developmental Neurotoxicity Study

The HIARC recommended that a developmental toxicity study is not required.

i. Evidence that suggest requiring a developmental neurotoxicity study:

None

ii. Evidence that do **not** support a need for a developmental neurotoxicity study:

No evidence of neurotoxicity or neuropathology in adult animals
No evidence of increased susceptibility in rats or rabbits in uteor or in rats following pre/post natal exposure.

6 HAZARD CHARACTERIZATION

Glyphosate is placed in Toxicity Category IV for the oral and dermal routes because of its low toxicity (Oral LD_{50}>5000 mg/kg; LD_{50}>5000 mg/kg). It is placed in Toxicity Category III and IV respectively, for eye and dermal irritation. Glyphosate is not a dermal sensitizer. The acute inhalation study was waived, however, no respiratory or systemic toxicity was seen following subchronic inhalation exposure. In the subchronic and chronic oral toxicity studies (1-year dog, 24-month mouse 2-year chronic/ carcinogenic rat, and 2-generation rat reproduction), systemic toxicity manifested most commonly as clinical signs, decreases in body weight and/or body weight gain, decreased food consumption, and/or liver and kidney toxicity at or at doses above the limit dose. No dermal or systemic toxicity was seen following repeated dermal exposures. There was no quantitative or qualitative evidence for increased susceptibility following in utero exposure to rats and rabbits or following pre/post natal exposure to rats. Glyphosate was not mutagenic in a full battery of assays. Based on the lack of evidence for carcinogenicity in two acceptable studies in mice and rats, glyphosate is classified as a "Group E" chemical (no evidence of carcinogenicity to humans).

7 DATA GAPS

None

8 ACUTE TOXICITY

Acute Toxicity of GLYPHOSATE

Guideline No.	Study Type	MRID #(S).	Results	Toxicity Category
81-1	Acute Oral	41400601	LD_{50} > 5,000 mg/kg	IV
81-2	Acute Dermal	41400602	LD_{50} > 5,000mg/kg	IV
81-3	Acute Inhalation	none	The requirement was waived	none
81-4	Primary Eye Irritation	41400603	Corneal Opacity or Irritation Clearing in 7 Days or Less	III
81-5	Primary Skin Irritation	41400604	mild or slight irritant	IV
81-6	Dermal Sensitization	41642307	not a sensitizer	none

ANNEX 142

9 SUMMARY OF TOXICOLOGY ENDPOINT SELECTION

The doses and toxicological endpoints selected for various exposure scenarios are summarized below.

EXPOSURE SCENARIO	DOSE (mg/kg/day)	ENDPOINT	STUDY
Acute Dietary	An endpoint attributable to a single dose was not available from the oral toxicity studies, including the rat and rabbit developmental studies.		
Chronic Dietary	NOAEL = 175 UF = 100	Maternal toxicity based on mortality and clinical signs (diarrhea and nasal discharge) at 350 mg/kg/day	Developmental toxicity -Rabbit
		Chronic RfD = 2.0 mg/kg/day	
Incidental Oral, Short-, and Intermediate-Term	NOAEL= 175	Maternal toxicity based on mortality and clinical signs (diarrhea and nasal discharge) at 350 mg/kg/day	Developmental toxicity -Rabbit
Dermal, Short-, Intermediate-, and Long-Term	No hazard was identified, therefore quantification of dermal risk is not required. No systemic toxicity was seen at the Limit Dose following repeated dermal applications, and there are no concerns for developmental or reproductive toxicity.		
Inhalation, Short-, Intermediate-, and Long-Term	No hazard was identified, therefore quantification of inhalation risk is not required. No systemic toxicity was seen at the Limit Dose following repeated dermal applications, and there are no concerns for developmental or reproductive toxicity.		

ANNEX 143

United States Environmental Protection Agency,
Office of Prevention, Pesticides and Toxic Substances, *Report on Issues Related to the Aerial Eradication of Illicit Coca in Colombia, Response from EPA Assistant Administrator Johnson to Secretary of State* (19 Aug. 2002)

U.S. DEPARTMENT OF STATE
DIPLOMACY IN ACTION

Response from EPA Assistant Administrator Johnson to Secretary of State, August 19, 2002

Report on Issues Related to the Aerial Eradication of Illicit Coca in Colombia

September 2002

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

U.S. Environmental Protection Agency Office of Pesticide Programs Details of the Consultation for Department of State Use of Pesticide for Coca Eradication Program in Colombia, August 2002

Table of Contents

ANNEX 143

2

-

-

EXECUTIVE SUMMARY

CONSULTATION REVIEW OF THE USE OF PESTICIDE FOR COCA ERADICATION IN COLOMBIA

BACKGROUND

FINDINGS

- -

- -

-

per se

SECTION 1. Description of Glyphosate Use in the U.S. for Comparison to Use in Colombia for Coca Eradication

INTRODUCTION:

SUMMARY:

USE OF GLYPHOSATE IN THE UNITED STATES

AGRICULTURAL SITES:

NON-AGRICULTURAL USES INCLUDING FORESTRY:

	-	-	-
	-	-	-
	-	-	-

PROPERTIES OF GLYPHOSATE:

FORMULATIONS OF GLYPHOSATE:

GLYPHOSATE USED WITH SURFACTANT FOR FOLIAR ABSORPTION:

REFERENCES:

REFERENCES:

SECTION 2. Human Health Risk Assessment for the Use of Glyphosate Herbicide as Part of the Aerial Eradication Program of Coca in Colombia, S.A.

I INTRODUCTION

II EXECUTIVE SUMMARY

USE PATTERN

-

HAZARD ASSESSMENT

Cosmo-Flux 411F

- *(information not included as it may be entitled to confidential treatment)*
(information not included as it may be entitled to confidential treatment)

Glyphosate

- - -
-

in utero -

- - -
- -

EXPOSURE

- -

dietary exposure

Handler (e.g., individuals mixing the concentrated formulated product to prepare the tank mix and loading the tank mix in the aircraft) exposure - - - -

- **post-application exposures**

- -
- - -

- -
-

ANNEX 143

spray drift

incident reports

-

glyphosate formulated product

glyphosate technical

formulated

formulated

-

- -

eye exposure

III BACKGROUND

-

In finalizing the current document, FEAD and HED consulted with OPP's Information Resources and Services Division/Public Information and Records Integrity Branch regarding CBI. It was determined that the document did contain some CBI and therefore, some sections have been adapted

in utero

IV HISTORICAL REGULATORY INFORMATION

-

- -

V HAZARD IDENTIFICATION

Glyphosate

- - - -

in utero -

-

Components of the Glyphosate Product

1. Polyoxyethylene alkylamine (POEA)

et al.

et al.

et al.

2. *(information not included as it may be entitled to confidential treatment)*

(information not included as it may be entitled to confidential treatment) *(study citation not included as it may be entitled to confidential treatment)* *(information not included as it may be entitled to confidential treatment)* *(information not included as it may be entitled to confidential treatment)* - *(information not included as it may be entitled to confidential treatment)* *(information not included as it may be entitled to confidential treatment)* *(study citation not included as it may be entitled to confidential treatment)* *(information not included as it may be entitled to confidential treatment)*

(study citation not included as it may be entitled to confidential treatment) *(information not included as it may be entitled to confidential treatment)* *(study citation not included as it may be entitled to confidential treatment)*

Cosmo - Flux 411F Adjuvant)

-

-

- *(information not included as it may be entitled to confidential treatment)* *(information not included as it may be entitled to confidential treatment)*

Components of Cosmflux

1. *(information not included as it may be entitled to confidential treatment)* *(information not included as it may be entitled to confidential treatment)*

2. *(information not included as it may be entitled to confidential treatment)* - *(information not included as it may be entitled to confidential treatment)* *(information not included as it may be entitled to confidential treatment)* *(information not included as it may be entitled to confidential treatment)*

VI DOSE RESPONSE ASSESSMENT

-

Glyphosate

March 26, 1998 and, again, on November 20 2001

-

- -

-

- -

- -

Table 1. Glyphosate Endpoint Selection Table

			-

ANNEX 143

-

-

-

III Ecological Risk Assessment

Glyphosate

Terrestrial

-

-

Aquatic

- -

Daphnia magna

- - -

- -

-

-

- -

Selenastrum capricornatum) *Lemna gibba)*
Navicula pelliculosa

Risk Specific to Formulations of Glyphosate

-

-

-

ANNEX 144

United States Department of State,
Bureau for International Narcotics and Law Enforcement Affairs,
Report on Issues Related to the Aerial Eradication of Illicit Coca in Colombia: Chemicals Used in the Aerial Eradication of Illicit Coca in Colombia and Conditions of Application (Sep. 2002)

U.S. DEPARTMENT OF STATE
DIPLOMACY IN ACTION

Chemicals Used for the Aerial Eradication of Illicit Coca in Colombia and Conditions of Application

Report on Issues Related to the Aerial Eradication of Illicit Coca in Colombia

September 2002

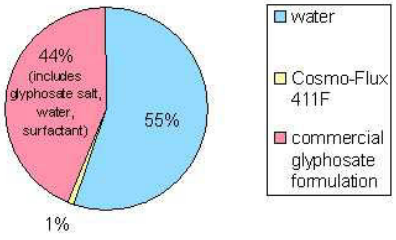
-

- -

-

- -

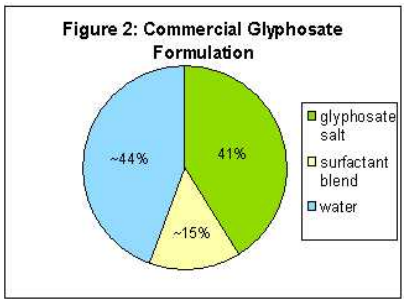
Figure 1: Coca Spray Mixture



Commercial glyphosate formulation:

-

Figure 2: Commercial Glyphosate Formulation

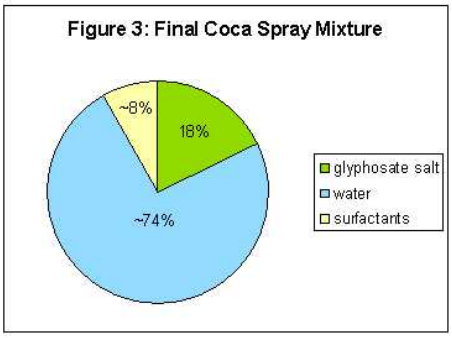


Surfactant:

-

ANNEX 144

Cosmo-Flux 411F:



Spray mixing and handling:

Storage and disposal of spray mixture:

Aircraft and spray equipment:

Spray pilots:

Reconnaissance:

Spray parameters:

ANNEX 144

Spraying and human and environmental health:

Eradication oversight:

ANNEX 145

(DOCUMENT INTENTIONALLY OMITTED)

ANNEX 146

United States Environmental Protection Agency, Office of Pesticide Programs, *Details of the 2003 Consultation for the Department of State: Use of Pesticide for Coca and Poppy Eradication Program in Colombia* (June 2003)

ANNEX 146

U.S. ENVIRONMENTAL PROTECTION AGENCY

OFFICE OF PESTICIDE PROGRAMS

DETAILS OF THE 2003 CONSULTATION FOR THE DEPARTMENT OF STATE

USE OF PESTICIDE FOR COCA AND POPPY ERADICATION PROGRAM IN COLOMBIA

JUNE 2003

ANNEX 146

I. PESTICIDE USE ASSESSMENT

A. Introduction

The Biological and Economic Analysis Division (BEAD) in the Office of Pesticide Programs within the Environmental Protection Agency (EPA) has augmented the 2002 EPA assessment and description of the use of glyphosate in the United States (1) as a basis for comparison to glyphosate use in Colombia for coca eradication with a discussion of changes in the program for 2003. This request has come from the Department of State (DoS) which is required to consult with the EPA before reporting to Congress on the use of glyphosate for the Andean counter drug initiative. This year DoS is required to include glyphosate for control of opium poppy in its consultation. This document compares the described use on opium poppy and coca to use within the US.

B. Summary

The use of glyphosate for control of opium poppy is conducted at 1 lb ai/acre (0.8 lb a.e/acre) and at a spray mixture (product + water diluent + Cosmoflux 411F surfactant) volume of about 5.5 gallons per acre (50 liters/hectare). This application rate is within the label recommendations for the amount of concentrated formulation per acre and the amount of total spray volume per acre for application for glyphosate products registered for use in the US.

C. Background

Glyphosate is the most widely used herbicide in the US (1). It is non-selective in action and is used where total vegetation control is desired. It is used on a variety of sites including agricultural crops, lawns, gardens, forests and utility grounds. Application is made to the target plant's foliage, and after being absorbed, glyphosate circulates within the plant, exerting herbicidal activity systemically. Glyphosate and its use within the US were described in the 2002 EPA assessment. In its assessment report, EPA described the use of glyphosate in the US in the following paragraph:

> "Glyphosate may be used on over 400 crop and non-crop sites. The largest agricultural use sites include soybeans, cotton and field corn. In addition to agricultural use, EPA estimates that 16-22 million pounds of the technical grade active ingredient were applied to non-agricultural sites in 1999 (this is the most recent year for which adequate data are available). This estimate includes both home owner and professional applications as well as use on forested lands. Based on EPA data for 1999, an estimated 1-2 million pounds of glyphosate was applied to forest acres, with more than 650,000 forest acres treated."

In 2002, a description of glyphosate use in forestry sites in the US was included since use for coca eradication would be most similar to the US labeled use for broad-spectrum post-emergence weed control for forestry site preparation and utility rights-of-way. For coca eradication, glyphosate is sprayed from fixed wing aircraft at speeds around 165 mph at 4.4 pounds active ingredient (isopropylamine salt) per acre in about two gallons of spray mixture per acre.

Aerial application of the glyphosate product to non-crop, non-timber, industrial and rights-of-way areas in the US is allowed using fixed wing aircraft and helicopter to control annual and perennial weeds and woody brush and trees. Although application may be made at up to 10 lb ai/year per acre in the US, the typical use rate per application is much lower, averaging less than one pound per acre on major agricultural sites (EPA has no data on average application rate to forest sites). In addition, product labeling recommends application at 3 to 15 gallons of total spray mixture volume per acre for aerial application to forestry sites.

D. Opium Poppy Eradication

Glyphosate used for the opium poppy eradication program is also applied aerially, however its use differs in several ways from the coca eradication program:

1. Total area sprayed is much smaller for poppy eradication. The State Department explains that:

> "Because Colombia cultivates much less opium poppy than coca and spray resources are limited, aircraft spray much more coca than poppy, therefore expending more spray chemicals in coca growing areas than in areas where opium poppy is cultivated. For example, in 2002, eradication aircraft sprayed totals of 122,700 hectares of coca [about 303,000 acres] and 3,000 hectares [about 7400 acres] of opium poppy."

2. Individual poppy spray sites are smaller and located at higher elevations. The State Department states:

> "While difficult to quantify precisely, opium poppy fields generally range from 0.5 to 5 hectares. Opium poppy is ordinarily cultivated at a higher altitude than coca, and thus opium poppy often is cultivated and sprayed in hilly to mountainous terrain."

3. The rate (or dose) of glyphosate for poppy eradication is lower than that for coca eradication. The State Department states:

> "Because the opium poppy is not a woody, hard-to-control species like the coca bush, opium poppy eradication uses a spray mixture with a substantially lower glyphosate content than the spray mixture used for coca eradication."

The Department of State described the concentrate formulation for use in 2003 as containing 41 percent glyphosate salt and 59 percent inert ingredients. The same concentrate formulation is being used for both coca and opium poppy eradication (1). Other similar products with this proportion of active to inert ingredients are registered with the US Environmental Protection Agency for use in the US on forestry and utility rights-of-way sites. A surfactant is added to the diluted spray mixture prior to spraying. This practice improves absorption of the herbicide by the plant and is standard practice for applying glyphosate to forestry sites in the US.

For opium poppy spraying, water, formulated glyphosate, and surfactant are combined in a spray mixture in the following percentages: 94 percent water, 5 percent glyphosate formulation, and 1 percent surfactant. This diluted spray mixture is applied to opium poppy at the rate of 50.0

battery of assays. Based on the lack of evidence for carcinogenicity in two acceptable studies in mice and rats, glyphosate is classified as a "Group E" chemical (no evidence of carcinogenicity to humans).

Components of the Glyphosate Product

1. Polyoxyethylene alkylamine (POEA). POEA is a compound that is used as a surfactant with many glyphosate formulations. In a safety evaluation and risk assessment of glyphosate, the Roundup formulation and the surfactant POEA, Williams *et al.* (2000) reported that POEA can cause severe skin irritation and be corrosive to the eyes. In subchronic oral studies, POEA was mainly a gastrointestinal irritant in rats at high doses (~ 100 mg/kg/day) and in dogs at lower doses (30 mg/kg/day). In a developmental toxicity study in rats, POEA did not cause any developmental effects up to 300 mg/kg/day, but did induce maternal toxicity at 100 and 300 mg/kg/day (Farmer *et al.*, 2000). The concentrated formulated Roundup product can also be strongly irritating to the eyes and slightly irritating to the skin (Williams *et al.*, 2000).

2. (*information not included as it may be entitled to confidential treatment*). (*information not included as it may be entitled to confidential treatment*) are substances that are not highly toxic by oral or dermal routes and are not irritating to the skin. They may cause mild, transient eye irritation. Many *(information not included as it may be entitled to confidential treatment*) are known not to be sensitizers (*information not included as it may be entitled to confidential treatment*). The molecular weight of a *(information not included as it may be entitled to confidential treatment*) determines its biological properties, and, thus, its toxicity. The lower molecular weight (*information not included as it may be entitled to confidential treatment*) tend to be more toxic than the higher-weighted (*information not included as it may be entitled to confidential treatment*) and are absorbed by the digestive tract and excreted in the urine and feces, while the higher molecular weight *(information not included as it may be entitled to confidential treatment*) are absorbed more slowly or not at all *(information not included as it may be entitled to confidential treatment*). (*information not included as it may be entitled to confidential treatment*) have low acute and chronic toxicity in animal studies. No significant adverse effects have been noted in inhalation toxicology studies, carcinogen testing, or mutagen assays. High oral doses have resulted in toxic effects to the kidneys and loose feces (*information not included as it may be entitled to confidential treatment*). Topical dermal application of (*information not included as it may be entitled to confidential treatment*) to burn patients with injured skin has resulted in toxicity. (*information not included as it may be entitled to confidential treatment*).

Cosmo - Flux 411F (Adjuvant)

The Cosmo-Flux 411F adjuvant product used in the glyphosate tank mix is produced by a Colombian company and is not sold in the U.S. The Agency is not in possession of toxicity data from direct dosing of test animals with Cosmo-Flux 411F. However, the Agency has made safety findings based on the toxicity of the individual components. As stated above, sale or use of spray adjuvant products in the U.S. are generally not regulated by EPA. However, the DoS

has provided the EPA with a copy of this product's label and a description of the product ingredients. To be able to provide an opinion on hazard characterization of the Cosmoflux ingredients, the EPA relied on available technical information from various sources. Cosmo-Flux 411F consists mainly of (*information not included as it may be entitled to confidential treatment*) with a nonionic surfactant blend primarily composed of (*information not included as it may be entitled to confidential treatment*). All ingredients of this product are substances that are not highly toxic by oral or dermal routes. They may cause mild eye and skin irritation. All components of the adjuvant have been approved for use in/on food by EPA (40 CFR 180.1001.

Components of CosmoFlux (Considered as CBI)

1. (*information not included as it may be entitled to confidential treatment*). The (*information not included as it may be entitled to confidential treatment*) can cause dermal and ocular irritation and, in high doses orally, can cause significant toxicity. However, small amounts are not a concern and these substances have been approved as food additives by the FDA and are exempt from tolerances by EPA on certain commodities.

2. (*information not included as it may be entitled to confidential treatment*). The other major component of Cosmo-Flux 411F, (*information not included as it may be entitled to confidential treatment*), is not considered highly toxic. It may cause mild eye and skin irritation. The corresponding monoester, (*information not included as it may be entitled to confidential treatment*), has low subacute, subchronic and chronic oral toxicity and is used as a direct food additive and a component in cosmetics. The higher molecular weight triester is less likely to be absorbed orally or dermally and most likely of less toxicological concern. The other minor components, are not known to be highly toxic compounds and would not be of toxicological concern at the concentrations and conditions in which they are used.

E. Dose Response Assessment

Dose response analysis is the second step in the risk assessment process i.e.; characterization of the quantitative relationship between exposure (dose) and response based on studies in which adverse health effects have been observed. The objective is to identify endpoints of concern which correspond to the route and duration of exposure based on the exposure patterns.

HED selects doses and endpoints (effects of concern) for risk assessment via an internal peer review process. HED uses a standing Committee - the Hazard Identification Assessment Review Committee (HIARC), to consider the available hazard data (studies required to be submitted by registrants in 40 CFR part 158 and open peer reviewed literature) to identify endpoints for use in risk assessment.

Ideally, each safety study identifies a dose level that does not produce a biological or statistically significant increased incidence of an adverse effect or no observable adverse effect level (NOAEL). The threshold dose is the smallest dose required to produce a detectable effect. Below this dose, there is no detectable response.

III. ECOLOGICAL RISK ASSESSMENT

A. Introduction

At the request of the Department of State (DoS), the Office of Pesticide Programs (OPP) of the U.S. Environmental Protection Agency (EPA) provides here an ecological risk assessment for the aerial coca and poppy eradication programs in Colombia. The Environmental Fate and Effects Division (EFED) performed a risk assessment for coca eradication in response to a similar request by DoS in 2002. That assessment concluded that the active ingredient glyphosate itself would likely pose little risk to non-target terrestrial and aquatic animals, but that non-target terrestrial plants would likely be damaged some distance from the intended spray area due to spray drift of glyphosate.

The proposed use of glyphosate on coca will be little changed from that described in 2002, with the exception of the use of a different glyphosate product in 2003. This will reduce the potential for eye irritation, and therefore may provide some benefit to people and terrestrial animals exposed to the spray. Other aspects of the proposed use remain the same, including the use of adjuvant CosmoFlux 411F. Therefore, as detailed below, the expected risks and uncertainties in EPA's environmental risk assessment remain essentially the same as described the previous year.

The request for a risk assessment for the use of glyphosate to control poppy production is new for 2003. However, as described below, the expected risks and uncertainties corresponding to this use are nearly identical to those for the coca use. The application rate of glyphosate is less for poppies than for coca, and therefore the risk to terrestrial animals is expected to be low. The potential for glyphosate runoff may be much greater for poppies, since the sprayed fields can be located on mountainsides. However, as detailed in the 2002 assessment for coca eradication, the concentration of active ingredient glyphosate that might be derived even from direct application to a small pond should not result in significant risk to non-target aquatic animals or plants. Therefore, runoff from the poppy or coca sprays would not be expected to pose a significant risk to non-target aquatic organisms.

The primary risk that might be associated with the poppy eradication program is that from spray drift to non-target terrestrial plants. As with coca applications, application to poppy fields will require application at speeds and application heights greater than might be desirable for drift control, due to the safety precautions needed for eradication sprays down a potentially forested mountainside. The added factor of steep slopes make it likely that spray drift from the lower rate poppy sprays could extend a greater distance than that from the coca eradication sprays which are understood to occur on more level terrain.

B. Ecological Risk Characterization

The following risk characterization for the coca eradication use is adapted from the 2002 ecological risk assessment for the use of glyphosate herbicide as part of the U.S. supported aerial eradication program of coca in Colombia:

The use of a glyphosate spray for coca and poppy eradication is unlikely to cause adverse effects to

terrestrial or aquatic animals but is likely to pose a substantial risk to nearby non-target plants. Vegetative vigor toxicity laboratory tests performed using a formulated glyphosate product (glyphosate acid WP 48.3%) on North American crops indicated toxicity to terrestrial plants with applications of less than 1.0 lb of the isopropylamine salt of glyphosate per acre, which corresponds to 0.75 lb acid equivalents (a.e.) per acre. The coca use rate is 1.11 gallons glyphosate/acre (3.34 lb acid equivalents/acre) for direct, aerial application to coca. A second application is possible if fields are replanted, or the first is determined after 3 to 6 months to have been inadequate. Because poppies are reportedly more sensitive to glyphosate, a lower application rate of 0.27 gallon/acre (0.8 lb a.e./acre) is used in spraying for poppy eradication. The DoS reports that the spray mixture for poppy eradication would include 5% formulated glyphosate, 1% Cosmo-Flux 411F, and 95% water (as opposed to 44%, 1% and 55%, respectively for the coca spray). The product claimed by the DoS to be used ib Colombia is widely used in the US on a variety of agricultural commodities and non-agricultural sites.

EPA used the AgDRIFT model to estimate potential spray drift. The model suggests that non-target plants hundreds of feet away may be exposed to a fraction of glyphosate applied to coca or poppy fields. Some of the important application parameters for estimating spray drift levels from coca and poppy eradication application are shown in Table 1.

Table 1. Important application parameters for defining off-target spray drift levels in coca and poppy eradication.

Application parameter	Coca spraying	Poppy spraying	Effect on off-target exposure
Application rate	3.34 lb a.e./acre	0.8 lb a.e./acre	Lower application rates result in lower off-target exposure
Flight speed during application	200 mph	135-145 mph	Lower flight speeds result in less secondary droplet break up, larger droplets, less drift, and lower off-target exposure
Estimate wind speed range	0-10 mph	0-4 mph	Lower wind speeds results in less movement of spray droplets off-target (i.e. lower drift)
Estimated droplet size range	300-1500 mm	300-1000 mm	Larger droplets are less prone to be blown off-target
Estimated release heights	<100 feet	30 -120 feet	Lower release heights result in shorter fall times for droplets and less opportunity to be blown off-target
Boom width	not available	70% of wingspan	Narrow boom widths result in fewer droplet being caught in wing tip vortices and lower drift levels
Slope	not available	not available	Drift can be carried farther when winds are blowing down steeper slopes

Figure 1.

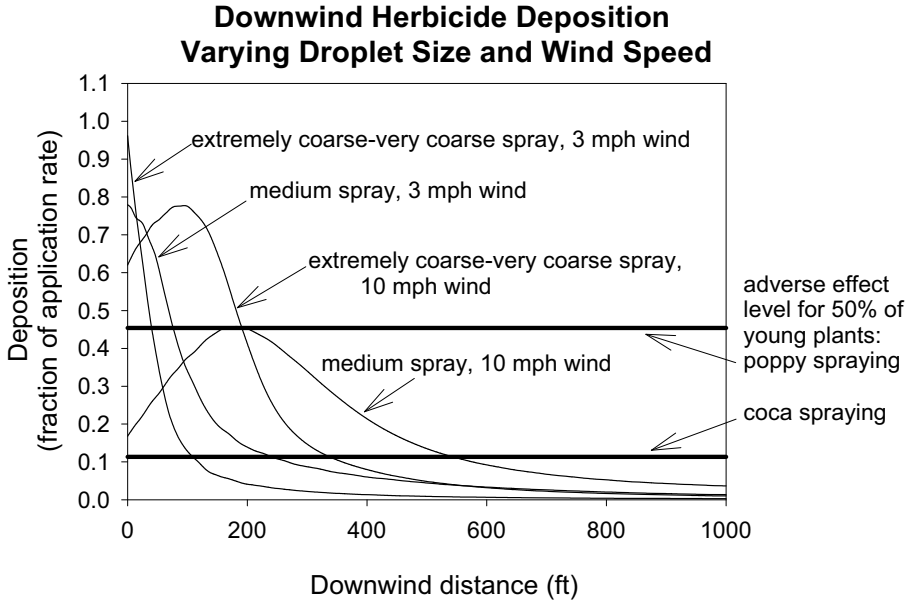


Figure 1 shows the lowest levels of drift are associated with applications using the extremely coarse to very coarse sprays at a 3 mph wind speed. The highest levels of drift are associated medium sprays at wind speeds of 10 mph. Downwind deposition levels from coca and poppy spraying is likely to be bounded by these estimates. The "effect level for 50% of young plants" is based of glyphosate toxicity studies on ten young crop plants. Older plants are generally less sensitive to herbicides than young, rapidly growing plants. At the level corresponding to approximately 11% and 44% of the coca and poppy application rates, respectively, 50% of plants species would be expected to show measurable reductions in dry weight. With a 10 mph wind, plants would be expected to be exposed at this 50% affect level up to 200 feet downwind of poppy spraying and 550 feet downwind of coca spraying. Of the affected plants some would likely recover while more sensitive plants may die, have reduced reproductive success, or reduced yields (crop plants).

There is uncertainty whether crops or other plants in Colombia, whether similar to crops tested in the US or not, would be affected similarly at the same exposure levels. However, since glyphosate is an effective, broad spectrum herbicide, risk to non-target plants outside of the application zone would be expected. The Agency's Ecological Incidents Information Sytem (EIIS) database includes several hundred reports of possible non-target plant incidents in the US attributed to use of glyphosate.

The use of the active ingredient glyphosate itself in poppy and coca eradication would not pose a significant direct risk to terrestrial or aquatic animals, although secondary adverse effects from the loss of habitat in the spray area are likely. Neither acute nor chronic adverse effects were observed in mammalian and avian laboratory toxicity tests submitted to the EPA by US industry, using the active ingredient alone.

Mortality was observed in fish and aquatic invertebrate studies. However, the resulting acute LC_{50} values (concentrations at which half the test animals died), and lowest effect levels for chronic effects, were in parts-per-million. Toxicity endpoints for aquatic plants also ranged from 0.85 to 39.9 ppm. Considerably lower surface-water exposure, in the parts-per-billion, could be expected from the use on coca or poppy using runoff simulations from Agency exposure models PRZM and EXAMS. The Agency considered an even more conservative scenario, estimating the concentration that would result from the direct application of 3.75 lb acid eq./acre of glyphosate to a 1-acre, 6-foot deep pond. The calculated maximum concentration of 230 ppb is well below the toxicity values measured for aquatic organisms in the laboratory.

It is possible that much greater exposure could occur from direct overspray of water bodies much smaller than a 1-acre, 6-foot deep pond, but such simulation is not a standard component of Agency risk assessments. The product label for glyphosate prohibits such direct overspray of water bodies, but it is possible that some ecologically important water bodies too small or ephemeral to appear on maps could be sprayed directly in a project as large as the coca eradication program.

Although the measured toxicity and estimated exposure indicate that only non-target terrestrial plants are likely to be adversely affected by the use on coca and poppy, there are important uncertainties that should be considered. One of these is the extrapolation of North American data to the conditions and wildlife found in Colombia. The toxicity of a pesticide to different classes of animals and plants can vary widely among species within an individual ecosystem. The Agency uses the test species as surrogates for other North American species not tested, but has little experience with tropical flora and fauna. Similarly, laboratory and field estimates of the environmental fate of pesticides, including potential surface-water contamination, are performed with North American soils, hydrology and climate data. The uncertainty of extrapolating North American exposure and effects data to this risk assessment would most effectively be reduced by identification of characteristics which define sensitive tropical ecosystems.

An important uncertainty in this risk assessment concerns differences in the tank mix used in Colombia from those used in the US. The Agency does not have ecological toxicity information on adjuvant Cosmo-Flux 411F, which is neither manufactured nor sold in the US. However, all of the individual components (surfactants) which comprise the adjuvant are substances with low oral and dermal mammalian toxicity. The toxicity of the blend of these surfactants is not known; although the Agency often requires formulation toxicity data for non-target plants and aquatic organisms, tank-mix adjuvants are not required to be included in these studies.

ANNEX 147

United States Department of Agriculture, Agricultural Research Service, *Pathogens of Narcotic Crops and Their Use in Biological Control Strategies to Reduce Narcotics* (1 Oct. 1998 – 30 Sep. 2003)

Back to Display | Exit to Menu | Exit to Home

Brief Format | Standard Tech. Report

Full w/Pub.History

Item No. 1 of 1

ACCESSION NO: 0402295 **SUBFILE:** CRIS
PROJ NO: 1275-22000-156-00D **AGENCY:** ARS 1275
PROJ TYPE: USDA INHOUSE **PROJ. STATUS:** NEW
START: 01 OCT 1998 **TERM:** 30 SEP 2003 **FY:** 1999

INVESTIGATOR: BAILEY, B. A.; VACANT; VACANT; FRAVEL, D. R.

PERFORMING INSTITUTION:
BELTSVILLE AGR RES CENTER
BELTSVILLE, MARYLAND 20705

PATHOGENS OF NARCOTIC PLANTS AND THEIR USE IN BIOLOGICAL CONTROL STRATEGIES TO REDUCE NARCOTICS

OLD PRIMARY CLASSIFICATION				
RPA	ACTVTY	CMMDTY	SCNCE	PRCNT
205	4600	2800	0712	010
205	4600	2800	0714	010
205	4600	2800	0914	010
205	4600	2800	1112	010
206	4700	2800	0212	010
206	4700	2800	0712	010
206	4700	2800	1112	010
209	4700	2800	0212	010
209	4700	2800	0712	010
209	4700	2800	1112	010

OLD PRIMARY HEADINGS: A4600 . Protection Against Diseases, Parasites; C2800 . Miscellaneous and New Crops; F0712 . Microbiology-Plant; R205 . Disease Control-Fruit, Vegetables; F0714 . Microbiology-Soils; F0914 . Nutrition and Metabolism-Other; F1112 . Pathology-Plant; A4700 . Protection Against Weeds; F0212 . Biology-Environmental, Systematic-Plant; R206 . Weed and Hazard Control-Fruit, Vegetables; R209 . Weed and Hazard Control-Field Crops

NEW CLASSIFICATION			

RPA	SUBJECT	SCIENCE	PRCNT
216	2221	1102	040
216	2221	1140	030
216	2221	1160	030

NEW HEADINGS: R216 . Integrated Pest Management Systems; S2221 . Narcotic plants; F1102 . Mycology; F1140 . Weed science; F1160 . Pathology

SPECIAL CLASSIFICATION AND HEADINGS
S2821 . Narcotic Plants -- 100%

BASIC 070% **APPLIED** 010% **DEVELOPMENTAL** 020%

OBJECTIVES: Identify new microorganisms with potential for use as natural herbicides for control of narcotic plants. Determine the epidemiology and infection processes of new organisms and develop fermentations, formulations and delivery systems for use against narcotic plants. Assess the potential impact natural herbicides have on target and nontarget organisms in the environment. Characterize the interaction between microorganisms and the narcotic host plants to allow for optimum control.

APPROACH: Selected microorganisms, including fungi which cause foliar and soilborne diseases, will be obtained from areas with indigenous weed target plants. Koch's postulates will be performed and factors favoring rapid disease development will be determined. Methods will be devised to grow biomass in liquid fermentors and formulate biomass in a form that can be delivered by aerial application. The mode of action will be determined and means for tagging the microorganism for field detection will be devised with use of microbial physiology and molecular biology techniques. The ecological relationships between plant pathogens and other organisms in the environment will be determined with the use of molecular biology and recombinant DNA techniques. Beltsville, MD, Bldg 011A, Rm 275, BL-2 for transformation work; BL-3 for plant treatment work; BA Biosafety Committee Approval on 11/30/99. Scientists and technicians associated with the project: Bryan A. Bailey and Mary Strem.

KEYWORDS: BIOLOGICAL CONTROL HERBICIDE PHYTOTOXIN MECHANISM NARCOTIC PLANTS WEEDS FOLIAR

PROGRESS: 1999/01 TO 1999/09
1. What major problem or issue is being resolved and how are you resolving it? The Agricultural Research Service has been charged with the development of control strategies for narcotic crops, including biological control measures. Biological control strategies have potential advantages over chemical control strategies which include specificity, low environmental impact, and in some cases, long term control. Extensive research must be carried out to determine the mode of action involved in the biocontrol strategy, to determine the impact of the environment on the biocontrol strategy, to determine the impact of the biocontrol strategy on the environment, and to develop the biocontrol strategy for large-scale application. In addition, biocontrol strategies are needed for diseases of crops that can be alternatives to growing illicit narcotic crops. **2. How serious is the problem? Why does it matter?** The illegal use of narcotics derived from the plant species Erythroxylum coca (coca), Papaver somniferum (opium poppy) and Cannabis sativa (marijuana) is pervasive throughout society in the US and around the world. The cost of the illegal use of narcotics to our society in both

monetary and human terms is staggering. The monetary loss in the US alone is estimated at $70 billion with 14,000 deaths annually (1997 National Drug Control Strategy). **3. How does it relate to the National Program(s) and National Component(s) to which it has been assigned?** This project is associated with National Program 304 with 100% on Crop Protection and Quarantine. Biocontrol of narcotic plants is directly related to both biocontrol of plant diseases and biocontrol of weeds. The fermentation and formulation technologies developed are transferable to both areas. Pathogens related to those being studied have and are being considered for biocontrol of weeds in many situations. Related organisms are also being considered for control of plant diseases and many of the same principles apply to both strategies. The basic research carried out contributes to the science of plant pathology by increasing our understanding of disease processes and mechanisms of plant/pathogen/microbial antagonist interactions. **4. What were the most significant accomplishments this past year?** Bioherbicides, which contain plant pathogenic fungi as the active component, are being developed as potential control measures for opium poppy. Pleospora papaveracea was evaluated in 1998 and 1999 field tests in Beltsville, MD. These field tests were designed to identify formulations which improved the activity of Pleospora papaveracea as a bioherbicide for the control of illegal opium poppy production. In addition, a liquid fermentation process for Pleospora papaveracea biomass production was developed. In a second area of research, the gene (NEP1) for a 24 kDa fungal protein (Nep 1) toxic to dicot plants including narcotic species was cloned. The gene was used to manipulate toxin production by fungi in order to determine its importance in the plant-microbe interaction. The protein has potential as a purified product to act as a contact herbicide and enhance biocontrol activity of some fungi. A program was organized and initiated to begin studies on biocontrol of serious diseases of cacao, a primary alternative crop to be grown in place of illicit narcotic plants. **5. Describe the major accomplishments over the life of the project including their predicted or actual impact.** The BPDL has been very successful in developing a biocontrol strategy for Erythroxylum coca. This has included developing the pathogen Fusarium oxysporum f. sp. erythroxyli isolate EN-4 through fermentation and formulation of biomass, and field testing, resulting in a defined biocontrol strategy ready for scale-up and deployment. A liquid fermentation technique was developed which produced a stable chlamydospore preparation suitable for incorporation into granular formulations. The growth medium consists of readily available and inexpensive agricultural byproducts. In addition to the use of available formulation processes, a new formulation was developed which has good storage characteristics. Field tests of the various formulations showed they were excellent at infesting soil with high populations of the pathogen and causing enhanced disease development in coca fields. Ecological studies demonstrated that ants transport the formulation below ground into the root zone and the fungus remains in the soil at detectable levels for months after treatments. Treatment of diverse soil types with the formulations results in the establishment of similar populations of the pathogen. Temperature and moisture conditions for optimum formulation performance were also defined. Fusarium wilt of coca was first reported in Peru in 1959. Research in this project found that the pathogen can be spread through infected seed. Growers' use of infected seed and planting material has likely been responsible for the spread of this disease. The genetic aspects of this ongoing natural epiphytotic of fusarium wilt in Peru have been studied and two distinct genetic types were identified based on RAPD and VCG analysis. These isolates are found throughout the coca producing areas of Peru and are expected to continue to impact coca production in Peru. The natural epiphytotic in Peru demonstrates the potential of this biocontrol strategy for reducing coca production. A protein which causes necrosis of coca leaves and other dicots was identified, purified and has been cloned from F. oxysporum f. sp. erythroxyli isolate EN-4. The protein is produced in high concentrations in liquid culture by many different F. oxysporum isolates as well as some other Fusarium species. In addition to causing necrosis in dicots, the 24 kDa protein induces

responses which are characterized as defense responses, including active oxygen production, K+ efflux, and hydrogen peroxide production. The 24 kDa protein has been used to evaluate the sensitivity of coca leaves to stress. This body of work has provided the foundation for more extensive research into biocontrol of narcotic crops. Research on biocontrol of production-limiting diseases of crops that could be grown as alternatives to coca (cacao, coffee, and potato) was initiated. A newly described antagonistic fungus, Trichoderma stromaticum, from the Amazon basin was field tested for control of witches'-broom disease of cacao in Peru and Brazil with promising results. **6. What do you expect to accomplish, year by year, over the next 3 years?** Formulations using new sources of the active ingredient (liquid fungal biomass) will be field tested in small plots of opium poppy. Continued efforts will be made to develop new sources of the active ingredient and formulations for the biocontrol of opium poppy. Liquid formulations of Pleospora papaveracea will be developed and combined with the Nep 1 protein in a large plot test evaluation on opium poppy. The importance of the Nep 1 protein in the plant-microbe interaction will be determined. Over the next three years, emphasis of the project will shift from biocontrol of narcotic plants to biocontrol of diseases of crops that can be grown as an alternative to coca. Further field testing for control of cacao (chocolate) diseases will continue in respective cacao producing countries where witches'-broom, Phytophthora black pod and Moniliophthora pod rot are serious production-limiting diseases. Basic studies on host/parasite/antagonist interactions, and on biocontrol agent ecology, will be initiated to better understand mechanisms of biocontrol of plant diseases. **7. What science and/or technologies have been transferred and to whom? When is the science and/or technology likely to become available to the end user (industry, farmer, other scientists)? What are the constraints if known, to the adoption & durability of the technology product?** All of this research has been made available to the public through publication in refereed scientific journals. This includes fermentation and formulation technologies. The major constraint limiting the use of this technology is diplomatic as the consent and active participation of foreign government would be required for implementation. Technology transfer for biocontrol of diseases of crop alternatives to narcotic plants has been done through information transfer to private industry (Cooperative Research and Development Agreement with a private company) and seminar and workshop presentations. A workshop manual was produced cooperatively with ARS, CABI-Bioscience (U.K.) and CATIE (Costa Rica). **8. List your most important non-peer reviewed publications and presentations to non-scientific organizations, and articles written about your work(NOTE: this does not replace your peer reviewed publications which are listed below).**

PUBLICATIONS: 1999/01 TO 1999/09

1. BAILEY, B.A., HEBBAR, K.P., STREM, M., LUMSDEN, R.D., DARLINGTON, L.C., CONNICK, JR., W.J. and DAIGLE, D.J. 1998. Formulations of Fusarium oxysporum ... biocontrol of Erythroxylum ... coca. Weed Sci. 46:682-689.
2. GRACIA-GARZA, J.A., FRAVEL, D.R., NELSON, A.J., ELIAS, K.S., BAILEY, B.A., and DARLINGTON, L.C. 1999. Potential for dispersal of Fusarium oxysporum f. sp. erythroxyli by infested seed. Plant Disease 83:451-455.
3. HEBBAR, K.P., LAMBERT, S., COSTA, J.B. and LUMSDEN, R.D. 1999. Formulations of Trichoderma stromaticum, a biocontrol agent of the witches'-broom pathogen Crinipellis perniciosa. Phytopathology 89:S-33.
4. HEBBAR, K.P., GUILTINAN, M.J. and LUMSDEN, R.D. 1998. Microbial ecology of cacao and its potential for biological control of fungal diseases. Phytopathology 88:S37.
5. THACKER, J.R.M., HEBBAR, P.K., et al. 1998. The effects of an organosilicone/latex-based ... Trichoderma ... witches'-broom ... cacao. Brighton Conference-Pests and Diseases Proceedings, Vol. 6D-4:561-566.

6. HEBBAR, K.P., GUILTINAN, M.J. and LUMSDEN, R.D. 1998. Biological control of black pod and witches'-broom diseases in cacao. 7th International Congress of Plant Pathology, p. 5.2.33, Edinburgh, Scotland.
7. KRAUSS, U. and HEBBAR, K.P. 1999. Research methodology in biocontrol of of plant diseases with special reference to fungal diseases of cocoa. Proc. Workshop Manual, 159 pp. CATIE, Turrialba, Costa Rica.

CRIS SUPPLEMENTARY DATA: **Region:** 1 **Process Date:** 2000/08/14 **Progress Update:** 2000/05/16

ANNEX 148

United States Department of State, Bureau for International Narcotics and Law Enforcement Affairs, *Report on Issues Related to the Aerial Eradication of Illicit Coca in Colombia: Updated Report on Chemicals Used in the Aerial Eradication Program* (Dec. 2003)

U.S. DEPARTMENT OF STATE
DIPLOMACY IN ACTION

Updated Report on Chemicals Used in the Colombian Aerial Eradication Program

Report on Issues Related to the Aerial Eradication of Illicit Coca in Colombia

December 2003

On September 4, 2002, the Department of State submitted to Congress the Secretary of State's determination and report to Congress on issues related to the eradication of illicit coca in Colombia in accordance with the FY 2002 Foreign Operations, Export Financing, and Related Programs Appropriations Act (P.L. 107-115). That document contained an explanation of the chemicals and methods used for the eradication of coca in Colombia and the safeguards in place to minimize the risk of harm to human health and the environment. It also contained the results of the Department of State's consultations with the United States Environmental Protection Agency (EPA), including EPA's analysis of the risks to human health and the environment that might be posed by coca eradication.

The Government of Colombia and the Department of State have implemented several changes in the program to address concerns raised by the EPA analysis. The first section of this document reviews the Department of State response to EPA's 2002 recommendation for additional controls for the spray program. Sections two and three explain the changes introduced by the Government of Colombia and the Department of State to respond to EPA and Congressional concerns about other aspects of aerial eradication in Colombia. A fourth section describes the changes in chemical composition and spraying methods since the Department of State's 2002 report. The final section reviews the chemicals and methods used for opium poppy eradication in Colombia, a part of the program that Congress did not ask the Department of State or EPA to address in FY 2002.

1. EPA Recommendation to Change Glyphosate Product Used by the Program

The EPA made one direct recommendation to the Department of State related to spray program controls in its "Office of Pesticide Programs Details of the Consultation for Department of State: Use of Pesticide for Coca Eradication Program in Colombia." On page 12 of that document, EPA recommended that " due to the acute eye irritation caused by the concentrated glyphosate formulated product and the lack of acute toxicity data on the tank mixture, the Agency recommends that DoS consider using an alternative glyphosate product (with lower potential for acute toxicity) in future coca and/or poppy aerial eradication programs." This was addressed to the possible risk of splashing the full-strength glyphosate into the eyes or onto the skin of persons filling the spray tanks on the airplane. It was not directed at potential risk to persons exposed to the spray mixture as actually applied by the planes.

At the time that EPA made this recommendation, there were no suitable replacement glyphosate formulations registered for sale and use in Colombia that offered lower potential for acute eye irritation. The Department of State worked with the program's glyphosate supplier to identify and to register for sale and use in Colombia a formulation of glyphosate with reduced potential for eye irritation. As soon as that product could be registered for sale and use in Colombia, the Department of State began to purchase it for use in the spray program and it remains the formulation used today.

Like the previous formulation, the new formulation is also registered with the EPA for sale in the United States for non-agricultural use. It also contains 41 percent glyphosate salt and 59 percent inert ingredients. Like the previous formulation, the formulation now used is made from a base material (glyphosate technical) that is produced by a manufacturing plant that is registered in the United States even though the formulation is produced and sold in Colombia. The glyphosate formulation now used is mixed with water and surfactant in the same proportions as the previous formulation to form the coca spray mixture.

The difference between the formulations is that the current product has an overall category III toxicological rating ("mildly toxic") on the scale used by the EPA, whereas the previously used glyphosate formulation was rated category I ("highly toxic"). The toxicity reduction is due to a change in the surfactant used in the glyphosate formulation. Of course, these ratings refer to the toxicological profile of the glyphosate formulations in their point of sale, undiluted form, and not the spray mixture (water, glyphosate formulation, and surfactant) that exits the spray aircraft.

The Department of State took these steps in part to address public concerns about the toxicity of the spray mixture and allegations that the combination of glyphosate and surfactant would pose a threat to human and environmental health. In that regard, the Department of State also contracted with an independent United States laboratory to determine the toxicity of the spray mixture (e.g., the glyphosate formulation with water and surfactant added), exactly as it is mixed in the field. Because final drafts of those toxicology tests were not completed in time for EPA's assessment in 2002, copies of the toxicology tests on the spray mixture currently used for coca eradication are enclosed as Attachment A. These tests show that the spray mixture rates a category III ("mildly toxic") for eye irritation and category IV, or "slightly toxic," in all other categories (e.g., acute oral, acute dermal, acute inhalation, skin irritation, sensitization).

2. EPA Advice Regarding Tracking Reported Health Complaints

EPA's "Office of Pesticide Programs Details of the Consultation for Department of State: Use of Pesticide for Coca Eradication Program in Colombia" also advised (on page 32) that: "(p)rospective tracking of reports of health complaints, documenting times of exposure and onset of symptoms, are recommended during future spray operations to evaluate any potential health effects and ameliorate or prevent their occurrence." Although this recommendation is not related to spray program controls, the Department of State has increased its efforts to track reported health complaints and to investigate any possible connection between any such complaints and the eradication of illicit crops.

The spray program tracks human health complaints in two ways. The first is to initiate an immediate investigation, often including clinical evaluation of the patient(s), upon notice to the U.S. Embassy of a problem. The Embassy's Narcotics Affairs Section (NAS) learns about cases through letters directed to the Embassy or GOC entities, from local counternarcotics base commanders, and from the members of the media. To investigate complaints of toxic exposure allegedly caused by spraying, NAS retains the services of two of Colombia's leading toxicologists, including the director of Colombia's national poison control center, the Uribe Cualla Centro de Asesoramiento Toxicológico.

Since submission to Congress of the FY2002 "Report on Issues Related to the Eradication of Illicit Coca in Colombia," two such complaints have been reported to the U.S. Embassy. In September 2002, the Embassy received a complaint of multiple cases of poisoning from spraying of coca in Puerto Asís (Putumayo department). A visit to the hospital and interviews with doctors there revealed no cases of poisoning or illness attributable to spray chemicals. The toxicologist learned of two hospitalized children who could have been the source of the complaint, and he reviewed their cases. One of those children was suffering from poisoning by an organophosphate insecticide. The other child was suffering from asthma. An English language version of the toxicologist's report from this investigation is enclosed as Attachment B.

In February 2003, a news report in the Bogotá daily "El Tiempo" attributed the spread of tuberculosis and cases of harelip and cleft palate in newborns to aerial spraying of coca in Tibú (Norte de Santander department). A toxicological review showed cleft palate and harelip to be a genetically inherited defect that has never been reported in humans as a result of exposure to any chemical substance. Tuberculosis is an infectious disease passed from person to person, and is also unrelated to any potential exposure to spray chemicals.

The Government of Colombia and the U.S. Embassy Bogotá have also taken a proactive approach to investigating any human health concerns manifest in areas where the spraying takes place. Both governments have collaborated to create a robust Medical Civic Action Program (Medcap) to search out cases of harm to health allegedly caused by the spraying. During these public health interventions that are timed to take place in areas where coca eradication has recently taken place, U.S. Embassy-contracted toxicologists talk to patients and talk to local medical personnel, looking for spray-related cases. As outlined in the chart below, a total of 1,029 patients made themselves available for Medcap medical personnel, had their medical conditions assessed, and received complimentary health care. Although Medcap personnel have encountered cases that were claimed to be spray-related, reviews of these cases have determined that events unrelated to eradication spraying had caused them. Through Medcap and other medical investigations, the U.S. Embassy has never found an instance of spray-related harm to human health. This is an ongoing program and the next Medcap is planned for the end of April in Caquetá, a few weeks into the spray campaign in that region.

Place and Date	Patients Assessed
Cartagena del Chairá (Caquetá) May 11, 2002	250
Solano (Caquetá) August 7, 2002	120
Santa Ana (Putumayo) September 21, 2002	260
Puerto Asís (Putumayo) November 9, 2002	250
San Vicente del Caguán (Caquetá) February 1, 2003	149

To further address public and Congressional concerns about the possibility of human health and environmental harm potentially caused by spraying, the Department of State is working with the Government of Colombia and Garzon Ingenieros Asociados Ltda, an accredited Colombian laboratory, to analyze water taken from areas where the spray program operates. Technology for monitoring soil is not available in Colombia, so the Department of State is working with the Government of Colombia and the U.S. Department of Agriculture Agricultural Research Service to analyze soil samples at the USDA/ARS laboratory at the University of Mississippi. The Department of State is paying for technicians from two Colombian government laboratories and the Ministry of the Environment to travel to Mississippi in April to learn how to perform the analysis. The soil and water analyses will determine the degree of persistence of glyphosate and its byproducts in Colombian soil and water, in the unlikely event there is something unique about Colombian soil and water that would invalidate the many studies done on the residual effects of glyphosate in other parts of the world. The Department of State, the Government of Colombia and a private Colombian university (Universidad de Los Andes) are developing demonstration plots in the five distinct environmental regions of the country to study glyphosate persistence and the regeneration of natural vegetation and other ecological dynamics following aerial eradication of illicit crops.

3. EPA Comment Regarding Spray Drift

Although not addressed to the Department of State as a recommendation, EPA also noted in its consultation with the Department of State some concern for spray drift and the potential for non-targeted, desirable vegetation to suffer from the spraying of nearby coca (or opium poppy). Informed of EPA's and Congressional concern, the Department of State and the Government of Colombia have incorporated several measures into the spray program to assist us with evaluation and control of spray drift.

The first of these steps was to reinforce the environmental safety component of spray pilot training. All pilots, both fixed wing spray pilots and rotary wing escort helicopter pilots, will receive briefings on the potential negative impact that spraying may have on the environment and techniques to minimize potential collateral damage to legal crops and the environment. These briefings will be conducted semi-annually, will emphasize the unique aspects of the Colombian operational theatre, and will solicit feedback from pilots on techniques to maximize application effectiveness and avoid damage to non-target vegetation. An outline of this briefing is included as Attachment C. Search and rescue helicopter crews that accompany each spray flight have also been directed to monitor drift patterns from above. They now assist in ensuring that spray does not drift beyond target crops and notify the spray aircraft flight lead when conditions might merit canceling a spray flight. A copy of the directive from the Department of State's Bureau of International Narcotics and Law Enforcement Affairs (INL) Office of Aviation to the eradication contractor that formalizes these new spray regulations is included as Attachment D.

The Department of State's Assistant Secretary for INL also directed the team of United States Department of Agriculture (USDA) and Government of Colombia scientists, responsible for the ground truth verification missions, to incorporate an analysis and quantification of overspray into ground truth verification exercises. While past verification missions sought out and noted cases of overspray, documenting the existence and extent of any damage to

crops or foliage not targeted for eradication, this is now a formal component of the ground truthing exercise. The most recent ground truth verification mission (December 9-20, 2002) found that incidences of overspray were minor. The USDA Agricultural Research Service report from this verification exercise has not yet been completed, and INL will forward a complete copy to EPA as soon as the Department of State receives the report.

4. Changes in Chemical Composition and Spraying Methods Since 2002 Report

Apart from changing to a more benign formulation of glyphosate spray mixture, as discussed earlier, there have been no changes to any of the components of the spray mixture. For some time in 2002, the Government of Colombia lowered the application rate of glyphosate for coca eradication from the traditional application rate of 10.4 liters per hectare to 8.0 liters per hectare. After extensive ground truth evaluation, it was determined that the lower rate was ineffective for killing coca. Thus the application rate was returned to its former rate of 10.4 liters per hectare, which was the rate reported in the Department's Report on Issues Related to the Eradication of Illicit Coca in Colombia in 2002 -- the rate that EPA evaluated when analyzing the potential for risks of adverse effects on human health and the environment posed by the coca eradication program.

The only changes in the methodology used to spray coca since the time of the last report is the addition of a new type of spray aircraft to the spray fleet. Four Air Tractor Model 802 (AT-802) aircraft are currently being used to spray coca, and another four will be delivered this year. These aircraft are manufactured in the United States for agricultural crop spraying and utilize the identical nozzles (same brand and diameter) in the identical configuration (nozzle angle, droplet size, calibration methods) as the OV-10 and T-65 spray aircraft. AT-802 flight speed during eradication operations is 165 m.p.h.

5. Differences Between Opium Poppy Spraying and Coca Spraying

The Secretary of State was not required to determine and report to Congress on any aspects of the opium poppy eradication program in FY2002, and thus the Department did not provide information to EPA on the chemicals and methodology of poppy spraying. Like the coca spray mixture described in the "Report on Issues Related to the Eradication of Illicit Coca in Colombia," the opium poppy spray mixture contains three components: water, an EPA-registered formulation of the herbicide glyphosate, and a surfactant (Cosmo-Flux 411F). Because the opium poppy is not a woody, hard-to-control species like the coca bush, opium poppy eradication uses a spray mixture with a substantially lower glyphosate content than the spray mixture used for coca eradication (see Attachment E). For opium poppy spraying, water, formulated glyphosate, and surfactant are combined into a spray mixture in the following percentages: 94 percent water, 5 percent glyphosate formulation, and 1 percent Cosmo-Flux 411F. This diluted mixture is applied to opium poppy at the rate of 50.0 liters/hectare (or 5.46 gallons per acre). This application rate is within the glyphosate manufacturer's label recommendations for both the amount of concentrated formulation per acre and the amount of total spray volume per acre.

Opium poppy spraying differs from coca spraying in several ways. Because Colombia cultivates much less opium poppy than coca and spray program resources are limited, aircraft spray much more coca than opium poppy, therefore expending more spray chemicals in coca growing areas than in areas where opium poppy is cultivated. For example, in 2002, eradication aircraft sprayed totals of 122,700 hectares of coca and 3,000 hectares of opium poppy. Opium poppy is generally cultivated in plots that are smaller than the average coca field. While difficult to quantify precisely, opium poppy fields generally range from 0.5 to 5 hectares. Opium poppy is ordinarily cultivated at a higher altitude than coca, and thus opium poppy often is cultivated and sprayed in hilly to mountainous terrain. For these reasons, the T-65 is the only aircraft used to spray opium poppy because it has a smaller wingspan (and spray swath) than the OV-10 or AT-802 and because it is a more agile aircraft capable of staying close to the ground in more steeply graded, rugged terrain.

Because of the challenges of mountain spraying, pilots undergo an extended training program before they are qualified to perform actual opium poppy spray operations in Colombia. As the Department of State reported in 2002, coca eradication pilots must have approximately 3,000 total flight hours before they are considered for the spray program and can receive preliminary training in illicit crop eradication. Most of these pilots also have at least 1,500 hours of commercial aerial application (crop dusting) experience. In addition to these requirements, opium poppy spray pilots must undergo 40 hours of follow-on training specific to the topography, wind conditions, and cloud cover that they will experience in their area of operations.

Attachments

Toxicological testing results for coca spray mixture (Purity Analysis for Glyphosate, Acute Oral Toxicity Study, Acute Dermal Toxicity Study, Acute Nose-Only Inhalation Toxicity Study, Primary Eye Irritation Study, Primary Skin Irritation Study, Dermal Sensitization Study).

"Investigative Report on Cases of Possible Human Health Effects in Puerto Asís," Jorge Hernán Botero Tobón, M.D. Bogotá, Colombia, September 19, 2002.

Outline of Spray Pilot Semi-Annual Briefing.

Memo from INL Office of Aviation Director of Operations to DynCorp Operations Manager re: Aerial Eradication Procedures, December 13, 2002.

Coca and Opium Poppy Spray Mixtures Comparison Graph.

ANNEX 149

United States Environmental Protection Agency, Office of Pesticide Programs,
Letter and Consultation Report from Administrator Leavitt (17 Nov. 2004)

Letter and Consultation Report from EPA Administrator Leavitt

Washington, DC
November 17, 2004

United States Environmental Protection Agency Washington, D.C. 20460

Nov. 17, 2004

The Honorable Colin L. Powell
Secretary
U.S. Department of State
Washington, D.C. 20520

Dear Secretary Powell:

I am pleased to inform you that the U.S. Environmental Protection Agency has completed its consultation review of the potential human health and environmental effects concerning the U.S.-supported aerial coca and poppy eradication program in Colombia.

In your letter of September 27, 2004, you asked the Agency to provide you with written confirmation that the Department of State and EPA have consulted in preparing a certification required by the Consolidated Appropriations Act, 2004. Specifically, you asked EPA to confirm: (1) that the Department of State and EPA have consulted concerning the U.S.-supported aerial coca eradication program in Columbia; (2) that the herbicide mixture employed by the U.S.--supported program of aerial eradication of coca and opium poppy in Colombia is being used in accordance with EPA label requirements for comparable use in the United States and any additional controls recommended by the EPA for this program, as well as with the Colombian Environmental Management Plan for aerial fumigation; and (3) that this herbicide mixture, in the manner it is being used, does not pose unreasonable risks to or have adverse effects upon humans or the environment.

EPA conducted its assessments based on information provided to us by the Department of State's Bureau of International Narcotics and Law Enforcement Affairs. As you know, INL has consulted with EPA's Office of Pesticide Programs, and as part of this effort, EPA has previously provided reviews of the Department of State's eradication spray program activities in 2002 and 2003. EPA has compared coca and poppy eradication practices with the closest approximate use in the United States, reviewed potential human health concerns, and evaluated toxicity testing conducted on the spray mixture that INL has indicated is being applied in Colombia. In this consultation review, we have also reviewed progress of the Colombian government's efforts to evaluate the effects of the spray program on human health and the environment in areas where it has been used to eradicate illicit crops.

I have attached the consultation review document that we trust will assist you in preparing the certification that must be submitted to Congress. Please let me know if you have additional questions concerning our consultation review.

Sincerely,

Michael O. Leavitt

Enclosure

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF PESTICIDE PROGRAMS
DETAILS OF THE 2004 CONSULTATION FOR THE DEPARTMENT OF STATE
USE OF A HERBICIDE FOR COCA AND POPPY ERADICATION PROGRAM IN COLOMBIA
OCTOBER 2004

EXECUTIVE SUMMARY

CONSULTATION REVIEW OF THE USE OF A HERBICIDE FOR COCA AND POPPY ERADICATION IN COLOMBIA, 2004

The Department of State (DoS) assists the Government of Colombia with training, contractor support, financial assistance, and technical and scientific advice for aerial pesticide spraying activities designed to eradicate the illicit crops coca and poppy in Colombia. The U.S. Environmental Protection Agency (EPA) has completed an assessment at the request of DoS, on whether the herbicide mixture, in the manner it is being used in Colombia for coca and poppy eradication, does not pose unreasonable risks or adverse effects to human health or the environment. The Agency has reviewed information provided to us by the DoS to confirm that the herbicide mixture is being used according to EPA label requirements for comparable use in the United States, any additional controls recommended by EPA for this program, and with the Colombian Environmental Management Plan for aerial fumigation.

EPA concludes from its assessment of the submitted and available information on the spray program and the herbicide glyphosate that there does not appear to be any evidence that glyphosate aerial spraying of coca or poppy has resulted in any adverse human health effects among the population where this spraying occurs in Colombia. There have been no substantive changes to the eradication program's method of aerial glyphosate application or the spray formulation. Although the measured toxicity and estimated exposure indicate that only nontarget terrestrial plants are likely to be adversely affected by the use on coca and poppy, important uncertainties should be considered. The Agency findings from 2002 and 2003 remain relevant to the current coca and poppy eradication activities in Colombia. The DoS and the Government of Colombia made modifications and enhancements to the spray program as EPA recommended in its prior assessments. This is an interim finding that may change as new information becomes available and followup is performed. Details of EPA findings are provided in the attached document.

I. BACKGROUND

The Department of State (DoS) assists the Government of Colombia with training, contractor support, financial assistance, and technical and scientific advice for an aerial pesticide spraying program designed to eradicate the illicit crops coca and poppy. The eradication program includes the use of a spray mixture of a glyphosate formulation, an adjuvant (Cosmo-Flux 411F), and water. The glyphosate tank mixture is applied aerially as a foliar application in certain provinces of Colombia. As required by the Consolidated Appropriations Act, 2004 (H.R.2673), DoS has consulted with the U.S. Environmental Protection Agency (EPA) to ensure that the herbicide mixture, in the manner it is being used, does not pose unreasonable risks or adverse effects to human health or the environment. As part of this effort, EPA has previously reviewed DoS eradication spray program activities in 2002 and 2003. This review updates and comments on the progress of the Colombian government to evaluate the effects of the glyphosate spray program on human health and the environment in areas where it has been used to eradicate illicit crops, as requested by DoS, in a letter dated September 27, 2004.

II. SUMMARY OF PREVIOUS ASSESSMENTS

In 2002, EPA reviewed the coca eradication program in Colombia and concluded that there was no evidence of significant human health or environmental risks from the spraying. EPA did recommend that DoS switch to a herbicide product with lower toxicity due to a potential hazard to the eyes of pesticide mixers/loaders. EPA also asked DoS to conduct field investigations of health complaints associated with coca eradication. The Agency further concluded that spray drift was likely to cause phytotoxicity downwind of sprayed coca fields. The Agency reached its conclusions from a thorough review and assessment of the available scientific studies on glyphosate and glyphosate-containing formulated products and their use in the United States and in conjunction with information on the spray program in Colombia. The final conclusion was that EPA could not verify the product formulation because the product was manufactured outside the United States and not registered by the EPA.

In 2003, DoS adopted EPA's recommendation and began using a lower-toxicity glyphosate product in its coca and poppy eradication programs, and implemented a program to investigate health complaints. Based on a comparison of the glyphosate use pattern in Colombia and approved use patterns of glyphosate products in the United States, EPA determined that application rates for both coca and poppy eradication in Colombia were within the parameters listed on U.S. labels. The Agency could not verify the quality of the product since it is formulated outside of the United States, but a review of toxicity testing on the spray mixture solution did not uncover any irregularities.

EPA concluded in 2003 that there were no risks of concern from dietary exposures or from exposures to mixer/loader/applicators or field workers, including bystanders. The concerns for mixer/loader eye irritation discussed in EPA's 2002 review were mitigated in 2003 by switching to a lower-toxicity glyphosate product registered by both EPA and the Government of Colombia.

The DoS and the Government of Colombia initiated two programs to investigate health complaints. Regarding potential environmental effects from the eradication programs, EPA concluded that the switch to a lower-toxicity product would present less risk of acute poisoning to wildlife, while potential phytotoxicity due to spray drift could still be a factor in both coca and poppy spraying. EPA recommended that DoS continue programs for investigating health complaints, and the Agency also asked DoS to develop a case definition for what would constitute a glyphosate-related adverse effects exposure, provide further documentation of its investigations and how they are conducted, and standardize data collection.

In February 2004, in response to a request from DoS, EPA reviewed the Environmental Management Plan for the Illicit Crop Eradication Program in Colombia (EMP). DoS asked EPA to assess whether use of the herbicide mixture in Colombia is in accordance with the EMP. The Plan described general descriptions of many activities related to the spray program including references to Colombian laws that were to be followed. EPA concluded that the Plan contained appropriate types of activities for a pesticide spray program. These activities include spray application requirements and restrictions, training and safety precautions for personnel who handle and apply the pesticide, handling of waste resulting from program operations, training public health workers to recognize and treat pesticide poisoning, handling of health and environmental complaints, environmental monitoring, and contingency plans for emergencies. EPA recognized that these types of activities were appropriate for pesticide spray programs and generally reflect similar activities that can be included on pesticide spray programs in the United States, depending on the specific pesticide, use conditions, known potential risks, and federal, state, or local laws.

EPA offered comments on two specific sections of the EMP. First, the Agency urged DoS to investigate methods for properly disposing of pesticide containers rather than reusing them. The second comment was regarding the statement in the EMP that there were no significant impacts to plants that surrounded the illicit crops being sprayed. EPA reiterated its position previously stated in the consultations - that glyphosate is highly toxic to many plants and that some level of adverse effects is likely to occur to some nontarget plants as a result of spray drift, as can be expected with herbicide applications. The Agency suggested an appropriate revision of the wording in the EMP.

III. ASSESSMENT OF THE AERIAL SPRAY PROGRAM IN 2004

In a letter dated September 27, 2004, to Michael O. Leavitt, Administrator of EPA, the Secretary of State formally asked EPA for a written response to confirm that the DoS and EPA have consulted concerning the U.S.-supported coca and poppy eradication program in Colombia. The Secretary asked EPA help certify that the herbicide mixture is being used in accordance with EPA label requirements for comparable use in the United States, any additional controls recommended by EPA for this program, and the Colombian Environmental Management Plan for aerial fumigation. The Secretary also asked EPA to confirm that the herbicide mixture, in the manner it is being used, does not pose unreasonable risks or adverse effects to humans or the environment.

ANNEX 150

Rick A. Relyea,
The Impact of Insecticides and Herbicides on the Biodiversity and Productivity of Aquatic Communities, Ecological Applications, Vol. 15, No. 2 (2005)

Ecological Applications, 15(2), 2005, pp. 618–627
© 2005 by the Ecological Society of America

THE IMPACT OF INSECTICIDES AND HERBICIDES ON THE BIODIVERSITY AND PRODUCTIVITY OF AQUATIC COMMUNITIES

RICK A. RELYEA[1]

Department of Biological Sciences, 101 Clapp Hall, University of Pittsburgh, Pittsburgh, Pennsylvania 15260 USA

Abstract. Pesticides constitute a major anthropogenic addition to natural communities. In aquatic communities, a great majority of pesticide impacts are determined from single-species experiments conducted under laboratory conditions. Although this is an essential protocol to rapidly identify the direct impacts of pesticides on organisms, it prevents an assessment of direct and indirect pesticide effects on organisms embedded in their natural ecological contexts. In this study, I examined the impact of four globally common pesticides (two insecticides, carbaryl [Sevin] and malathion; two herbicides, glyphosate [Roundup] and 2,4-D) on the biodiversity of aquatic communities containing algae and 25 species of animals.

Species richness was reduced by 15% with Sevin, 30% with malathion, and 22% with Roundup, whereas 2,4-D had no effect. Both insecticides reduced zooplankton diversity by eliminating cladocerans but not copepods (the latter increased in abundance). The insecticides also reduced the diversity and biomass of predatory insects and had an apparent indirect positive effect on several species of tadpoles, but had no effect on snails. The two herbicides had no effects on zooplankton, insect predators, or snails. Moreover, the herbicide 2,4-D had no effect on tadpoles. However, Roundup completely eliminated two species of tadpoles and nearly exterminated a third species, resulting in a 70% decline in the species richness of tadpoles. This study represents one of the most extensive experimental investigations of pesticide effects on aquatic communities and offers a comprehensive perspective on the impacts of pesticides when nontarget organisms are examined under ecologically relevant conditions.

Key words: *amphibian decline;* Anax junius; Bufo americanus; Daphnia; Dytiscus; *frogs;* Hyla versicolor; Lestes; Pseudacris crucifer; Rana pipiens; Rana sylvatica; Tramea.

INTRODUCTION

A central goal of ecology is to understand patterns of species abundance and diversity in communities and ecosystems. A great deal of research has documented the patterns of biodiversity and productivity using relatively pristine systems or experimental mesocosms that approximate natural systems (Tilman et al. 2001, Chase and Leibold 2002, Downing and Leibold 2002, Naeem 2002). However, many ecosystems are far from pristine due to a variety of anthropogenic influences, including exposure to a plethora of pesticides (Harris et al. 1998, McConnell et al. 1998, LeNoir et al. 1999, Sparling et al. 2001, Davidson et al. 2002). Herbicides and insecticides have the potential to cause dramatic changes in natural communities, yet our knowledge of pesticide effects on natural communities is largely limited to cases in which pesticides have been intentionally or accidentally applied to natural sites with subsequent floral and faunal surveys (e.g., reptiles and amphibians, Lambert [1997]; macroinvertebrates, Leonard et al. [1999]; plankton and fish, Favari et al. [2002]). In contrast, experimental efforts to understand community effects have primarily used single pesticides and have focused on a narrow range of taxonomic groups including zooplankton (Hanazato and Yasuno 1987, 1989, 1990, Havens 1994, 1995) and larval amphibians (e.g., Boone and Semlitsch 2001, 2002; but see Boone and James 2003). The challenge is to combine the best of both approaches by examining the impact of different pesticides on a broad diversity of taxa while taking advantage of the power that comes from experimental replication.

Aquatic communities are particularly well suited to experimental investigations of pesticide effects. There is a long history of using outdoor aquatic mesocosms to create experimental communities that can be replicated and manipulated (Morin 1981, Werner and Anholt 1996, Relyea and Yurewicz 2002, Downing and Leibold 2002). Mesocosms offer the potential to assemble diverse communities of predators, herbivores, and producers and make testable predictions about the impact of pesticides based on single-species laboratory tests (i.e., LC50 tests that estimate the lethal concentration necessary to kill 50% of a test population). For example, in pond communities, one would predict that the application of insecticides at realistic concentrations should have a direct lethal impact on aquatic in-

[1] E-mail: relyea@pitt.edu

ANNEX 150

sect predators, but no direct impact on herbivores or producers. However, insecticides may cause trophic cascades including indirect positive effects on the herbivores and indirect negative effects on the resources. In contrast, herbicides might have a direct negative impact on producers but no direct impact on herbivores or predators. However, herbicides may cause trophic cascades including indirect negative effects on herbivore biomass and predator biomass (Diana et al. 2000). In summary, mesocosms allow investigators to examine the impacts of relevant pesticide concentrations using realistic population densities, reasonable time scales, and relatively natural conditions.

In this study, I assembled diverse communities in outdoor aquatic mesocosms and then examined the impact of two insecticides and two herbicides (applied separately) on the diversity of the communities as well as the survival and biomass of each taxon in the community. Based on the known impact of these pesticides, I tested the following hypotheses. (1) All of the pesticides will reduce overall biodiversity. (2) The insecticides will reduce the diversity and abundance of insects (USDI [U.S. Fish and Wildlife Service] 1980) and zooplankton (Havens 1994, 1995), but will have no direct impact on the snails and tadpoles (Relyea 2003*b*, 2004). (3) Because of the reduction of insect predators, the insecticides will have an indirect positive effect on the biomass of herbivores and an indirect negative effect on the biomass of producers (i.e., periphyton). (4) The herbicides will reduce the biomass of producers but will have no direct impact on the snails and tadpoles. (5) Because of the reduction of producers, the herbicides will have an indirect negative effect on the biomass of herbivores and predators.

Pesticide background

The four pesticides used in the experiment were two insecticides (carbaryl and malathion) and two herbicides (2,4-D and glyphosate). Carbaryl and malathion are both broad-spectrum insecticides that kill by inhibiting acetylcholine esterase. In the United States, 1–2 $\times 10^6$ kg of carbaryl (commercial name: Sevin) are applied to rangelands, forests, oceans, homes, gardens, and 1.3 $\times 10^6$ ha of crops (Donaldson et al. 2002); see the online National Pesticide Use Database.[2] The half-life for carbaryl depends on pH and ranges from 0.1 days to 4 years (Aly and El-Dib 1971, Wauchope and Haque 1973). Malathion is applied to >800 000 ha of cropland including fruits, vegetables, and cotton at an annual amount of 14–16 $\times 10^6$ kg (Donaldson et al. 2002, National Pesticide Use Database [footnote 2]), and is a preferred insecticide for combating the mosquitoes that carry malaria and West Nile virus. The half-life of malathion is 2–26 days, depending on pH (Guerrant et al. 1970, Wang 1991). Glyphosate (commercial names: Roundup, Rodeo) is a broad-spectrum herbicide that kills plants by inhibiting the synthesis of essential amino acids. The most popular formulation, Roundup, actually is a combination of the active ingredient (glyphosate) and a surfactant that helps the herbicide to penetrate plant leaves (polyehtoxylated tallowamine; POEA). It is the second most commonly applied herbicide in the United States, with 38–43 $\times 10^6$ kg of active ingredient applied to homes, gardens, forests, wetlands, and 8.2 $\times 10^6$ ha of cropland in the United States (Donaldson et al. 2002, National Pesticide Use Database). The half-life of roundup is 7–70 days (Giesy et al. 2000). The herbicide 2,4-D is a broadleaf herbicide that operates as a growth regulator by altering proper cell division in plants. It is widely used in agriculture, with 24–28 $\times 10^6$ kg applied to nearly 33 $\times 10^6$ ha (Donaldson et al. 2002, National Pesticide Use Database). The half-life of 2,4-D is from 10 to >50 days, according to NIH data (*available online*).[3] These four pesticides are among the top 10 pesticides used in the United States for agriculture and home use (Donaldson et al. 2002), and all of them are either applied directly to aquatic habitats or can make their way into aquatic habitats via unintentional overspray, aerial drift, or runoff.

Methods

The experiment was a completely randomized design with five pesticide treatments that were each replicated six times for a total of 30 experimental units. The experimental units were 1200-L polyethylene tanks that were filled with 1000 L of well water during 26–28 April 2002. On 6 May, I added 300 g of dry leaves (*Quercus* spp.) and 25 g of rabbit chow to serve as habitat structure and an initial nutrient source. I also added an aliquot of zooplankton and phytoplankton that was a mixture from six local ponds. On 23 May, I placed two 10 × 10 cm ceramic tiles in each tank (oriented vertically) to serve as future estimates of periphyton growth in each tank.

Five days later, I began adding macro-organisms that I collected from natural habitats, either as mixtures of ≥10 egg masses that were previously hatched in wading pools (four of the five tadpole species), or as larvae and adults dip-netted from ponds and wetlands (Table 1). On 28 May, I added five species of larval anurans, two species of snails, and one species of larval damselfly (predators on zooplankton). The following day, I added a third snail species. On 30 May, I added the remaining predators: larval *Anax* and *Tramea* dragonflies (predators on both tadpoles and snails), larval *Dytiscus* and *Acilius* beetles (predators on tadpoles and zooplankton, respectively), *Notonecta* and *Belostoma* hemipterans (predators on both tadpoles and snails), and recently hatched spotted salamander larvae (predators on zooplankton). All of these species naturally coexist and, for each species, I used densities that were

[2] ⟨http://www.ncfap.org⟩

[3] ⟨http://toxnet.nlm.nih.gov⟩

ANNEX 150

TABLE 1. A list of the taxa used in the experiment.

Common name	Species	Size	Density†	Trophic level
Spotted salamander‡	*Ambystoma maculatum*	49 ± 3 mg	2	predator
Diving beetle‡	*Dytiscus* sp.	28 ± 1.1 mm	1	predator
Diving beetle‡	*Acilius semisulcatus*	21 ± 0.4 mm	1	predator
Dragonfly‡	*Anax junius*	39 ± 0.9 mm	1	predator
Dragonfly‡	*Tramea* sp.	23 ± 0.6 mm	1	predator
Damselfly‡	*Lestes* sp.	15 ± 0.3 mm	1	predator
Backswimmer	*Notonecta undulata*	10 ± 0.3 mm	3	predator
Water bug	*Belostoma flumineum*	20 ± 0.2 mm	1	predator
Wood frog‡	*Rana sylvatica*	104 ± 10 mg	10	herbivore
Leopard frog‡	*Rana pipiens*	42 ± 8 mg	10	herbivore
American toad‡	*Bufo americanus*	45 ± 5 mg	10	herbivore
Gray tree frog‡	*Hyla versicolor*	4 ± 0 mg	10	herbivore
Spring peeper‡	*Pseudacris crucifer*	214 ± 16 mg	10	herbivore
Snail	*Physa integra*	62 ± 4 mg	10	herbivore
Snail	*Helisoma trivolvis*	434 ± 31 mg	10	herbivore
Snail	*Stagnicola elodes*	177 ± 20 mg	10	herbivore
Cladoceran	*Daphnia pulex*	···	···	zooplankton
Cladoceran	*Daphnia ambigua*	···	···	zooplankton
Cladoceran	*Daphnia longiremis*	···	···	zooplankton
Cladoceran	*Ceriodaphnia* sp.	···	···	zooplankton
Cladoceran	*Scapholebris* sp.	···	···	zooplankton
Copepod	*Eurytemora affinis*	···	···	zooplankton
Copepod	*Eurycyclops agilis*	···	···	zooplankton
Copepod	*Mesocyclops edax*	···	···	zooplankton
Copepod	*Leptochaptumorus siciloides*	···	···	zooplankton

Notes: Standard length was used as an initial size measure for the aquatic insects, whereas mass was used as an initial size measure for amphibians and snails. Values are means ± 1 SE. The tadpoles and snails are herbivores on periphyton, whereas the zooplankton are herbivores on phytoplankton.

† Density is the number of individuals per 1000-L experimental tank.

‡ Larval stages were used in the experiment.

within the range of natural densities based on seven years of quantitative surveys of natural aquatic habitats (R. A. Relyea, E. E. Werner, D. K. Skelly, and K. L. Yurewicz, *unpublished data*).

There were five pesticide treatments: controls (250 mL of water added), carbaryl, malathion, glyphosate, or 2,4-D. For all four chemicals, I wanted to simulate the impact of a direct overspray on a wetland. Thus, I purchased commercial forms of each chemical and had the concentrations of each chemical's active ingredient independently confirmed by the Mississippi State Laboratory (Mississippi State, Mississippi, USA) using high-pressure liquid chromatography (carbaryl, 22.3%; malathion, 50.6%; 2,4-D, 44.5%; glyphosate, 25.2%). Based on the surface area of the cattle tanks (2.41 m^2), I applied each chemical at the manufacturer's recommended maximum application rates (Sevin, 0.955 mL/m^2; malathion, 0.234 mL/m^2; 2,4-D, 0.117 mL/m^2; Roundup, 6.4 mL/m^2). Thus, I added 2.3 mL of Sevin, 0.6 mL of malathion, 0.3 mL of 2,4-D, and 15.3 mL of Roundup. Because the tanks contained 1000 L of water, these application rates translated to 0.51 mg carbaryl/L, 0.32 mg malathion/L, 0.12 mg 2,4-D/L, and 3.8 mg glyphosate/L. The pesticides were added immediately after all taxa had been added to the tanks (30 May).

On 12 June, the experiment was terminated. I began by first sampling the zooplankton using a 0.2-L tube sampler that was plunged into the tanks in the center and at each of the four cardinal directions. The five samples were combined and filtered through 62-μm Nitex screening (Small Parts, Miami, Florida, USA). All zooplankton were preserved in 70% ethanol and subsequently counted and identified to species. Next, the ceramic tiles were removed and the periphyton was scrubbed (using toothbrushes) onto oven-dried, preweighed filter paper. The algae-covered filters were oven-dried again for 15 h at 80°C and then weighed to determine the dry mass of algae on each tile. Finally, the tanks were drained and all macro-organisms were sorted from the leaves, counted, and weighed. Amphibians were preserved in 10% formalin and invertebrates were preserved in 70% ethanol.

Statistical analyses

I analyzed the data using ANOVAs. The first analysis examined the impact of the pesticides on total species richness of the animals in the community using a one-way ANOVA. The second analysis examined species richness and biomass of the four major functional groups: predators (insects and salamanders), large herbivores (snails and tadpoles), zooplankton, and periphyton algae (algae was not separated into species). The third set of analyses examined the abundance of individual species within each of the three animal groups (predators, large herbivores, and zooplankton). Because much of these latter data contained heterogeneous errors (some treatments had 0% survival), I first ranked the data and then conducted a MANOVA on the ranked values. When I found a significant multivariate effect,

ANNEX 150

I conducted univariate analyses. When I found significant univariate effects, I conducted mean comparison tests using Fisher's test. I weighed all animals coming out of the tanks at the end of the experiment and found no significant treatment effects on mass for any of the taxa ($P > 0.05$), so I chose to not include the mass data in the analysis. Thus any differences in biomass among treatments simply reflect differential survival across treatments. Two of the tanks developed an unusual red periphyton that was not present in any other tanks in the experiment (and had not been observed in dozens of previous mesocosm experiments). Both tanks had been randomly assigned the control treatment and both were removed from the analysis.

Results

The first analysis examined the impact of the pesticides on the species richness of all animal taxa in the communities (Fig. 1). There was a significant impact of pesticides on total animal richness ($F_{4,23} = 10.1$, $P < 0.001$). Compared to the control tanks, species richness was 15% lower with Sevin ($P = 0.041$), 30% lower with malathion ($P < 0.001$), and 22% lower with Roundup ($P = 0.005$). The addition of 2,4-D had no effect ($P = 0.543$).

The analysis of species richness and biomass by functional group produced a significant multivariate effect (Wilks' $F_{28,63} = 5.5$, $P < 0.001$; Fig. 1). The richness of predators, large herbivores (tadpoles and snails), and zooplankton were all affected by the treatments ($P < 0.001$). Predator richness declined with Sevin and malathion ($P < 0.03$), but not with 2,4-D or Roundup ($P > 0.35$). Large-herbivore richness decreased with Roundup ($P < 0.001$), but was not affected by the other three pesticides ($P > 0.7$). The richness of zooplankton declined significantly with Sevin ($P = 0.044$) and malathion ($P = 0.008$), but not with 2,4-D or Roundup ($P > 0.3$).

The biomass of predators, large herbivores, zooplankton, and periphyton also differed among treatments (univariate tests; $P < 0.03$; Fig. 2). Predator biomass was lower with Sevin, malathion, and Roundup ($P < 0.001$), but not with 2,4-D ($P = 0.406$). The biomass of the large herbivores was higher with Sevin ($P = 0.039$), unaffected by malathion and 2,4-D ($P > 0.25$), and lower with Roundup ($P = 0.024$). The abundance of zooplankton was not different between the control tanks and the four pesticide treatments ($P > 0.09$). Periphyton biomass was unaffected by Sevin, malathion, and 2,4-D ($P, > 0.15$), but was 40% greater with Roundup ($P = 0.028$).

In the remaining analyses, I examined the impact of pesticides on the survival of each species in the three functional groups. In the MANOVA on predator species, I found a significant multivariate effect of the pesticides (Wilks' $F_{28,63} = 2.5$, $P = 0.002$; Fig. 3). There were no pesticide effects on the survival of *Anax junius* dragonflies, water bugs (*Belostoma flumineum*), or damselflies (*Lestes* sp.) (univariate test, $P > 0.25$); marginally significant effects on the survival of *Dytiscus* beetles (univariate test, $P = 0.081$); and significant effects on the survival of *Tramea* dragonflies, backswimmers (*Neonecta undulata*), and spotted salamanders (*Ambystoma maculatum*) (univariate test, $P \leq 0.03$). *Dytiscus* beetles were eliminated with Sevin and malathion ($P = 0.054$), whereas *Tramea* dragonfly survival was reduced with malathion ($P = 0.016$) and nearly reduced with 2,4-D ($P = 0.065$). Backswimmer survival was increased with 2,4-D ($P = 0.035$), whereas spotted salamander survival was marginally higher with Sevin ($P = 0.075$) and significantly higher with 2,4-D ($P = 0.011$). No diving beetle (*Acilius semisulcatus*) larvae survived in any of the tanks.

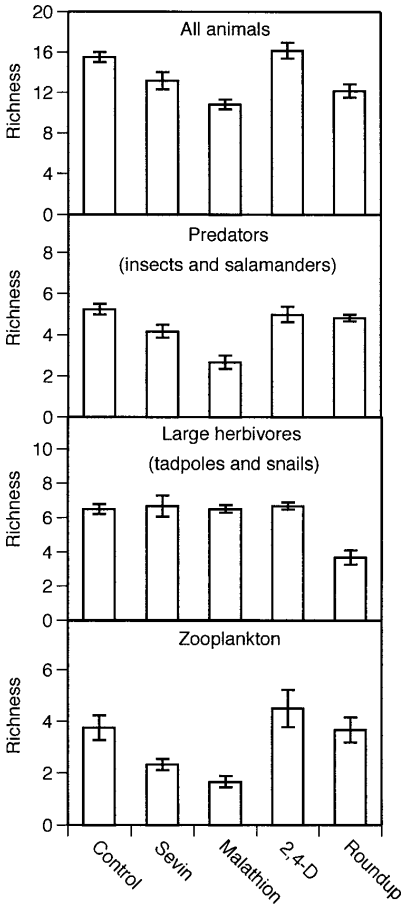


FIG. 1. The impact of four different pesticides on the species richness of predators (insects and spotted salamanders), large herbivores (tadpoles and snails), and zooplankton in aquatic mesocosm communities. Data are means ± 1 SE.

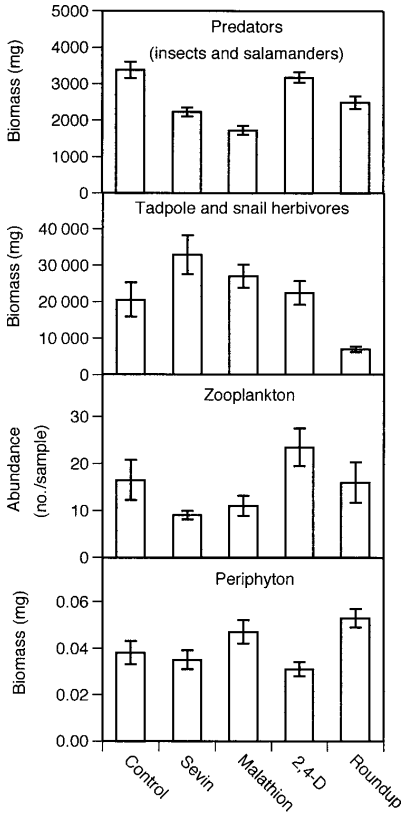


FIG. 2. The impact of four different pesticides on the biomass (or abundance) of predators (insects and spotted salamanders), large herbivores (tadpoles and snails), zooplankton, and periphyton in aquatic mesocosm communities. Data are means ± 1 SE.

In the MANOVA on zooplankton species, there was a significant multivariate effect of pesticides (Wilks' $F_{36,58} = 3.4$, $P < 0.001$). In univariate tests, there was no effect of the pesticides on *Daphnia longiremis*, *Ceriodaphnia* sp., *Scapholebris* sp., *Eurycyclops* sp., or *Leptochaptumorus* sp. ($P > 0.1$). However, there were significant impacts on *Daphnia pulex*, *Daphnia ambigua*, *Eurytemora* sp., and *Mesocyclops* sp. ($P \leq 0.02$; Fig. 4). *Daphnia pulex* was completely absent from tanks with Sevin or malathion ($P < 0.001$). *Daphnia ambigua* showed a similar pattern, although the effects of Sevin and malathion were not significantly different from the controls ($P = 0.063$ and $P = 0.136$, respectively). *Eurytemora* was more abundant with Sevin and malathion ($P \leq 0.03$), but nearly absent with Roundup ($P = 0.028$). *Mesocyclops* was more abundant with Sevin ($P = 0.021$), but was unaffected by the other pesticides.

In the MANOVA on the large herbivores, I found a significant multivariate effect of the pesticides (Wilks' $F_{32,61} = 2.9$, $P < 0.001$). There was no effect of pesticides on any of the three snail species (univariate tests, $P > 0.1$). Across all treatments, the mean survival (±1 SE) was 3 ± 1% for *Physa integra*, 24 ± 4% for *Stagnicola elodes*, and 61 ± 3% for *Helisoma trivolvis*. Among the tadpoles, there were significant impacts of pesticides on leopard frogs (*Rana pipiens*), wood frogs

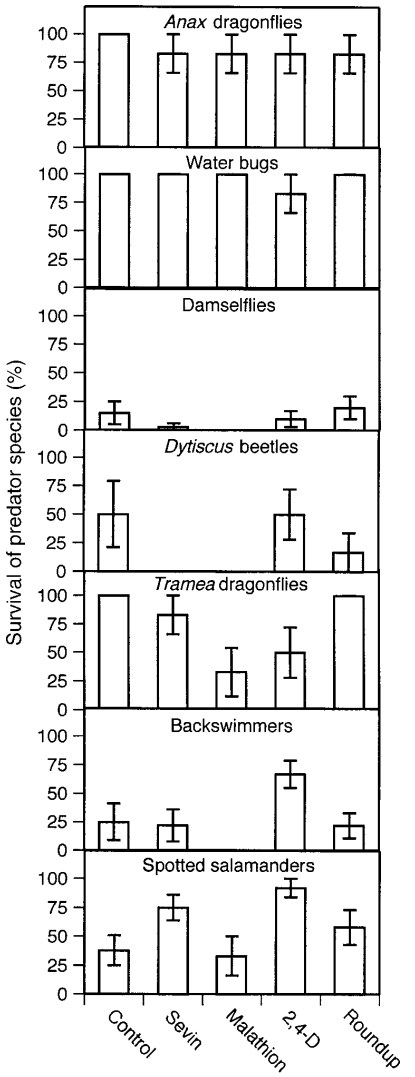


FIG. 3. The impact of four different pesticides on the survival of individual species of predators (insects and spotted salamanders). Data are means ± 1 SE.

ANNEX 150

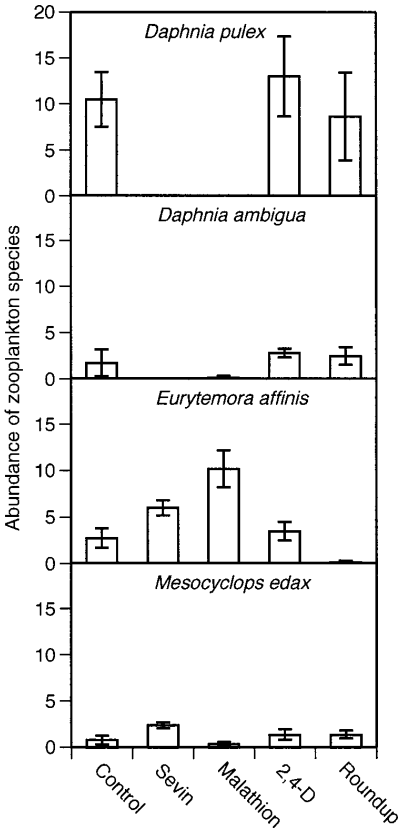


FIG. 4. The impact of four different pesticides on the abundance of individual species of zooplankton. Data are means ± 1 SE.

(*R. sylvatica*), and gray tree frogs (*Hyla versicolor*) (univariate tests, $P < 0.01$; Fig. 5) but no impacts on toads (*Bufo americanus*) or spring peepers (*Pseudacris crucifer*) ($P \geq 0.09$). Leopard frog survival improved from 28% to 58% with Sevin ($P = 0.037$) and 28% to 43% with malathion, but the latter effect was not significant ($P = 0.391$). Leopard frogs were completely exterminated with Roundup ($P = 0.004$). Gray tree frog survival was unaffected by the insecticides, but gray tree frogs were eliminated with Roundup ($P = 0.003$). Wood frog survival improved from 50% to 72% with Sevin ($P = 0.054$) and 50% to 67% with malathion, although the latter effect was not significant ($P = 0.194$). Wood frog survival was reduced to only 2% with Roundup ($P = 0.012$). None of the species was affected by 2,4-D ($P > 0.5$).

DISCUSSION

The results of this study indicate that pesticides can have profound impacts on the diversity and productivity of aquatic communities over relatively short time scales (two weeks). However, the impacts on the communities were very pesticide specific. As expected, the two insecticides reduced the diversity and biomass of the insect predators, completely exterminating *Dytiscus* beetles and reducing the abundance of *Tramea* and backswimmers (the latter was only reduced with malathion). This effect was predictable from the large literature on the susceptibility of aquatic insects and crustaceans to carbaryl and malathion. The $LC50_{72\text{–}96\,h}$ values range from 0.005 to 0.026 mg/L for carbaryl (USDI 1980) and 0.005 to 0.18 mg/L for malathion (USDI 1980, Key et al. 1998, Leight and Van Dolah 1999).

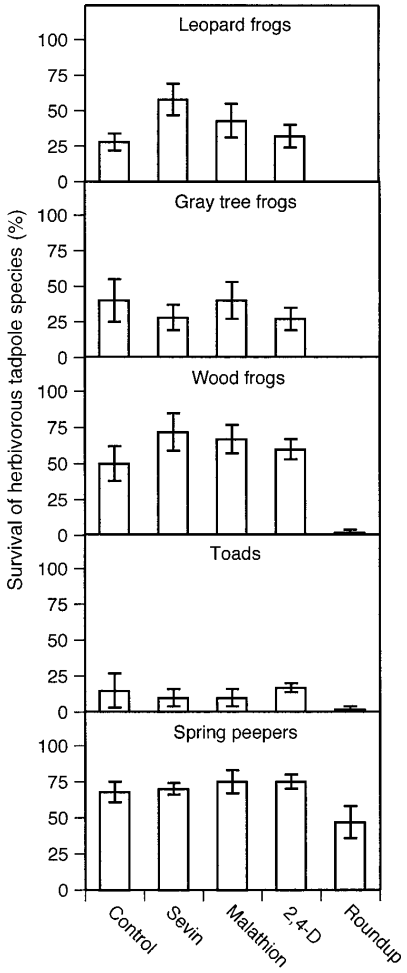


FIG. 5. The impact of four different pesticides on the survival of individual species of herbivorous tadpoles. Data are means ± 1 SE.

Interestingly, the two insecticides had no effect on two of the insect species (*Anax* dragonflies and water bugs; few damselflies survived in any of the treatments, making it difficult to draw any firm conclusions), suggesting that insects vary in their susceptibility to the insecticides (when applied at these recommended rates). In other words, the insecticides did not eliminate the entire insect community. Thus, although predation from aquatic insects can be reduced with the application of insecticides, major predators such as *Anax* dragonflies (Relyea 2001, 2003*a*) will continue to consume prey (although pesticide effects on the foraging behavior of these predators are unknown).

In addition to the effects on insects, the insecticides also affected the zooplankton by eliminating cladocerans while favoring copepods. The change in zooplankton community composition with acetylcholine esterase-inhibiting insecticides is in accord with a number of previous studies. At higher concentrations (>1 mg/L), carbaryl (the active ingredient of Sevin) can completely wipe out nearly all species of zooplankton. However, under lower concentrations, such as those used in the current study, carbaryl only eliminates cladoceran zooplankton. As a result, the phytoplankton resource can increase and provide an indirect, positive effect on the abundance of grazing copepods (copepod body size also may have increased, but this was not measured). However, copepods typically cannot graze the smallest algae that are consumed by the cladocerans; hence, the copepod populations are unable to completely compensate for the decrease in cladoceran abundance (Hanazato and Yasuno 1990, Hanazato 1991, Havens and Hanazato 1993, Havens 1994, 1995, Wong et al. 1995). Thus, it appears that these two insecticides can have both direct and indirect effects on zooplankton.

At the concentrations used, the insecticides were predicted to have no direct negative effects on the survival of the large herbivores (snails and tadpoles). There appear to be very few comparative data addressing the impacts of carbaryl and malathion on snails (Martinez-Tabche et al. 2002), but the current study suggests minimal impacts. In contrast, we have a large number of studies on the impacts of carbaryl and malathion on tadpoles. The LC50 for carbaryl ranges from 1 to 18 mg/L (Marchal-Segault 1976, Marian et al. 1983, Bridges 1997, Zaga et al. 1998, Relyea and Mills 2001, Relyea 2003*b*) for all amphibians and from 1.2 to 3.4 mg/L for the populations of wood frogs, leopard frogs, toads, and gray tree frogs used in the current study (Relyea [2003b]; including LC50 estimates when Sevin is combined with predator chemical cues). The LC50 values for malathion range from 1.2 to 5.9 across all amphibians, including the populations of wood frogs, leopard frogs, toads, and gray tree frogs used in the current study (Fordham et al. 2001, Relyea 2004). Because the current study used concentrations of carbaryl and malathion that were well under these LC50 values (0.51 and 0.32 mg/L, respectively), there should have been minor negative impacts of insecticides on tadpole survival and this is what I observed.

Interestingly, the survival of tadpoles actually increased with the addition of insecticides; this was probably an indirect effect of high predator mortality. The addition of Sevin reduced the biomass of the insect predators by 44%, increased tadpole (wood frog and leopard frog) survival by 22–30%, and increased total tadpole biomass by 85%. Similarly, the salamander larvae (which were small and susceptible to insect predation) experienced a 37% increase in survival when Sevin was added. While the addition of malathion reduced the biomass of the insect predators by a similar amount as Sevin (48%), the 15–17% increase in wood frog and leopard frog survival was not significant and the salamander survival was unchanged. Thus, changes in predator biomass do not completely explain changes in herbivore survival, suggesting that we also need to examine how the different pesticides affect the foraging behavior of the surviving predators. For example, Boone and Semlitsch (2001, 2002) found that carbaryl (in the absence of insect predators) can have both positive and negative effects on tadpole survival. In contrast to the tadpoles, snails did not experience a positive indirect effect on their biomass because the specialist snail predator (*Belostoma*) was not killed by the insecticides. This suggests that although higher concentrations of carbaryl and malathion certainly can kill many amphibians (>5 mg/L; Boone and Semlitsch 2001, 2002, Relyea 2003*b*, 2004), under lower concentrations these insecticides, and perhaps other insecticides that share the same mode of action, actually can have positive indirect effects on the survival and biomass of tadpoles. Thus, in assessing the impacts of insecticides on amphibians, it is critical that we consider both relevant concentrations and relevant ecological contexts.

The two herbicides had very different effects on the community than the two insecticides. Although glyphosate and 2,4-D are designed to kill plants, they did not reduce the biomass of periphyton in the experiment. In fact, 2,4-D had few effects on any species or trophic group in the entire community during the 14-day experiment (only backswimmers and spotted salamanders increased survival with 2,4-D, although the causes are unclear). This general lack of impact from 2,4-D is consistent with past toxicity studies that have found relatively high $LC50_{96\text{-h}}$ values for 2,4-D, including 45 mg/L for lake trout (*Salvelinus namaycush*), 301 mg/L for American eels (*Anguilla rostrata*), and 363–389 mg/L for cladocerans (*Daphnia magna*; USDI 1980, Verschueren 1983). In this system, 2,4-D appeared to have no substantial impact on a diverse aquatic community.

In stark contrast, Roundup had a major effect on the community. Roundup reduced tadpole richness by 70% by completely exterminating two species (leopard frogs

ANNEX 150

and gray tree frogs) and nearly exterminated a third species (wood frogs). Roundup did not have a significant effect on toads, spring peepers, and the spotted salamanders, although few toads survived even in the control treatments, making it difficult to assess the effects of Roundup on survival. These reductions in tadpole survival were concomitant with a decrease in predator biomass, suggesting that Roundup also caused a trophic cascade from the herbivores to the predators. In comparison to the 3.8 mg/L of glyphosate used in the mesocosm study (based on the manufacturer's recommended application rate; AI = active ingredient), concentrations of glyphosate in nature have been observed up to 2.3 mg AI/L and are capable of being as high as 3.7 mg AI/L (Giesy et al. 2000).

Giesy et al. (2000) recently reviewed the toxicity of glyphosate and found that its toxicity (expressed as mg of active ingredient per liter) to invertebrates can be quite high, ranging from 3.5 mg AI/L in crayfish (*Orconectes nais*; $LC50_{96\text{-h}}$) to 5600 mg AI/L in midge larvae (*Chironomus riparius*; $LC50_{48\text{-h}}$). As expected from these previous studies, glyphosate had no effect on the insect predators and snails in the mesocosm experiment. Glyphosate also has a wide range of toxic effects on fish, ranging from 3.5 mg AI/L in *Tilapia* sp. ($LC50_{96\text{-h}}$) to >1300 mg AI/L in sheepshead minnows (*Cyprinodon variegatus*; $LC50_{96\text{-h}}$). Prior tests of glyphosate on amphibians have been rare. In four species of Australian tadpoles (*Crinia insignifera*, *Heleioporus eyrei*, *Limnodynastes dorsalis*, and *Litoria moorei*), Mann and Bidwell (1999) found that $LC50_{48\text{-h}}$ values in the laboratory ranged from 3.9 to 15.5 mg AI/L for Roundup (glyphosate plus POEA surfactant), 108 to 161 mg AI/L for technical grade glyphosate acid, and >450 mg AI/L for glyphosate isopropylamine salt (the latter two formulations lack the POEA surfactant). Perkins et al. (2000) conducted laboratory experiments on *Xenopus laevis* tadpoles and found $LC50_{96\text{-h}}$ values of 12.4 mg AI/L for Roundup, 6.8 mg/L for the POEA surfactant alone, and 9729 mg AI/L for Rodeo (an aquatic form of glyphosate that lacks the POEA surfactant). Smith (2001) examined the impact of Kleeraway (another form of glyphosate that includes the POEA surfactant) and found that nearly half of western chorus frog tadpoles (*Pseudacris triseriata*) died at 0.75 mg AI/L; plains leopard frog larvae (*Rana blairi*) experienced 0% and 100% survival at 0.75 mg AI/L in two separate experiments. All tadpoles of both species died at higher concentrations (7.5, 750, and 7500 mg AI/L). These studies suggest that the high mortality associated with commercial forms of Roundup is actually due to the POEA surfactant and not to glyphosate itself.

The high mortality rates of tadpoles associated with Roundup are in agreement with those of several other experiments that I have recently completed on tadpole species from the midwestern United States. Using static exposure experiments in the laboratory, I reared six different species of tadpoles under a range of Roundup concentrations to estimate the LC50 values. The estimated $LC50_{16\text{-d}}$ values for these North American species were lower than previously observed for most amphibian species (Mann and Bidwell 1999, Perkins et al. 2000), ranging from 0.5 to 2.5 mg AI/L (Relyea, *in press*). This suggests that a direct overspray at the manufacturer's recommended rate (a realized pond concentration of 3.8 mg/L) should be highly lethal to these amphibians. The current study is consistent with this prediction.

I have also conducted a second outdoor mesocosm experiment in the absence of predators (to eliminate this source of mortality) and with the addition of either no soil, sand, or loam (because soil is known to absorb the two components of Roundup (glyphosate and the POEA surfactant) and remove them from the water column; Giesy et al. 2000). I exposed communities of three tadpoles species to 3.8 mg AI/L of glyphosate (in the form of Roundup, similar to the current experiment) and found that it reduced tree frog tadpole survival from 75% to 2%, toad tadpole survival from 97% to 0%, and leopard frog tadpole survival from 98% to 4% (R. A. Relyea, *unpublished manuscript*). Moreover, the addition of soil did not diminish the toxic effect. Collectively, the available data indicate that, contrary to conventional wisdom, current application rates of Roundup can be highly lethal to many species of amphibians. This result is of particular interest in light of the global decline of amphibians (Wake 1998, Alford and Richards 1999, Houlihan et al. 2001, Blaustein and Kiesecker 2002) which, in some cases, is correlated with a proximity to agricultural areas that use pesticides (Bishop et al. 1999, Davidson et al. 2001, 2002, Sparling et al. 2001).

Although Roundup is an herbicide, two lines of evidence suggest that the widespread tadpole mortality was directly due to toxicity and not to the destruction of the tadpoles' algal food source. First, much of the mortality occurred within the first 24 hours (*personal observations*). This mortality rate was much faster than would be expected to occur with a lack of food (Audo et al. 1995) and was consistent with our single-species laboratory experiments that did not use algal food sources (Relyea, *in press*). Second, the biomass of periphyton did not decrease with Roundup. Roundup actually caused a 40% increase in periphyton by removing a large fraction of the herbivores and allowing periphyton to attain a higher standing crop. Thus, there was a positive, indirect effect of Roundup on periphyton. This indicates that Roundup directly kills amphibians rather than indirectly causing amphibians to starve to death.

Conclusions

This study highlights the importance of examining the impact of pesticides within the natural ecological context in which the taxa live. Single-species toxicity

ANNEX 150

studies are invaluable to assess the relative lethality of different chemicals on both target and nontarget species. However, when toxicity studies are embedded in the nexus of interactions that compose natural food webs, we can arrive at very different interpretations due to the prevalence of both direct and indirect effects. At realistic concentrations, the two insecticides had substantial negative effects on the predatory insects and cladocerans, but they had substantial indirect positive effects on the copepods and tadpoles. The two herbicides had quite contrasting effects; 2,4-D had no impact on the community, whereas Roundup caused a major reduction in amphibian diversity, an indirect, positive impact on the periphyton that the tadpoles consume, and an indirect, negative effect on the biomass of insect predators. It is important to note that these impacts occurred over relatively short time scales (two weeks). Over longer time scales (months to years, depending on the species), many of the taxa have the potential to recover their population sizes, provided that the pesticide exposure is not a recurring event.

Although there is currently a strong empirical and theoretical push to understand the factors that determine species diversity and abundance in relatively pristine systems (Tilman et al. 2001, Chase and Leibold 2002, Downing and Leibold 2002, Naeem 2002), few habitats are untouched by anthropogenic effects, including the direct application or drift of pesticides (Lambert 1997, LeNoir et al. 1999, Leonard et al. 1999, Favari et al. 2002). We need to understand how these effects impact natural systems and whether they contribute to the global decline in biodiversity.

Acknowledgments

My thanks to Josh Auld, Jason Hoverman, Laura Howell, Adam Marko, and Nancy Schoeppner for assisting with the experiments. I thank Josh Auld, Jason Hoverman, April Randle, and Nancy Schoeppner for reviewing the manuscript. The research was supported by the National Science Foundation.

Literature Cited

Alford, R. A., and S. J. Richards. 1999. Global amphibian declines: a problem in applied ecology. Annual Review of Ecology and Systematics **30**:133–165.

Aly, O. M., and M. A. El-Dib. 1971. Studies on the persistence of some carbamate insecticides in the aquatic environment–I: hydrolysis of sevin, baygon, pyrolan and dimetilan in waters. Water Research **5**:1191–1205.

Audo, M. C., T. M. Mann, T. L. Polk, C. M. Loudenslager, W. J. Diehl, and R. Altig. 1995. Food deprivation during different periods of tadpole (*Hyla chrysoscelis*) ontogeny affects metamorphic performance differently. Oecologia **103**:518–522.

Bishop, C. A., N. A. Mahony, J. Struger, P. Ng, and K. E. Pettit. 1999. Anuran development, density and diversity in relation to agricultural activity in the Holland River watershed, Ontario, Canada (1990–1992). Environmental Monitoring and Assessment **57**:21–43.

Blaustein, A. R., and J. M. Kiesecker. 2002. Complexity in conservation: lessons from the global decline of amphibian populations. Ecology Letters **5**:597–608.

Boone, M. D., and S. M. James. 2003. Interactions of an insecticide, herbicide, and natural stressors in amphibian community mesocosms. Ecological Applications **13**:829–841.

Boone, M. D., and R. D. Semlitsch. 2001. Interactions of an insecticide with larval density and predation in experimental amphibian communities. Conservation Biology **15**: 228–238.

Boone, M. D., and R. D. Semlitsch. 2002. Interactions of an insecticide with competition and pond drying in amphibian communities. Ecological Applications **12**:307–316.

Bridges, C. M. 1997. Tadpole swimming performance and activity affected by acute exposure to sublethal levels of carbaryl. Environmental Toxicology and Chemistry **16**: 1935–1939.

Chase, J. M., and M. A. Leibold. 2002. Spatial scale dictates the productivity–biodiversity relationship. Nature **416**: 427–430.

Davidson, C., H. B. Shafer, and M. R. Jennings. 2001. Declines of the California red-legged frog: climate, UV-B, habitat, and pesticides hypotheses. Ecological Applications **11**:464–479.

Davidson, C., H. B. Shafer, and M. R. Jennings. 2002. Spatial tests of the pesticide drift, habitat destruction, UV-B, and climate-change hypotheses for California amphibian declines. Conservation Biology **16**:1588–1601.

Diana, S. G., W. J. Resetarits, Jr., D. J. Shaeffer, K. B. Beckman, and V. R. Beasley. 2000. Effects of atrazine on amphibian growth and survival in artificial aquatic communities. Environmental Toxicology and Chemistry **19**:2961–2967.

Donaldson, D., T. Kiely, and A. Grube. 2002. Pesticides industry sales and usage: 1998 and 1999 market estimates. USEPA Report Number 733-R-02-001, U.S. Environmental Protection Agency, Washington, D.C., USA.

Downing, A. L., and M. A. Leibold. 2002. Ecosystem consequences of species richness and composition in pond food webs. Nature **416**:837–841.

Favari, L., E. Lopez, L. Martinez-Tabche, and E. Diaz-Pardo. 2002. Effect of insecticides on plankton and fish of Ignacio Ramirez reservoir (Mexico): a biochemical and biomagnification study. Ecotoxicology and Environmental Safety **51**:177–186.

Fordham, C. L., J. D. Tessari, H. S. Ramsdell, and T. J. Keefe. 2001. Effects of malathion on survival, growth, development, and equilibrium posture on bullfrog tadpoles (*Rana catesbeiana*). Environmental Toxicology and Chemistry **20**:179–184.

Giesy, J. P., S. Dobson, and K. R. Solomon. 2000. Ecotoxicological risk assessment for Roundup® herbicide. Reviews of Environmental Contamination and Toxicology **167**:35–120.

Guerrant, G. O., L. E. Fetzer, Jr., and J. W. Miles. 1970. Pesticide residues in Hale County, Texas, before and after ultra-low volume aerial application of malathion. Pesticide Monitoring Journal **4**:14–20.

Hanazato, T. 1991. Effects of long- and short-term exposure to carbaryl on survival, growth, and reproduction of *Daphnia ambigua*. Environmental Pollution **74**:139–148.

Hanazato, T., and M. Yasuno. 1987. Effects of a carbamate insecticide, carbaryl, on summer phyto- and zooplankton communities in ponds. Environmental Pollution **48**:145–159.

Hanazato, T., and M. Yasuno. 1989. Effects of carbaryl on spring zooplankton communities in ponds. Environmental Pollution **56**:1–10.

Hanazato, T., and M. Yasuno. 1990. Influence of time of application of an insecticide on recovery patterns of a zooplankton community in experimental ponds. Archives of Environmental Contamination and Toxicology **19**:77–83.

Harris, M. L., C. A. Bishop, J. Struger, B. Ripley, and J. P. Bogart. 1998. The functional integrity of northern leopard

ANNEX 150

frog (*Rana pipiens*) and green frog (*Rana clamitans*) populations in orchard wetlands. II. Genetics, physiology, and biochemistry of breeding adults and young-of-the-year. Environmental Toxicology and Chemistry **17**:1338–1350.

Havens, K. E. 1994. An experimental comparison of effects of two chemical stressors on a freshwater zooplankton assemblage. Environmental Pollution **84**:245–251.

Havens, K. E. 1995. Insecticide (carbaryl, 1-napthyl-n-methylcarbamate) effects on a freshwater plankton community: zooplankton size, biomass, and algal abundance. Water Air and Soil Pollution **84**:1–10.

Havens, K. E., and T. Hanazato. 1993. Zooplankton community responses to chemical stressors: a comparison of results from acidification and pesticide contamination research. Environmental Pollution **82**:277–288.

Houlihan, J. E., C. S. Findlay, B. R. Schmidt, A. H. Meyers, and S. L. Kuzmin. 2001. Quantitative evidence for global amphibian population declines. Nature **404**:752–755.

Key, P. B., M. H. Fulton, G. I. Scott, S. L. Layman, and E. F. Wirth. 1998. Lethal and sublethal effects of malathion on three life stages of the grass shrimp, *Palaemonetes pugio*. Aquatic Toxicology **40**:311–322.

Lambert, M. R. K. 1997. Environmental effects of heavy spillage from a destroyed pesticide store near Hargeisa (Somaliland) assessed during the dry season, using reptiles and amphibians as bioindicators. Archives of Environmental Contamination and Toxicology **32**:80–93.

Leight, A. K., and R. F. Van Dolah. 1999. Acute toxicity of the insecticides endosulfan, chlorpyrifos, and malathion to the epibenthic estuarine amphipod *Gammarus palustris* (Bousefield). Environmental Toxicology and Chemistry **18**: 958–964.

LeNoir, J. S., L. L. McConnell, G. M. Fellers, T. M. Cahill, and J. N. Seiber. 1999. Summertime transport of current-use pesticides from California's central valley to the Sierra Nevada Mountain range, USA. Environmental Toxicology and Chemistry **18**:2715–2722.

Leonard, A. W., R. V. Hyne, R. P. Lim, and J. C. Chapman. 1999. Effect of endosulfan runoff from cotton fields on macroinvertebrates in the Namoi River. Ecotoxicology and Environmental Safety **42**:125–134.

Mann, R. M., and J. R. Bidwell. 1999. The toxicity of glyphosate and several glyphosate formulations to four species of southwestern Australian frogs. Archives of Environmental Contamination and Toxicology **26**:193–199.

Marchal-Segault, D. 1976. Toxicité de quelques insecticides pour des têtards de *Bufo bufo* (Amphibiens, Anoures). Bulletin Ecology **7**:411–416.

Marian, M. P., V. Arul, and T. J. Pandian. 1983. Acute and chronic effects of carbaryl on survival, growth, and metamorphosis in the bullfrog (*Rana tigrina*). Archives of Environmental Contamination and Toxicology **12**:271–275.

Martinez-Tabche, L., M. M. Galar, H. E. Olvera, R. A. Chehue, E. L. Lopez, L. Gomez-Olivan, and O. T. Sierra. 2002. Toxic effect and bioavailability of malathion spiked in natural sediments from the Ignacio Ramirez dam on the snail *Stagnicola* sp. Ecotoxicology and Environmental Safety **52**: 232–237.

McConnell, L. L., J. S. LeNoir, S. Datta, and J. N. Seiber. 1998. Wet deposition of current-use pesticides in the Sierra Nevada Mountain range, California, USA. Environmental Toxicology and Chemistry **17**:1908–1916.

Morin, P. J. 1981. Predatory salamanders reverse outcome of competition among three species of anuran tadpoles. Science **212**:1284–1286.

Naeem, S. 2002. Ecosystem consequences of biodiversity loss: the evolution of a paradigm. Ecology **83**:1537–1552.

Perkins, P. J., H. J. Boermans, and G. R. Stephenson. 2000. Toxicity of glyphosate and triclopyr using the frog embryo teratogenesis assay—*Xenopus*. Environmental Toxicology and Chemistry **19**:940–945.

Relyea, R. A. 2001. The relationship between predation risk and anti-predator responses in larval anurans. Ecology **82**: 541–554.

Relyea, R. A. 2003*a*. How prey respond to combined predators: a review and an empirical test. Ecology **84**:1827–1839.

Relyea, R. A. 2003*b*. Predator cues and pesticides: a double dose of danger for amphibians. Ecological Applications **13**: 1515–1521.

Relyea, R. A. 2004. Synergistic impacts of malathion and predatory stress on six species of North American tadpoles. Environmental Toxicology and Chemistry **23**:1080–1084.

Relyea, R. A. *In press*. The lethal impacts of Roundup and predatory stress on six species of North American tadpoles. Archives of Environmental Contamination and Toxicology.

Relyea, R. A., and N. Mills. 2001. Predator-induced stress makes the pesticide carbaryl more deadly to grey treefrog tadpoles (*Hyla versicolor*). Proceedings of the National Academy of Sciences (USA) **98**:2491–2496.

Relyea, R. A., and K. L. Yurewicz. 2002. Predicting community outcomes from pairwise interactions: integrating density- and trait-mediated effects. Oecologia **131**:569–579.

Smith, G. R. 2001. Effects of acute exposure to a commercial formulation of glyphosate on the tadpoles of two species of anurans. Bulletin of Environmental Contamination and Toxicology **67**:483–488.

Sparling, D. W., G. M. Fellers, and L. S. McConnell. 2001. Pesticides and amphibian population declines in California, USA. Environmental Toxicology and Chemistry **20**:1591–1595.

Tilman, D., P. B. Reich, J. Knops, D. Wedin, T. Mielke, and C. Lehman. 2001. Diversity and productivity in a long-term grassland experiment. Science **294**:843–845.

USDI [U.S. Fish and Wildlife Service]. 1980. Handbook of acute toxicity of chemicals to fish and aquatic invertebrates. Resource Publication Number 137, U.S. Government Printing Office, Washington, D.C., USA.

Verschueren, K. 1983. Handbook of environmental data of organic chemicals. Second edition. Van Nostrand Reinhold, New York, New York, USA.

Wake, D. B. 1998. Action on amphibians. Trends in Ecology and Evolution **13**:379–380.

Wang, T. 1991. Assimilation of malathion in the Indian River estuary, Florida. Bulletin of Environmental Contamination and Toxicology **47**:238–243.

Wauchope, R. D., and R. Haque. 1973. Effects of pH, light and temperature on carbaryl in aqueous media. Bulletin of Environmental Contamination and Toxicology **9**:257–260.

Werner, E. E., and B. R. Anholt. 1996. Predator-induced behavioral indirect effects: consequences to competitive interactions in anuran larvae. Ecology **77**:157–169.

Wong, C. K., K. H. Chu, and F. F. Shum. 1995. Acute and chronic toxicity of malathion to the fresh-water cladoceran *Moina macrocarpa*. Water Air and Soil Pollution **84**:399–405.

Zaga, A., E. E. Little, C. F. Raben, and M. R. Ellersieck. 1998. Photoenhanced toxicity of a carbamate insecticide to early life stage anuran amphibians. Environmental Toxicology and Chemistry **17**:2543–2553.

ANNEX 151

Keith R. Solomon et al.,
Environmental and Human Health Assessment of the Aerial Spray Program for Coca and Poppy Control in Colombia, prepared for the Inter-American Drug Abuse Control Commission (CICAD) section of the Organization of American States (OAS) (31 Mar. 2005)

ENVIRONMENTAL AND HUMAN HEALTH ASSESSMENT OF THE AERIAL SPRAY PROGRAM FOR COCA AND POPPY CONTROL IN COLOMBIA

Dr. Keith R Solomon
Centre for Toxicology and Department of Environmental Biology,
University of Guelph, Guelph, ON, N1G 2W1, Canada
Dr. Arturo Anadón
Departamento de Toxicología y Farmacología
Facultad de Veterinaria,
Universidad Complutense de Madrid
Avda. Puerta de Hierro, s/n
Madrid 28040
Spain
Dr. Antonio Luiz Cerdeira
EMBRAPA, Ministry of Agriculture
Jaguariuna, SP 13820-000, Brazil
Dr. Jon Marshall
Marshall Agroecology Limited
2 Nut Tree Cottages, Barton, Winscombe,
Somerset, BS25 1DU, UK
Dr. Luz-Helena Sanin
Department of Public Health Sciences,
Faculty of Medicine, University of Toronto, Toronto, ON, M5S 1A8, Canada,
Autonomous University of Chihuahua,
and National Institute of Public Health, Mexico

A report prepared for the Inter-American Drug Abuse Control Commission (CICAD) section of the Organization of American States (OAS)

Washington, DC, USA

March 31, 2005

EXECUTIVE SUMMARY

This report was prepared for the Inter-American Drug Abuse Control Commission (CICAD) section of the Organization of American States (OAS) in response to requests from the Governments of Colombia, the United States, and the United Kingdom. The request was to conduct a science-based risk assessment of the human health and environmental effects of the use of glyphosate for the control of the illicit crops, coca and poppy, in Colombia. This became the purpose of the study, which was conducted in a number of steps.

The initial step in the process was to establish an international Panel of experts in human, animal, and environmental toxicology, in epidemiology, in agronomic practices, and in ecology (the Scientific Advisory Team - SAT). In the second step, the SAT formulated a framework to conduct this risk assessment. The framework is similar to those commonly used for assessing risks in a number of jurisdictions and consisted of a problem formulation, characterization of the human health and environmental effects of the substances used in the eradication program, characterization of human and environmental exposures, and the drawing together of these in a risk characterization. During the process of conducting the risk assessment, the SAT used scientific literature and government reports but, where data gaps and uncertainties related to the specific uses in Colombia were identified, studies were initiated to assemble additional data for use in the risk assessment. Several of these studies were carried out in Colombia. The Colombian Team (PTG) were contracted specifically to CICAD and worked under the direction of the SAT to collect data in the Colombian environment. During the conduct of our study, members of the SAT made a number of visits to Colombia to view, at first hand, all aspects of the program, to gather local information and data, and to oversee the local studies of the PTG.

The SAT recognized that the growing and production of illicit drugs in Colombia has significant political, social, and economic, implications. However, this study was focused specifically on the human health and environmental significance of the production and eradication of coca and poppy through the use of aerially applied herbicide. The production of coca and poppy as well as the processing and production of cocaine and heroin also involves significant environmental impacts. Both coca and poppy are grown intensively in a process that involves the clearing of land, the planting of the crop and protection against pests such as weeds, insects, and pathogens. All of these activities can impact human health and the environment and some, such as clear-cutting, do so to a significant extent. The total land area used for these activities is small relative to the entire country. However, much of the production takes place in remote areas that are close to or part of the Andean Biodiversity Hotspot.

In Colombia, the herbicide glyphosate is widely used in agriculture and for purposes other than eradication of coca and poppy. Only 10-14% of the total use in Colombia is in the eradication program. Similarly many of the pesticides and other substances used in the production of coca and poppy are also widely used in agriculture. The aerial eradication spray program in Colombia is conducted with modern state-of-the-art aircraft and spray equipment. The spray equipment is similar to that used for forest spraying in other parts of the world and produces large droplets which minimize drift of spray. Identification of target fields and electronic documentation

of locations and areas sprayed is conducted with high precision. As a result of the use of best available spray and navigation technology, the likelihood of accidental off-target spraying is small and is estimated to be less than 1% of the total area sprayed.

The physical, chemical, and biological properties of glyphosate and an adjuvant (Cosmo-Flux®) added to the spray mix were characterized through the scientific literature and through new studies specifically conducted for this risk assessment. Glyphosate is a widely-used herbicide that is well characterized in terms of physical, chemical, and biological properties. Glyphosate is not highly mobile in the environment and is rapidly and tightly bound on contact with soil and aquatic sediments. Glyphosate has a very short biological activity in soils and water, does not biomagnify or move through the food chain, and does not leach into groundwater from soil.

Exposures of humans to glyphosate under the conditions of use could not be measured directly in the growers of illicit crops and thus were estimated from literature values with adjustments for the rates of application used in the eradication program in Colombia. Estimated exposures resulting from direct overspray, contact with treated foliage after re-entry to fields, inhalation, diet, and drinking water were small and infrequent. In a special study in five watersheds, weekly analyses of surface waters and sediments over a period of 24 weeks showed that, on most occasions, glyphosate was not present at measurable concentrations; only two samples had residues above the method detection limit of 25 µg/L. As most of the glyphosate used in Colombia is in agriculture, this confirms that, regardless of use pattern, glyphosate is not mobile in environment and it will not move from the treated fields in significant amounts. In analyses of water samples taken from the same five watersheds, several other pesticides were found, including the herbicide 2,4-D and the insecticide endosulfan, the latter a product that is banned in Colombia.

Concentrations of glyphosate in several environmental matrices resulting from the eradication spray program were estimated. Concentrations in air were predicted to be very small because of negligible volatility. Glyphosate in soils that are directly sprayed will be tightly bound and biologically unavailable. Based on observations in other temperate and tropical areas, no residual activity is expected in soil and even the most sensitive organisms, plants, will not be prevented from re-establishing themselves. In Colombia, this is evidenced by the rapid recovery of sprayed fields through successful replanting of coca and/or colonization by invasive species of plants. Concentrations of glyphosate plus Cosmo-Flux® will be relatively large in shallow surface waters that are over-sprayed (maximum instantaneous concentration of 1,052 µg AE/L in water 300 mm deep); however, no information was available on the number of fields in close proximity to surface waters and it was not possible to estimate the likelihood of such contamination.

The toxicity of glyphosate has been rigorously assessed in a number of jurisdictions and in the published literature. Glyphosate itself has low toxicity to non-target organisms other than green plants. It is judged to have low acute and chronic toxicity, carcinogenic, mutagenic, or a reproductive toxicant. With respect to humans, is not considered hazardous, except for the possibility of eye and possibly skin irritation (from which recovery occurs). The toxicity of the formulation as used in the eradication program in Colombia, a mixture of glyphosate and Cosmo-Flux®, has been characterized in specific tests conducted in laboratory animals. The mixture has low

toxicity to mammals by all routes of exposure, although some temporary eye irritation may occur. By extrapolation, the spray mixture is also not expected to be toxic to terrestrial mammals and vertebrates. Epidemiology studies conducted in a number of jurisdictions around the world have not suggested a strong or consistent linkage between glyphosate use and specific human health outcomes. A preliminary epidemiology study was conducted in Colombia to assess any linkage between glyphosate and the reproductive outcome, time to pregnancy, in humans. This study did not show any association between time to pregnancy and the use of glyphosate in eradication spraying.

New data from the environmental literature on the toxicity of some formulations of glyphosate suggest that amphibians may be the most sensitive group of aquatic organisms. Special tests of the spray mixture as used in Colombia were conducted using standardized environmental test organisms. These tests revealed that the mixture of glyphosate and Cosmo-Flux® was not toxic to honey bees. The mixture was, however, more toxic to aquatic organisms than formulated glyphosate alone. Extensive studies on the use of glyphosate in agriculture and forestry in temperate and tropical areas have been published in the literature. These have shown that direct effects on non-target organisms other than plants are unlikely to occur. Indirect effects on terrestrial arthropods and other wildlife have, however, been observed. These are the result of habitat alteration and environmental change brought about by the removal of target plants through the effects of glyphosate. Similar effects would be expected regardless of the type of method used to control plants and also occur as a result of clear-cutting, burning, and conversion of natural areas into agricultural lands. Because of the lack of residual activity, recovery of glyphosate-treated areas will be dependent only on the nature of the recolonizing species and the local conditions. Given experience in other tropical regions and in Colombia, this process will be rapid because of good conditions for plant growth. However, return to the conditions of tropical old-growth forest that existed prior to clear-cutting and burning may take hundreds of years. It is important to recognize that the impact here is not the use of glyphosate but the original act of clear-cutting and burning that is the primary cause of the effects on the environment.

The risk assessment concluded that glyphosate and Cosmo-Flux® as used in the eradication program in Colombia did not present a significant risk to human health. Estimated acute worst-case exposures in humans via all routes were less than doses of concern, even for chronic responses. In the entire cycle of coca and poppy production and eradication, human health risks associated with physical injury during clear-cutting and burning and the use of pesticides for protection of the illicit crops were judged to be more important than those from exposure to glyphosate.

For the environment, risks from the use of glyphosate and Cosmo-Flux® to terrestrial animals were judged to be small to negligible. Moderate risks could occur in aquatic organisms in shallow surface waters that are over-sprayed during the eradication program. However, the frequency of occurrence and extent to which this happens are unknown as data on the proximity of surface waters to coca fields were not available. Considering the effects of the entire cycle of coca and poppy production and eradication, clear-cutting and burning and displacement of the natural flora and fauna

were identified as the greatest environmental risks and are considerably more important than those from the use of glyphosate.

Strengths and uncertainties in the assessment were identified and used to develop recommendations which were then prioritized. It is recommended that the current application practices for eradication spraying be retained but that additional data be gathered over a longer time period to better characterize the impacts of coca and poppy production in the Andean Biodiversity Hotspot and the possibility of non-target effects in surface waters located close to fields. If shallow waters are routinely found close to fields, it is recommended that other formulants be tested for the purposes of selecting products that present a lower risk to aquatic organisms. Although no association was observed between eradication spraying and reproductive outcomes in humans, additional studies to identify possible risk factors associated with other human activities or environmental factors should be considered.

2.1.1 Glyphosate

Glyphosate is one of the most widely used pesticides on a global basis. Uses include agricultural, industrial, ornamental garden and residential weed management. In agriculture, the use of glyphosate is increasing and use in soybeans is probably greater since the introduction of glyphosate-tolerant crops (Wolfenbarger and Phifer 2000). Other agricultural uses for glyphosate-based products include its use by farmers as a routine step in pre-plant field preparation. Non-agricultural users include public utilities, municipalities, and regional transportation departments where glyphosate is used for the control of weeds or noxious plants. The environmental and human-health properties of glyphosate have been extensively reviewed in the literature (Giesy et al. 2000, Solomon and Thompson 2003, Williams et al. 2000) and by regulatory agencies (NRA 1996, USEPA 1993a, 1997, 1999, World Health Organization International Program on Chemical Safety 1994). The following sections highlight key issues with regard to those properties of glyphosate that are fundamental to the assessment of risks associated with the coca and poppy eradication programs in Colombia.

2.1.1.1 Structure and chemical properties

The chemical name of glyphosate (acid) is N-(phosphonomethyl) glycine (MW = 167.09) and that of the most common technical form, the isopropylamine salt (IPA) is N-(phosphonomethyl) glycine isopropylamine salt (MW = 226.16). The Chemical Abstracts Registry (CAS) number of the acid is 114370-14-8 and for the IPA salt is 1071-83-6. The chemistry of glyphosate is important in determining its fate in the environment. Glyphosate (Figure 3) is a weak organic acid comprising a glycine moiety and a phosphonomethyl moiety. Chemically and physically, glyphosate closely resembles naturally occurring substances and it is not chemically reactive, not mobile in air or soils, does not have great biological persistence, and does not bioaccumulate or biomagnify through the food chain (CWQG 1999, Giesy et al. 2000, USEPA 1993a, Williams et al. 2000, World Health Organization International Program on Chemical Safety 1994).

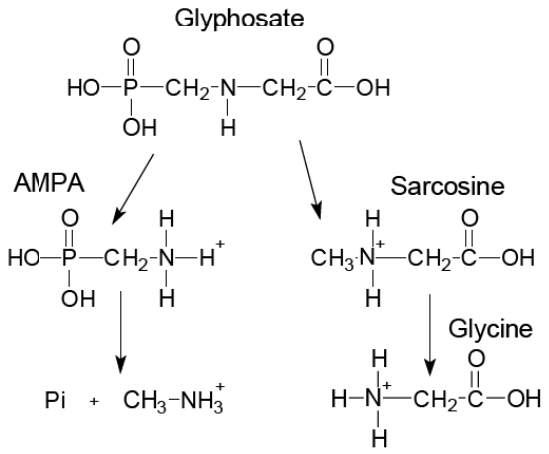


Figure 10 The structure of glyphosate and its major metabolic and breakdown products. From (Liu et al. 1991)

Glyphosate is readily ionized and, as the anion, will be strongly adsorbed to organic matter in soils of normal pH (Figure 4). It thus has low mobility in soils and is rapidly removed from water by adsorption to sediments and suspended particulate matter.

2.1.1.2 Mechanism of action of glyphosate

The mechanism of action of glyphosate is via the inhibition of the enzyme 5-enolpyruvyl shikimate-3-P synthetase, an essential enzyme on the pathway to the synthesis of the aromatic amino acids in plants (Devine et al. 1993). This inhibition results in decreases in the synthesis of the aromatic amino acids, tryptophan, phenylalanine, and tyrosine, as well as decreased rates of synthesis of protein, indole acetic acid (a plant hormone), and chlorophyll. The death of the plant is slow and is first seen as a cessation of growth, followed by chlorosis and then necrosis of plant tissues. Inhibition of 5-enolpyruvyl shikimate-3-P synthetase is specific to plants. Many animals obtain their aromatic amino acids from plants and other sources and do not possess this pathway of synthesis. For this reason, glyphosate is relatively non-toxic to animals but is an effective herbicide in plants.

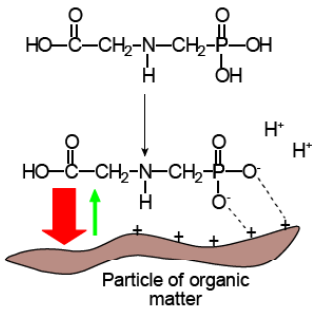


Figure 11 Binding of glyphosate to soil particles

2.1.1.3 Global and local registration and use

Glyphosate has been registered since 1971 and is currently widely used as a broad-spectrum, non-selective, post-emergence herbicide in a number of countries around the world (World Health Organization International Program on Chemical Safety 1994). It is rapidly translocated from the leaves of treated plants to other parts of the plant, including the growing tips of stems and roots, and to underground storage organs, such as rhizomes and tubers. It is very effective for the control of perennial weeds and is more efficacious than many other non-selective herbicides that only affect the above-ground parts of the plant. Applied to soil, glyphosate shows low activity because the strong binding to soil organic matter makes the substance biologically unavailable to plants. Glyphosate has been used extensively in Colombia and many other countries for agricultural and other purposes for many years. Use of glyphosate in the coca and poppy spray program is shown in Table 3 and represents a relatively small fraction of the total use in Colombia.

Table 3. Use glyphosate in eradication spraying in Colombia 2000 to 2004

Year	Amount sold in Colombia (L)[a]	Amount used in the eradication of illicit crops (L)[b]	Percent of total amount sold
2000	7,037,500	603,970	8.6%
2001	9,473,570	984,848	10.4%
2002	NA	1,061,538	11%[c]
2003		1,381,296	14%[c]
2004		1,420,130	14%[c]

[a] Data from (ICA 2003). [b] Data from (Direccion Nacional de Estupefacientes 2002, Policia Nacional Direccion Antinarcoticos 2005). [c]Estimated from total used in 2001 but likely less than this value.

2.1.1.4 Environmental fate

The environmental fate of glyphosate has been extensively reviewed (CWQG 1999, Giesy et al. 2000, NRA 1996, World Health Organization International Program on Chemical Safety 1994); only key issues relevant to water and soil/sediment are summarized below.

As a result of its specific physicochemical properties, glyphosate is immobile or only slightly mobile in soil. The metabolite of glyphosate, aminomethyl phosphoric acid (AMPA, Figure 3), is somewhat more mobile in soil but is rapidly broken down, resulting in minimal amounts leaching in normal agricultural soils. The strong binding of glyphosate to soil results in almost immediate loss of biological activity, however, the bound residues do break down sufficiently rapidly that accumulation will not occur, even over many years of regular use. Contamination of groundwater from the normal use of glyphosate is unlikely except in the event of a substantial spill or other accidental and uncontrolled release of large amounts into the environment.

The great water solubility of glyphosate and its salts suggests that it would be mobile in water, however, strong and rapid binding to sediments and soil particles, especially in shallow, turbulent waters, or those carrying large loads of particulates, removes glyphosate from the water column (Tooby 1985). In normal agricultural uses, it is not expected to run-off or leach into surface waters.

In water, the two major pathways of dissipation are microbiological breakdown and binding to sediments (Giesy et al. 2000, World Health Organization International Program on Chemical Safety 1994). Glyphosate does not degrade rapidly in sterile water, but in the presence of microflora (bacteria and fungi) in water, glyphosate is broken down to AMPA (Figure 3) and eventually to carbon dioxide (Rueppel et al. 1977). Other metabolic pathways have been reported (Liu et al. 1991), including further degradation of AMPA to inorganic phosphate and CH_3-NH_3, and via sarcosine to glycine (Figure 3). None of these products are considered herbicidal and they would not be expected to be highly toxic to aquatic organisms at concentrations that would result from field use of glyphosate in aquatic systems. Photodegradation also may take place under field conditions where sufficient penetration of UV light occurs.

The dissipation of glyphosate from treated foliage and from leaf litter has also been characterized. As would be expected, most of the glyphosate sprayed on the plants penetrates into plant tissues after application, but some is available for washoff for several days after application (World Health Organization International Program on Chemical Safety 1994). If the plant dies as a result of this exposure, glyphosate would be present in the dead and decaying plant tissues. Glyphosate residues in leaf litter dissipate rapidly with a time to 50% disappearance (DT50) of 8-9 days under temperate forestry conditions (Feng and Thompson 1990). Similar rapid dissipation from fruits and lichen has also been observed (Stiltanen et al. 1981).

Dissipation under tropical conditions such as in Colombia will likely be more rapid than in temperate regions because of higher temperatures and moisture content which promote microbiological activity as well as chemical degradation of many pesticides. Large areas of Brazil, Colombia, Central America, most of Africa between the Sahara and Kalahari deserts, India, inland Indochina, and portions of Northern Australia share similar tropical conditions and some of those countries depend heavily on herbicides

such as glyphosate (Racke et al. 1997). Glyphosate has been used in large areas of Brazil on no-tillage crops in general and, more recently, on transgenic soybeans. Comparing the fate of pesticides in tropical and temperate conditions, Racke et al. (1997) found no evidence of particular behavior of the pesticides in the tropics, they even concluded a greater rate of degradation under tropical conditions. The authors stated:

> *"Since soil microbial activities are strongly modulated by temperature, pesticide degradation would be expected to be greater in tropical soils, which experience higher year-round temperatures, than in temperate soils. This explanation would be consistent with observations of the elevated rates of soil organic matter turnover that characterize udic and ustic (rainy season) tropical environments. The few available studies which have directly compared pesticide fate in temperate and tropical soils held under identical conditions (i.e., laboratory) reveal no significant differences in either the kinetics or pathway of degradation. It appears that there are no inherent differences in pesticide fate due to soil properties uniquely possessed by tropical soils. Tropical soils themselves defy easy categorization, and their properties are as varied in nature as those from temperate zones. Pesticides appear to dissipate significantly more rapidly from soil under tropical conditions than under temperate conditions. The most prominent mechanisms for this acceleration in pesticide dissipation appear to be related to the effect of tropical climates, and would include increased volatility and enhanced chemical and microbial degradation rates on an annualized basis.*

2.1.2 Formulants and adjuvants

Formulants are substances that are added to a pesticide active ingredient at the time of manufacture to improve its efficacy and ease of use. These formulants serve many purposes and comprise a large range of substances, ranging from solvents to surfactants to modifiers of pH. The glyphosate formulation used in Colombia includes several formulants. Adjuvants are added to formulated pesticides at the time of application and, like formulants, increase efficacy, or ease of use in special situations where pests are difficult to control or where non-target effects need to be minimized. In the control program in Colombia, an adjuvant, Cosmo-Flux®, is added at the time of spraying.

The relatively great water solubility and the ionic nature of glyphosate retard penetration through plant cuticular waxes (Figure 5). For this reason, glyphosate is commonly formulated with surfactants which decrease the surface tension of the solution and increase penetration into the tissues of the plants (Giesy et al. 2000, World Health Organization International Program on Chemical Safety 1994).

2.1.2.1 *Surfactants in the glyphosate formulation*

The glyphosate formulation as used in eradication spraying in Colombia contains several formulants which are common to the commercial product as used in agricultural.

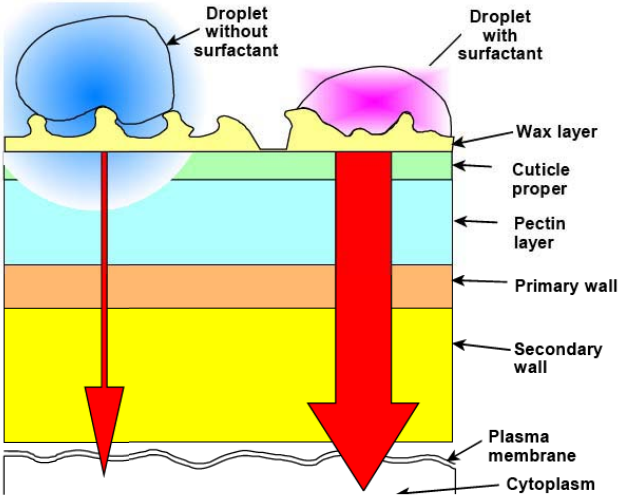


Figure 12 Penetration of an herbicide such as glyphosate through plant cuticular waxes in the absence (left) and presence of surfactants (right).

2.1.2.2 *Cosmoflux 411F*

As mentioned above, an adjuvant, Cosmo-Flux®, is added to the glyphosate at the time of spraying. Cosmo-Flux® is an agricultural adjuvant containing non-ionic surfactants (a mixture of linear and aryl polyethoxylates – 17% w/v) and isoparaffins (83% v/v) (Cosmoagro 2004). Adjuvants such as these are commonly added to pesticide formulations to improve efficacy through several mechanisms (Reeves 1992, Tadros 1994).

For example, surfactants such as the polyethoxylates in Cosmo-Flux®, increase efficacy through increasing target surface adherence, promoting better droplet spread, better dispersion, prevention of aggregation, and enhanced penetration of herbicides into target plant tissues through the reduction of surface tension on plants. Surfactants can also disrupt the water insoluble wax cuticle, thus increasing the penetration of herbicide active ingredient.

Base oils, such as the isoparaffins in Cosmo-Flux®, are another class of adjuvants used in pesticide formulations. They are used primarily to aid foliar absorption of the pesticide by disrupting the waxy cuticle on the outer surface of foliage which increases cell membrane permeability (Manthey and Nalewaja 1992).

2.1.3 Coca and poppy control programs

As discussed briefly above, the coca and poppy control programs make use of several procedures to identify, locate, map coca and poppy fields. The initial step in this process is the use of satellite images to locate the coca and poppy fields. These images are provided by North American and European governments to the Government of Colombia. The images are used to locate potential areas of coca and poppy production. Further visual observations are made using overflights with observers and/or photographs from a low-altitude aerial-photography plane, such as a Cessna Caravan, to verify the presence of the coca and poppy fields. The camera used for this purpose is multi spectral high-resolution. Maps are generated in a Geographic Information System (GIS) and are used to produce updated co-ordinates for the spray pilots as well as information for downloading into the aircraft navigation systems

(Figures 6 and 7). The field operation offices for the control program have computers and a satellite uplink for data transfer. The spray-planes, such as AT 65s, AT 802s, or OV 10s, are equipped with high resolution tracking equipment and Del Norte positional data recorders that display position, provide directional guidance, and store positional data on data cards for later analysis. Thus the locations of the fields, the flight-paths of the spray-planes, and the areas where spray is released are known to within a resolution of several meters.

Since 1994, the coca and, more recently, poppy fields have been identified and sprayed during the eradication program. Total areas of identified fields, and area sprayed in Colombia are shown in Figure 8. With increasing areas sprayed, the total area planted to coca has generally decreased since 2000.

2.1.3.1 Receiving environment

Colombia is located between about 4ºS and 12°N of the equator. The country presents very varied topography ranging from snow-capped peaks through high mountain plateaus to low-lying tropical regions. In general, coca tends to be grown at altitudes below 1,500 m and poppy at greater altitudes, usual 2,200 m. The biodiversity hotspot for the tropical Andean region includes significant areas of Colombia (Figure 9). The tropical Andes biodiversity region is estimated to contain 15-17 percent of the world's plant life in only 0.8 percent of its area. It has a area of 1,258,000 square kilometers, and extends from Western Venezuela to Northern Chile and Argentina and includes large portions of Colombia, Ecuador, Peru, and Bolivia (Centre for Biodiversity 2004).

Because the diversity hotspots are mainly associated with the Andean highlands and coca is mostly grown in lower altitudes, there is only some overlap between the areas of coca production and regions of high biodiversity. Poppy is grown at greater altitude and this overlaps with the biodiversity hotspot; however, the total areas grown at this time are small (Figure 8). E xact areas used for coca and poppy production within the diversity hotspot are not known, however, this information would be useful for assessing total impacts of production, especially for rare and endangered species of plants.

2.1.3.2 Method of application

All coca and poppy fields are sprayed by aerial application from fixed-wing aircraft. The procedure described below is based on observations recorded for the AT 65, AT 802, and OV 10 aircraft.

The spray-planes are loaded in a special area of the tarmac at one of a number of bases throughout Colombia (Figure 10). Glyphosate and Cosmo-Flux® are stored in plastic containers in a tarp-lined area protected by a berm to contain accidental spills. The areas may be in the open or covered. The glyphosate is transferred from 200-L plastic barrels to a larger plastic storage tank (Figure 10-A). Cosmo-Flux® is transferred from 20-L plastic containers to a mixing tank. The required amounts of the components of the application mixture (glyphosate, Cosmo-Flux®, and water from a local source) are pumped through a metering pump (Figure 10-B) into the aircraft using a Table of Mixing Proportions to ensure the correct ratio of amounts are loaded. Appropriate protective equipment is used by the mixer-loaders who are trained in the loading procedures (Figure 10-C).

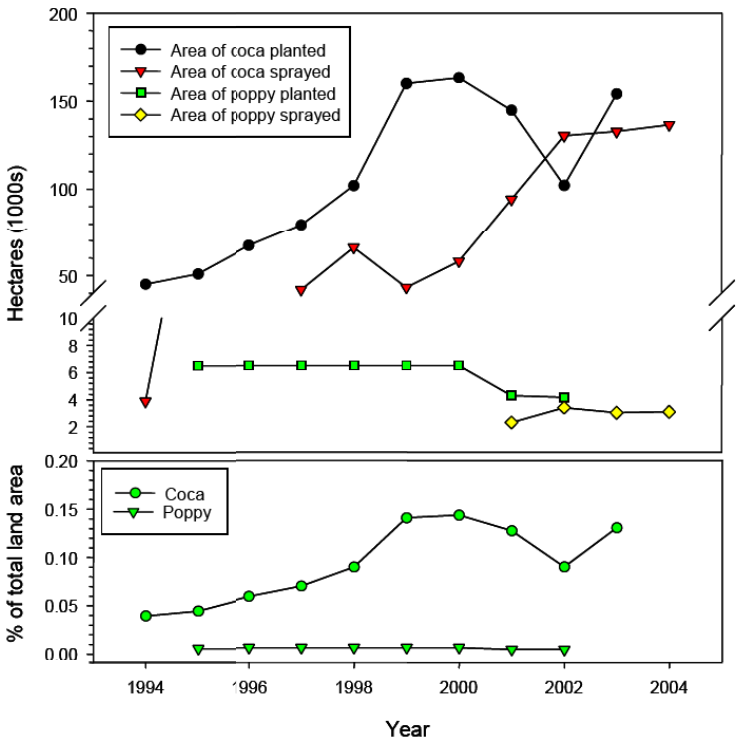


Figure 15 Areas planted with coca and poppy in Colombia from 1994 to 2002 as ha (above) and as a percent of the total land area of Colombia (below). From (Direccion Nacional de Estupefacientes 2002, Policia Nacional Direccion Antinarcoticos 2005)

The spray boom (Figure 10-D) on the aircraft is equipped with rain-drop nozzles (Figure 10-E). These nozzles produce droplets with a volume mean diameter (VMD) between 300-1,500 µm and are similar to those used in forestry spraying for site preparation (Payne 1993). The aircraft spray systems are electronically calibrated to disperse a specified quantity of spray mix per hectare, compensating for variances in ground speed. These electronic spray controls are checked each day by technicians and also during the pilot's preflight inspection. During actual spray operations, the pilot monitors the spray system by observing the readings of the spray pressure and the spray flow rate gauges (U.S. Department of State 2002).

Table 4. Application rates of glyphosate and Cosmo-Flux® for control of coca and poppy

	Litres/ha		Kg/ha	
	Coca	**Poppy**	**Coca**	**Poppy**
Glyphosate	10.4	2.5	4.992	1.2
Cosmo-Flux®	0.24	0.51		

From (Direccion Nacional de Estupefacientes 2002)

Each spray operation (Figure 10-F and G), which may consist of 2 or more spray-planes, is escorted by search-and-rescue (SAR) helicopter(s) in case of an accident or incident. Spraying is only conducted in daylight hours before mid-afternoon to ensure that conditions are appropriate for application. If rain is imminent, visibility is poor, or the wind speed is in excess of 7.5 km/h (4 knots), spraying is not carried out. Wind speed is checked during the operation by the SAR and other helicopters with the aid of smoke generated by the spray-planes. The spraying is done at about 30 m above ground and, although the flight path is determined from the GIS information and the Del Norte guidance system (Figure 10-H), the actual spraying is controlled by the pilots. In personal communications with five of the pilots, it was stated that, according to spraying guidelines, fields are not sprayed if people are seen to be present.

After a spray operation, the flight path of the spray-planes and the areas sprayed is downloaded from the Del Norte system (Figure 10-I) and processed by GIS to show the spray patterns and calculate the areas spayed (Figure 10-J). This information is transmitted to the DIRAN where records of the spray operations are retained and used for compilation of annual reports and statistics (Direccion Nacional de Estupefacientes 2002).

2.1.3.3 Frequency of application

The frequency of application varies with the local conditions and the actions taken by the growers after the coca or poppy is sprayed. When coca is sprayed, some growers will prune the bushes down to about 10 cm above ground in an attempt to prevent translocation of the herbicide to the roots. Sometimes, these plants will recover and resprout; however, they will not yield large amounts of coca leaves for several months. If the field is replanted to coca from seedlings, reasonable productivity may not be achieved 4-6 months. If the field is replanted from cuttings, productivity may be achieved sooner. Thus, spraying of a particular coca field may have a return frequency of about 6 to 12 months.

Being an annual, poppy is grown from seed. In the climatic conditions under which it is grown in Colombia, poppy fields would be harvested twice a year. If sprayed before reaching maturity and replanted immediately after spraying, they may be sprayed four times a year.

A) Mixing area for glyphosate and adjuvants

B) Mixer for glyphosate and adjuvant

C) Mixer-loader

D) Spray boom

E) Nozzle

F) AT-65 spray plane

G) OV10 Spray plane being loaded

H) Del Norte GPS system

I) Positional data

J) Spray locations

Figure 17 Photographs of aspects of the spray operation (photographs K R Solomon).

3 EXPOSURE CHARACTERIZATION

Exposure characterization is one of the key components to any risk assessment (NRC 1993, USEPA 1992, 1998). No measurements of farmer or pesticide applicator exposures have been made in Colombia. An assessment of pesticide use among farmers in the Amazon Basin of Ecuador has shown that paraquat and glyphosate are widely used. Risk behaviors were identified as frequent pesticide use, washing pesticide equipment in water sources used by humans, inadequate disposal of empty pesticide containers, eating and drinking during pesticide application, and using inadequate protective clothing (Hurtig et al. 2003). However, agricultural uses such as these are quite different from the aerial applications of glyphosate for eradication of coca and poppy in Colombia. In the following sections, the potential for exposures in humans and the environment to glyphosate as used in the eradication program of humans is discussed and characterized.

3.1.1 Human exposure groups

In the case of human exposures to pesticides in the agricultural setting there are usually two groups that are considered – applicators and bystanders. The group that experiences the greatest probability of exposure is the applicator group, which, in this case, includes the mixer-loaders, the spray-plane pilots, and the technicians who work on and service the aircraft. The second group is the made up of bystanders who may come into contact with the herbicide during application via direct deposition if they are within the spray swath, are directly exposed to spray drift, are exposed to deposits of spray when they reenter treated fields, or are exposed to the herbicide through the consumption of food items that have been sprayed, or drinking water that has been contaminated.

3.1.2 Applicator exposure

Risk to applicators was not a specific target of this assessment; however, exposure can be characterized for this group. Based on observations of the spray operations in several locations in Colombia, a number of measures are taken to reduce the potential for exposure of applicators (Table 6).

Table 6. Protective measures used to reduce exposure of applicators to glyphosate and formulants as used in poppy and coca eradication programs in Colombia.

Applicator subgroup	Mixer-loader	Spray pilot	Aircraft technician
Technology for handling of the formulation and spray mix.	Use of closed-loading systems and pumps to mix and transfer glyphosate and Cosmo-Flux® to the aircraft.	Not involved in mixing and loading.	Not normally involved in mixing and loading. Aircraft are washed down regularly so that exposure via contaminated surfaces in reduced.
Protective equipment worn.	Long pants, long sleeves, full rubber apron, rubber gloves, cloth hat or cap, particulate air filter and	None other than normal clothing, long sleeves, long pants, jacket, and boots.	Short or long sleeves, shorts or long pants, boots or sneakers, cloth cap or none.

Table 6. Protective measures used to reduce exposure of applicators to glyphosate and formulants as used in poppy and coca eradication programs in Colombia.

Applicator subgroup	Mixer-loader	Spray pilot	Aircraft technician
	dark glasses, leather military-style boots.		
Equipment used to remove contamination, should it occur.	Eye-wash station at all locations, clean water for washing hand and any contaminated surfaces, a shower in some locations.	Same as is available to the mixer loader.	Same as is available to the mixer loader.

No measures of exposure were available for mixer loaders in Colombia; however, they are likely to be similar to those of applicators in other situations. Based on observations on forestry and agricultural applicators (Acquavella et al. 2004, and summarized in Williams et al. 2000), exposures are generally small. From several studies, peak estimated exposure in applicators from all routes was 0.056 mg/kg body weight. The estimate of chronic exposure from all routes was 0.0085 mg/kg/day based on an 8 hour day and a 5 day work week. In the results of the recently published Farm Family Exposure Study, the greatest estimated systemic dose in a sample of 48 applicators was 0.004 mg/kg (Acquavella et al. 2004). In the spray program in Colombia, mixing and loading is done by one or two individuals who wear appropriate protective equipment. Pilots have limited opportunity for exposure and, as has been observed in other studies (Frank et al. 1985), will likely experience less exposure.

Exposures of mixer-loaders under the conditions of use in Colombia are likely to be similar to those observed in agricultural applications. Exposures for spray pilots and technicians will likely also be less than an agricultural applicator.

While most of the protective clothing worn by the mixer loaders is appropriate, the need for a respirator is questionable and the use of dark glasses in place of a full face shield is judged inappropriate. Dark glasses will not protect the eyes from a splash to the forehead that runs into the eyes, a vulnerable area in terms of glyphosate exposure during mixing and loading (Acquavella et al. 1999). A full face shield would offer better protection. As glyphosate is not volatile, nor atomized during mixing and loading, use of a respirator offers little reduction in potential exposure and complicates the use of a full face shield. The usefulness of a respirator is judged to be small.

3.1.3 Bystander exposure

Bystanders are the second group that can be exposed to glyphosate during application. Bystanders can be classified into several classes, depending on their route of exposure. These are discussed in the following sections.

3.1.3.1 Bystanders directly over-sprayed

Although it is unusual for people to be present in a coca field during application, it is possible that a person could be standing directly in the spray swath and would

cases), however, the RR for multiple myeloma incidence was 2.6 (95% CI of 0.7–9.4 based on 32 cases in the total of 2,088 cancers), prompting the authors to suggest that this should be followed up in future studies.

Overall, there is no strong evidence to link glyphosate exposure to increased risk of cancer. Taken with the lack of any evidence of genotoxicity or carcinogenicity of glyphosate in laboratory studies (Williams et al. 2000), it is highly unlikely that glyphosate is carcinogenic in humans.

Neurological effects. A recent study on farmers in the Red River Valley in MN, USA, reported on the link between glyphosate and Attention Deficit Disorder and Attention Deficit Hyperactivity Disorder (ADD/ADHD) in children of farmers who applied it (Garry et al. 2002). They reported OR of 3.6 (95% CI, 1.3–9.6), however, the study suffered from several potential sources of error. The authors noted the lack of uniform diagnostic neurobehavioral information related to (ADD/ADHD) and that their study identified 14 cases of ADD/ADHD among 1,532 live births, a frequency that was actually considerably lower than background rates of ADD/ADHD that had previously been reported by researchers in Canada and the US. Notwithstanding, while Garry et al. (2002) concluded that their study showed a tentative association between ADD/ADHD and the use of glyphosate, they also noted that other experimental evidence did not support this conclusion, including that glyphosate was not genotoxic and that little, if any, evidence of neurotoxicity has been associated with exposure to glyphosate, except in cases of intentional oral overdose. Finally, the authors did express concern that their tentative conclusions could be explained by random chance alone, and stated the need for further detailed neurodevelopmental studies to resolve these outstanding issues. Overall, there appears to be little evidence to support a link between glyphosate exposure and neurobehavioral problems in children of exposed applicators.

Reproductive outcomes. Several papers have reported on the relation between adverse reproductive outcomes and the use of glyphosate. In a study in Ontario, Canada, Arbuckle et al. (2001) observed a moderate increase in the risk of late abortions associated with preconception exposure to glyphosate (OR = 1.7 95%CI,1.0-2.9). Another study in Ontario (part of the Ontario Farm Family Health Study) reported a positive association (decrease in fecundability of 20%, ratio range = 0.51-0.80) when both spouses participated in activities where they could be exposed to pesticides. This was observed for 6 of 13 pesticides categories, one of which was glyphosate (Curtis et al. 1999). The study was based on 2,012 planned pregnancies. There was no strong or consistent pattern of associations of pesticide exposure with time to pregnancy. For exposure intervals in which only the men participated in pesticide activities or in which neither men nor women participated in pesticide activities but pesticides had been used on the farm, conditional fecundability ratios ranged from 0.75 to 1.50, with no apparent consistency among pesticide classes, chemical families, or active ingredients. Again, while this study did suggest a linkage between pesticide exposure and fecundability, there is no evidence from laboratory studies that glyphosate is a reproductive toxicant at exposures that would be expected in humans (Williams et al. 2000).

Overall, there is little epidemiological evidence to link glyphosate to any specific diseases in humans. This conclusion is supported by laboratory toxicity studies. However, responses related to reproductive outcomes such as fecundability measured through time to pregnancy offer a useful measure of possible effects that can be applied

mediated by the removal of deciduous plants. Where the herbicide was used, number of bird species declined, total number of individuals increased, and common species dominated. Populations of residents, short-distance migrants, ground gleaners, and conifer nesters increased significantly after herbicide treatment. Deciduous nesters and foliage gleaners increased in abundance (nonsignificantly) in control and manually thinned areas. Warbling Vireos (*Vireo gilvus*), which are deciduous specialists, declined in areas treated with herbicide and may be particularly susceptible to the indirect effects of glyphosate application on plant removal (Easton and Martin 1998, Easton and Martin 2002).

Nevertheless, control of *Cirsium arvense* (Canada thistle) using wick application of glyphosate in wildfowl areas can enhance plant diversity that is of benefit to water birds (Krueger-Mangold et al. 2002). However, the broad spectrum activity of glyphosate means that accidental overspray of rare non-target plant species during control of invasive plants will cause damage (Matarczyk et al. 2002).

Beneficial insects. Glyphosate is not considered toxic to honeybees, with a reported LD50 of >100 µg/bee (USEPA 2001), however, the formulation, with the adjuvant Cosmo-Flux®, as used in Colombia may have different toxicity because of the surfactants added to the mixture. To test this hypothesis, toxicity testing of a mixture of a commercial formulation of glyphosate and the surfactant Cosmo-Flux® 411F, was conducted to determine the acute contact toxicity to honey bees (*Apis mellifera* L.) (Stantec 2005a). This was done in accordance with the testing methods and guidelines developed by the Organization for Economic Cooperation and Development (OECD) Method #214, "Honeybees, Acute Contact Toxicity Test" (OECD 1998a) and the United States Environmental Protection Agency (U.S. EPA) Office of Prevention, Pesticides and Toxic Substances (OPPTS) Ecological Effects Test Guideline 850.3020, "Honey Bee Acute Contact Toxicity" (USEPA 1996a). The results of this study showed that the mixture of glyphosate and Cosmo-Flux® 411F is acutely nontoxic via contact exposure to honey bees (i.e., did not cause mortality or stress effects in bees within 48-hours of treatment) at concentrations equal to or less than 56.8 mg AE/bee. These results are similar to those for glyphosate and formulations from the US EPA ECOTOX data base (USEPA 2001) and show that the formulated product as used in Colombia is not hazardous to bees and, by extrapolation, to other beneficial insects.

4.1.3.2 Effects in aquatic animals

Several extensive reviews of the effects of glyphosate on aquatic organisms have concluded that glyphosate presents an essentially negligible risk to aquatic organisms (Giesy et al. 2000, Solomon and Thompson 2003, World Health Organization International Program on Chemical Safety 1994). Several recent publications have reported on the effects of glyphosate and several of its formulations in frogs. The acute toxicity of technical-grade glyphosate acid, glyphosate isopropylamine and three glyphosate formulations to Australian frogs was measured (Mann and Bidwell 1999). The authors reported the acute toxicity for adults of one species and tadpoles of four species of southwestern Australian frogs in 48-h static/renewal tests. The 48-h LC50 values for Roundup® Herbicide (MON 2139) tested against tadpoles of *Crinia insignifera*, *Heleioporus eyrei, Limnodynastes dorsalis*, and *Litoria moorei* ranged between 8,100 and 32,200 µg/L (2,900 and 11,600 µg/L glyphosate acid equivalent

[AE], while the 48-h LC50 values for Roundup® Herbicide tested against adult and newly metamorphosed *C. insignifera* ranged from 137,000-144,000 µg/L (49,400-51,800 µg/L AE). These values were different, depending on the type of dilution water (lake or tap water). For the purposes of this risk assessment, the most sensitive stage was used.

Touchdown® Herbicide (4 LC-E) tested against tadpoles of *C. insignifera, H. eyrei, L. dorsalis*, and *L. moorei* was slightly less toxic than Roundup® with 48-h LC50 values ranging between 27,300 and 48,700 µg/L (9,000 and 16,100 µg/L AE). Roundup® Biactive (MON 77920) was practically nontoxic to tadpoles of the same four species producing 48-h LC50 values of 911,000 µg/L (328,000 µg/L AE) for *L. moorei* and >1,000,000 µg/L (>360,000 µg/L AE) for *C. insignifera*, *H. eyrei*, and *L. dorsalis*. Technical glyphosate isopropylamine salt was practically nontoxic, producing no mortality among tadpoles of any of the four species over 48 h, at concentrations between 503,000 and 684,000 µg/L (343,000 and 466,000 µg/L AE). The toxicity of technical-grade glyphosate acid (48-h LC50, 81,200 -121,000 µg/L) is likely to be due to acid intolerance. Slight differences in species sensitivity were evident, with *L. moorei* tadpoles showing greater sensitivity than tadpoles of the other four species. Adult and newly emergent metamorphs were less sensitive than tadpoles.

A series of studies on frogs were conducted with several formulations of glyphosate in relation to its use in forestry in Canada (Chen et al. 2004, Edginton et al. 2004, Thompson et al. 2004, Wojtaszek et al. 2004). Using a formulation of glyphosate (Vision®) containing glyphosate and ethoxylated tallowamine surfactant - POEA, LC50 values as low as 880 µg/L (as glyphosate) were reported for tadpoles of *Xenopus laevis*, *Bufo americanus*, *Rana clamitans*, *Rana pipiens* (Edginton et al. 2004). Embryo stages were less sensitive than older larvae and toxicity was affected by the pH of the exposure medium, although not in a consistent manner. For the purposes of this assessment, values obtained at the most sensitive pH and for the most sensitive stage were used.

In a related study on the toxicity of the Vision® formulation of glyphosate to the zooplankton organism, *Simocephalus vetulus*, and tadpoles (Gosner stage 25) of *Rana pipiens,* interactions between pH and food availability were reported (Chen et al. 2004). Both high pH (7.5 vs. 6.5) and food deprivation increased the toxicity of this formulation. As only two concentrations were tested (750 and 1,500 µg/L), LC50 values could not be determined.

Field studies conducted on larvae of *Rana clamitans* and *Rana pipiens* with the Vision® formulation of glyphosate showed that, in the presence of natural factors such as sediment and environmentally relevant pH, the toxicity of the formulation was reduced as compared to laboratory observations (Wojtaszek et al. 2004). The authors reported 96-h median lethal concentration (LC50) values ranging from 2,700 to 11,500 µg/L (as glyphosate) (Wojtaszek et al. 2004). Although the authors used a formulation of glyphosate containing the more toxic surfactant POEA, the results confirm that, in the presence of sediments, reduction in the bioavailability of glyphosate (and formulants) occurs and this further reduces risks, a conclusion reached for this forestry use (Thompson et al. 2004) but which is equally relevant to the use of glyphosate in Colombia.

In another study on amphibians, the toxicity of a number of glyphosate formulations to frogs (*Rana clamitans, R. pipiens, R. sylvatica*, and *Bufo americanus*) was reported (Howe et al. 2004). The formulations included Roundup Original®, glyphosate technical, the POEA surfactan used in some glyphosate-based herbicides, and five newer glyphosate formulations of glyphosate. As expected, the most toxic of the materials was the POEA surfactant, followed by Roundup Original®, Roundup Transorb®, and Glyfos AU®. No significant acute toxicity was observed with glyphosate technical material (96-h LC50 >17,900 µg/L). LC50 values for Roundup Original® in *R. clamitans, R. pipiens,* and *R. sylvatica* were 2,200, 2,900, and 5,100 µg/L (AE), respectively. These values were used in this risk assessment. Several other formulations of glyphosate were also tested in *R. clamitans* and these (Roundup Biactive®, Touchdown®, and Glyfos BIO®) were essentially non-toxic with LC50 values of >57,000 µg/L.

In a study carried out with several commercial pesticide formulations in leopard frogs (*Rana pipiens*), green frogs (*R. clamitans*), bullfrogs (*R. catesbeiana*), the American toad (*Bufo americanus*), and gray tree frogs (*Hyla versicolor*), effects of Roundup® and interactions with other pesticides were reported (Relyea 2004). The formulation of Roundup® used in this study contained the more toxic POEA surfactant. Survival and growth over a 16 day period were not significantly affected by the glyphosate formulation at 1,000 µg/L (glyphosate AE) but some species were affected at 2,000 µg/L. Some interactions were observed between the glyphosate formulation and other pesticides such as the insecticides diazinon, carbaryl, and malathion. A recent paper reported that a glyphosate formulation containing POEA was highly toxic to tadpoles of several species of frogs exposed under realistic conditions in small (1000-L) field microcosms (Relyea 2005). The tadpoles (Wood frog, *Rana sylvatica*; leopard frog, *Rana pipiens*; American toad, Bufo americanus; gray tree frog, Hyla versicolor; and the spring peeper, Pseudacris crucifer) were exposed to a concentration of 3,800 µg/L (AE) of glyphosate formulation applied as a commercial formulation (unspecified) directly to the surface of the water. The rate of application was equivalent to 16 kg/ha, a value that is unrealistic and probably the result of an error in the methods. At this concentration, glyphosate formulated with POEA would be expected to be lethal to tadpoles. The discussion in the paper that suggests that use of glyphosate may be having adverse effects on frogs thus based on a flawed study design and is not supported by other data, much of which is discussed above.

Effects on other non-target aquatic organisms have also been recently reported in the literature. In studies on the toxicity of glyphosate to several aquatic algae and zooplankton, Tsui and Chu (2003) showed that technical glyphosate was considerably less toxic than the product Roundup®, which is formulated with the POEA surfactant. LC and EC50 values for technical glyphosate ranged from 5,890 to 415,000 µg/L. In tests conducted in the presence of sediment (Tsui and Chu 2004), these same authors showed that biological availability of glyphosate was significantly reduced by binding to sediment. The reduction in porewater concentration that resulted from the presence of sediments was proportional to the amount of organic carbon in the sediments.

Tests on the fish *Oreochromis niloticus* (Nile tilapia) exposed for 3 months to sublethal concentrations (5,000 and 15,000 µg/L) of glyphosate as Roundup® caused significant damage to gill, liver, and kidney tissue. The structural damages could be

correlated to the significant increase ($p \leq 0.05$) in aspartate aminotransferase, alanine aminotransferase, and alkaline phosphatase activities in the second and third months of exposure. The results indicated that long-term exposure to Roundup® at large, although sublethal concentrations had caused histopathological and biochemical alterations of the fish (Jiraungkoorskul et al. 2003). Because technical glyphosate was not tested and the contribution of the surfactants to this response cannot be judged.

In studies on the freshwater mussel *Utterbackia imbecillis*, a commercial formulation of Roundup® was reported to have low toxicity (24-h LC50 of 18,300 µg/L and a No Observed Effect Concentration (NOEC) of 10,040 µg/L – 7,442 µg/L AE) to larval mussels (Conners and Black 2004). In studies on genotoxicity in these mussels, there was no significant difference in response between the control and mussel larvae treated at ¼ the NOEC, ≈ 2,500 µg/L (1,850 AE).

Response of total free amino acids profiles of snails to glyphosate exposures has been studied (Tate et al. 2000). These authors showed that exposure of the aquatic snails (*Pseudosuccinae columella*) to technical glyphosate at nominal concentrations of 1000-10,000 µg/L lead to increased egg-laying and increased amino acid concentrations in the tissues. Technical glyphosate was not particularly toxic with a 24-LC50 of 98,900 µg/L. The effect on egg-laying and amino acid concentrations was stimulative rather than adverse but the authors speculate that it could lead to increases in incidence of diseases for which the snails are intermediate hosts. Increases in parasites may affect organisms in the environment. Similar stimulation was observed in the rotifer *Brachionus calyciflorus* where growth rates and sexual and asexual reproduction were stimulated in the presence of glyphosate (formulated, but formulation unknown) at concentration of ≥4,000 µg/L (growth) and ≥2,000 µg/L for reproduction and resting egg production (Xi and Feng 2004). Again, although stimulatory and not "adverse" the authors point out that the increases in one species may affect other species indirectly.

In a study on grazing of the alga, *Scenedesmus spp*. by the aquatic crustacean, *Daphnia pulex*, technical glyphosate was shown to have no adverse effect, although it appeared to stimulate the growth of the algae (Bengtsson et al. 2004). Stimulation of algal growth was suggested to be due to release of nitrogen and phosphorus from the metabolism of glyphosate by the *Daphnia*. Similar stimulation was also seen in the effects of glyphosate (Rodeo®, a formulation without any surfactants) on the primary productivity of a natural phytoplankton algal assemblage dominated by species of diatoms and a dinoflagelate (Schaffer and Sebetich 2004). A 60% increase in productivity as measured by assimilation of $^{14}CO_2$ was observed at concentrations of glyphosate of 125, 1,250, and 12,500 µg/L, with no apparent concentration-response. The authors speculate that the increase was caused by the release of nitrogen and phosphorus from the breakdown of glyphosate.

The effects of glyphosate on fish and other aquatic organisms are clearly related to the surfactant in the formulation rather than the glyphosate itself. Surfactants can disrupt cell membranes and this type of response would be expected. For this reason, the glyphosate formulation and the surfactant (Cosmo-Flux®-411) as used in Colombia for the eradication of coca and poppy were tested for toxicity to the aquatic organisms, algae, crustacea, and fish (Section 4.2.2). The protocols used are described below and results are summarized in Table 19.

Algal tests. The testing of a mixture of a commercial formulation of glyphosate and the surfactant Cosmo-Flux® 411F, was conducted to determine growth inhibition of the freshwater green alga, *Selenastrum capricornutum* Printz, according to the Organization for Economic Co-operation and Development (OECD) Method # 201, "Alga, Growth Inhibition Test" (OECD 1984b) and in general accordance with OPPTS Method 850.5400, "Algal Toxicity, Tiers I and II" (USEPA 1996b).

Water Flea. Tests were conducted to determine the acute toxicity of a commercial formulation of glyphosate and the surfactant Cosmo-Flux® 411F to *Daphnia magna* according to OECD Method #202, "*Daphnia sp.*, Acute Immobilization Test and Reproduction Test" (OECD 1984a), however, the reproduction component of the test was not conducted.

Rainbow Trout and Fathead Minnow. Tests were conducted to determine the acute toxicity of a commercial formulation of glyphosate and the surfactant Cosmo-Flux® 411F to *Oncorhynchus mykiss* and *Pimephales promelas* according to OECD Method #203, "Fish, Acute Toxicity Test" (OECD 1992). In all of these tests, OECD Principles of GLP (OECD 1998b) were followed.

Table 19. Toxicity values obtained from toxicity tests conducted on a mixture of glyphosate and Cosmo-Flux®.

Test species	Common name	96 hour LC/EC50 in µg/L (as glyphosate AE)	Reference
Selenastrum	Algae	2,278-5,727[a]	(Stantec 2005b)
Daphnia magna	Water flea	4,240 (3,230-5,720)[b]	(Stantec 2005e)
Onchorynchus mykiss	Rainbow trout	1,850 (1,410-2,420)[b]	(Stantec 2005c)
Pimephales promelas	Fathead minnow	4,600 (1,810-1,173)[b]	(Stantec 2005d)

[a] Lowest and highest effect measures in the study

[b] LC/EC50 and 95% Confidence Interval

The acute toxicity data for formulated glyphosate in aquatic animals from Solomon and Thompson (2003) were combined with some of the new data for amphibians described above and are displayed graphically as a point of reference for characterizing the toxicity of glyphosate plus Cosmo-Flux® as used in Colombia (Figure 17). The graph is presented as a cumulative frequency distribution in a manner similar to that used in probabilistic risk assessments for pesticides (Solomon and Takacs 2002). These data show that the combination of formulated glyphosate and Cosmo-Flux®, as used in Colombia, is more toxic to the aquatic organisms tested than formulations without the addition of surfactants and adjuvants. This is not altogether surprising. It has been shown that the toxicity of glyphosate itself to aquatic organisms is very small (Solomon and Thompson 2003) but, when mixed with some surfactants and adjuvants, this toxicity can be increased. The toxicity of Cosmo-Flux® was not

tested on its own; however, from experience with other adjuvants, it is clearly the cause of the increased toxicity of the mixture.

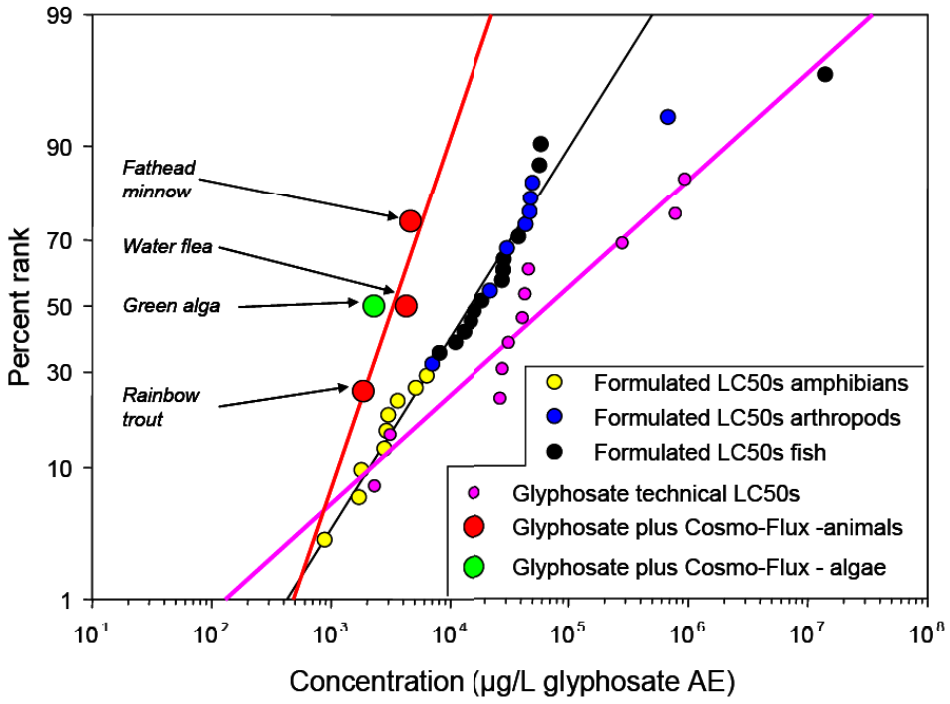


Figure 24 Distribution of toxicity values for glyphosate technical, formulated glyphosate (Roundup®) in all aquatic organisms and in fish and the glyphosate and Cosmo-Flux® 411 mixture as used in Colombia

It is interesting to note that larval amphibians appear to be more susceptible to glyphosate formulation than are other aquatic animals. The reason for this is likely the surfactants in the formulation of Roundup®; as discussed above, other formulations of glyphosate are less toxic to amphibians (Howe et al. 2004).

4.1.3.3 Effects of glyphosate on plants

There are differences in glyphosate uptake between different coca species and between young and mature plants of *Erythroxylum coca* and *E. novogranatense* (Ferreira and Reddy 2000). Leaf absorption is greater in young plants of both species and greater in *E. novogranatense*. Earlier studies showed that control of regrowth was better in *E. novogranatense* for equivalent dose of glyphosate (Ferreira et al. 1997). This study also indicated that defoliation of *E. coca* 24 hours prior to application resulted in no significant effect of glyphosate (applied up to 6.7 Kg/ha) on regrowth. This confirms that, as for other plants, uptake via the leaves is the major route of penetration into the plant.

A study on the control of the perennial weed pepperweed (*Lepidium latifolium*) has shown better control with glyphosate following mowing. The mechanism is via the

better movement of glyphosate to roots from leaves lower in the canopy. Following mowing, the leaf distribution and the spray deposition is closer to the ground, giving better basipetal translocation to roots and better subsequent control (Renz and DiTomaso 2004). In forestry situations with an aerial application, spray deposition is typically much greater higher in the canopy, (e.g. Thompson et al. 1997). Studies of glyphosate efficacy on annual weeds have indicated that application during the day (09:00 and 18:00h) gives best control (Martinson et al. 2002, Miller et al. 2003).

Resistance to glyphosate is known for an increasing number of species, including *Conyza canadensis* (Mueller et al. 2003), Illinois waterhemp (*Amaranthus rudis* and *A. tuberculatus*) (Patzoldt et al. 2002), *Eleusine indica* (Baerson et al. 2002), *Lolium multiflorum* (Perez and Kogan 2003) and *Lolium rigidum* (Neve et al. 2003a, b). Rates of evolution of resistance in the latter species are dependent on herbicide use patterns as part of crop production.

Non-target impacts of glyphosate on seed germination and growth characteristics of the F1 generation of treated wild plant species have been reported. Blackburn and Boutin (2003) noted effects on seven out of 11 species tested with 1%, 10% or 100% of a 0.89 Kg a.i./ha label rate of glyphosate formulated as Roundup® solution sprayed near seed maturity. Effects of glyphosate drift on rice seed germination were reported by (Ellis et al. 2003) and (May et al. 2003) noted reduced seed production in alfalfa in the year following applications of glyphosate at 1.760 Kg a.i./ha for *Cirsium arvense* control. Nevertheless, applications of glyphosate at 0.420 kg AE/ha on susceptible soybean had adverse effects on sprayed plants, but not on progeny (Norsworthy 2004). Subtle adverse effects of glyphosate on pollen viability and seed set in glyphosate-resistant cotton were noted by (Pline et al. 2003). Pollen viability of glyphosate-resistant corn was also significantly reduced by glyphosate applied at 1.12 kg AI/ha, but yield and seed set is not significantly affected (Thomas et al. 2004). These data indicate that drift might cause subtle ecological changes to plant communities associated with changes in plant recruitment. However, this would be significant only for communities largely made up of monocarpic plant species (that flower once and die, especially annuals) dependent on seeds for recruitment.

4.2 SURFACTANTS

There are a number of formulations of glyphosate on the market and these may contain a number of surfactants (Giesy et al. 2000, Solomon and Thompson 2003, Williams et al. 2000). Normally, this would not be an issue in the risk assessment of a pesticide, however, in the case of glyphosate; the active ingredient is of very low toxicity to non-target organisms, thus making the surfactant toxicity more important in the risk assessment process. For example, tests on Ca^{2+}-activated ATPase and cholinesterase (ChE) activities in the nervous system of the slug *Phyllocaulis soleiformis* showed no effects of pure glyphosate. An effect noted with the formulation Gliz 480CS® was caused by non-glyphosate components of the formulation (da Silva et al. 2003). Technical grade glyphosate at concentrations of 52 mM (870 mg/L) did not affect the protozoans *Tetrahymena thermophila* or the parasite *Ichthyophthirius multifiliis*. However, the commercial formulation Glyphosate® was up to 100 times more toxic, reflecting data for fish species and other aquatic invertebrates and caused by surfactants in the formulation (Everett and Dickerson 2003).

Table 20. Summary of reasonable worst-case estimated exposures of humans to glyphosate resulting from use in the eradication of coca and poppy in Colombia and margins of exposure.

Source of exposure	**Exposure value in mg/kg**		**Margin of exposure compared to the most sensitive NOEL(175 mg/kg)**	
	Coca	Poppy	Coca	Poppy
Direct overspray	0.04	0.01	4,918	20,417
Reentry	0.26	0.06	676	2,804
Inhalation	0.01	0.01	28,226	28,226
Diet and water	0.75	0.18	234	972
Worst case total exposure from all sources	1.05	0.26	167	680
Source of exposure	Exposure value in mg/kg		Margin of exposure for the US EPA RfD (2 mg/kg/day)	
	Coca	Poppy	Coca	Poppy
Direct overspray	0.04	0.01	56	233
Reentry	0.26	0.06	8	32
Inhalation	0.01	0.01	323	323
Diet and water	0.75	0.18	2.7	11.1
Worst case total exposure from all sources	1.05	0.26	1.9	7.8

5.2 ENVIRONMENT

Assessment of the environmental risks of glyphosate and Cosmo-Flux® to aquatic organisms was based on data from the literature and from studies conducted on the mixture of formulated glyphosate and Cosmo-Flux® as used in Colombia. As discussed in Section 4.1.2, the toxicity of the mixture of glyphosate and Cosmo-Flux® was greater than that reported for formulated glyphosate itself. When the toxicity values for the mixture as used in Colombia are compared to the range of estimated exposures that would result from a direct overspray of surface waters (Table 10), it is clear that aquatic animals and algae in some shallow water bodies may be at risk (Figure 19).

are judged to be small. The resultant concentrations in soil and water that may result from an accidental overspray also have high certainty. The environmental behavior of glyphosate is well characterized and, under the conditions of use in the eradication program in Colombia, will not persist, accumulate, or biomagnify in the environment. Analyses of surface waters and sediments in one watershed where eradication spraying was carried out did not reveal the presence of significant concentrations of glyphosate, confirming the conclusion based on its properties that it is not mobile in the environments where it is applied. Residues of glyphosate were not frequently detected in areas where eradication spraying was not conducted but where glyphosate use was known to occur in agriculture. Given that considerably more glyphosate is used in agriculture and other non-eradication uses (~85%), this further confirms that glyphosate is not sufficiently mobile to result in significant contamination of surface waters in Colombia, regardless of the use pattern.

Uncertainties in the exposure characterization lie in lack of precise measurements of the proximity of sprayed fields to surface waters and the proportion of treated areas that are in close proximity to these surface waters. The sampling of the surface waters only took place for a period of 24 weeks and only 5 locations were sampled in this way. Although two of these were scheduled to be sprayed, only one location was treated during the sampling period. For logistical reasons, it was also not possible to sample close to the application sites. If sampling had been conducted at more sites closer to the sprayed fields and over a longer time period, residues may have been detected more frequently.

6.3.1.2 Human exposures

Human exposures to glyphosate were estimated from extensive and well documented studies in other jurisdictions and are judged to be accurate with respect to bystanders who are directly over-sprayed. Exposures were judged to be small and, in all cases, considerably below thresholds of concern.

Application rates of glyphosate used for coca eradication are greater than those used in conventional agriculture suggesting that experience and exposures measured under these conditions may not be applicable to bystander exposures in eradication spraying in Colombia. While this may be true, the margins between exposures doses at which chronic effects may occur are great enough to provide a wide margin of safety to bystanders. Less information is available regarding the likelihood of exposure upon reentry to coca fields immediately after spraying. This relates to the anecdotal evidence that picking of leaves or pruning of plants immediately after they are sprayed with glyphosate will “save” the plants. Exposures under these conditions are unmeasured, but are estimated to be considerably below the US EPA reference dose.

6.3.2 Effects

6.3.2.1 Environmental effects

The environmental toxicology database for glyphosate is relatively large and its effects in non-target organisms are well known or can be extrapolated. Glyphosate itself is of low toxicity to non-target organisms, however, there are a number of formulations of glyphosate that exist in the marketplace and these may contain many

different surfactants and/or adjuvants. It is also known that it is the surfactants that determine the toxicity of the formulation as many are more toxic than technical glyphosate itself. Because of this, the Panel had several toxicity tests conducted with the formulated product of glyphosate plus Cosmo-Flux® as used in the eradication program in Colombia. This reduced uncertainty with respect to toxicity to beneficial insects such as the honeybee and to aquatic organisms. Recent studies have reported that amphibians, such as frogs, are amongst the more sensitive aquatic organisms with respect to formulations of glyphosate such as Roundup® and Vision®. We did not conduct toxicity studies in amphibians with the mixture of glyphosate plus Cosmo-Flux® and this is a source of some uncertainty for ecological risks for frogs.

6.3.2.2 Effects in humans

The database of effect data for glyphosate is large and its risks to humans and the environment have extensively reviewed and assessed in a number of national and international jurisdictions as well as in the open scientific literature. In all cases, glyphosate has been judged to be of low risk. However, some of the studies on which these assessments are based were conducted prior to the refinement of testing guidelines and the availability of new and more sensitive methods of analysis and effect characterization, such as those based on alteration in the concentrations of neurotransmitters and their metabolites in the central nervous system. In the process of reassessment and re-registration, older studies will be replaced with newer tests conducted according to current guidelines. Given the large and expanding use of glyphosate in agriculture, the priorities for updating the database will likely be high. Changes in the regulatory status of glyphosate should be monitored and any newly identified risks included in an updated risk assessment.

There is considerable literature on the epidemiology of pesticides and possible effects on human health. As a result of recent work, it is clear that many epidemiology studies are confounded by the use of poor and inaccurate surrogates for exposures to pesticides. The Panel also conducted a preliminary epidemiological study to assess possible linkages between the use of glyphosate and adverse human-health outcomes and recognizes that, for clear logistical reasons, no measures of exposure were available for the various groups enrolled in the study other than the use of glyphosate for eradication spraying in the region. The results of this study do not suggest that there is an association between the use of glyphosate in the eradication program and time to pregnancy (TTP) as a reproductive outcome. A somewhat greater risk for longer TTP was observed in one region (Valle del Cauca) where eradication spraying is not conducted but it was not possible to identify any specific factors that may have been responsible for this observation.

6.3.3 Confounding risks

Through the Tier-1 and Tier-2 hazard assessments of the other substances used in the production and refining of cocaine and heroin, the Panel recognizes that some of these substances present a significantly greater hazard to both humans and the environment than does the mixture of glyphosate and Cosmo-Flux® used in the eradication program in Colombia. Exacerbating these hazards is the lack of information about the conditions of use of these substances. Because of the lack of specific data

ANNEX 152

National University of Colombia, Institute of Environmental Studies, *Observations on the "Study of the effects of the Program for the Eradication of Unlawful Crops by aerial spraying with glyphosate herbicide (PECIG) and of unlawful crops on human health and the environment* (10 May 2005)

[seal]
UNIVERSIDAD NACIONAL DE COLOMBIA
BOGOTA CAMPUS
INSTITUTE FOR ENVIRONMENTAL STUDIES – IDEA

Remarks on the "Study of the Effects of the Illegal Crop Eradication Program by Aerial Spraying of the Herbicide Glyphosate (PECIG) and on Illegal Crops on Human Health and the Environment"

Tomás León Sicard
Agronomist PhD
Director Research Program on Impacts of Illegal Crops (PIAC) IDEA – UN
Director (e) Institute for Environmental Studies IDEA – Universidad Nacional

Javier Burgos Salcedo
Biologist candidate PhD.
Researcher – Professor Masters in Environment and Development Program IDEA – UN

Catalina Toro Pérez
Architect candidate PhD.
Researcher – Professor Masters in Environment and Development Program (PIAC) IDEA – UN

César Luengas Baquero
Zootechnician Esp.
Researcher – Professor Masters in Environment and Development Program (PIAC) IDEA – UN

Claudia Natalia Ruiz Rojas
Civil Engineer MS
Researcher – Professor Masters in Environment and Development Program (PIAC) IDEA – UN

Claudia Patricia Romero Hernández
Topographical Engineer MS
Researcher – Professor Masters in Environment and Development Program (PIAC) IDEA – UN

Bogota, 11 May 2005

INTRODUCTION

The aforementioned document, which was prepared by Drs. Keith Solomon, Arturo Anadón, Antonio Luiz Cerdeira, Jon Marshall, and Luis Helena Sanín (hereinafter Solomon and collaborators), constitutes an important national reference for the future research work that is done on the subject. It is accompanies by abundant bibliographic references and valuable information on some topics, with broad arguments on the selected topics.

The document, which was prepared under the auspices of CICAD (Inter-American Commission for the Control of Drug Abuse), a division of the Organization of American States, has deficiencies in how it is structured, given that it lacks the desired order in this type of scientific document. It lacks a unifying narrative which, starting from a clear definition of the problems to be evaluated and the starting hypotheses, presents the procedures used (methodology), the results found and a final discussion thereof. Those items are mixed throughout the text, making reading it difficult.

The central thesis of the study is to prove that, "i) … exposure to glyphosate and its adjuvants as used in the poppy and coca eradication program do not give rise to acute or chronic adverse effects in non-target organisms, exposed by different routes; and … ii) that such exposure does not give rise to acute or chronic adverse effects in non-target organisms exposed by different routes…." In this effort Solomon and collaborators essentially appeal to a review of the existing literature and, on occasions, experimental tests performed in a laboratory.

Based on the text presented, the following remarks can be made:

1. On the Preface (page 2)

In the first place we must call attention to the starting arguments of the study: the authors acknowledge that, "…the Illegal Crop Eradication Program is the subject of intense debates for political, social and other reasons...," and therefore, "…all social, political, and economic matters are specifically excluded from the study and *the final report is based strictly on science and on arguments based on science*… (the italics is ours)."

That asseveration by the authors is very polemical, at least for three reasons: first, because it excludes the social, human and economic sciences from the environmental analysis; second, because it accentuates only explanations that

come from the natural or "hard" sciences in a phenomenon which, in reality, touches upon many more of the aspects considered by them, and third because it is unavoidable that in this study, or any other of the same nature undertaken either by researchers in the country or, as in the present case, by an expressly selected international group, will be used for political purposes.

Science cannot remain neutral with respect to society by claiming that its method is pure and impartial, when its motivations and results are added to the social debate. Moreover when it is a matter of subjects as socially, economically, politically, and

[PAGE 3]

militarily sensitive, such as the one discussed in the study, that are at the center of polemics with worldwide repercussions, and are related to fundamental human rights such as the right to life, a healthy environment, and the health of Colombians.

Insofar as the first matter indicated, we must insist that, for more than thirty years, the world has acknowledged that the environmental dimension is, precisely, the conjuncture of complex society – nature or ecosystem – culture dynamic, and that has been stated in a vast amount of literature from the ecological to the anthropological, sociopolitical, and economic [see original for references].

Despite their good intention of delimiting the field of study, which in and of itself is a legitimate position, the authors cannot forget the complexity of the matter, especially because it has effects both on their methodology and on their conclusions.

On their methodology, because they forgot to include the economic, institutional, political, or social effects that spraying with herbicides on producers' fields has (loss or reduction in the yields of legal crops, affecting pets, displacements of the population, changes in the family relations of the affected farmers, or sharpening of the armed conflict in Colombia, just to cite five examples).

On their conclusions because, as can be seen on page 107, the authors state that, "the additional risks associated with the spraying program are small," when the study did not consider, or if did so tangentially, the direct or indirect risks on nearby ecosystems or agroecosystems, losses of biodiversity, displacements of populations or an increase in erosive processes as a result of the use of the herbicide.

In the second place, total trust in science is also relative. The arguments against glyphosate are also abundant in worldwide literature; however, they were not sufficiently explored by the authors. This means that science faces problems when it seeks to be objective, because it is a human exercise. Here it is worthwhile to note the famous example of the glass filled halfway with water: for some observers it is half-full and for others it is half-empty. The claimed scientific objectivity of the positive sciences, is also in doubt.

In relation to the third point it is sufficient to indicate that, from the very day on which the authors publicly stated their results, the reactions from civil society and from the government could not wait, some in favor and others against the study, certifiable evidence of its undeniable political importance.[a]

[PAGE 4]

2 On the focus of the work

The project has a serious deficiency: it was based on secondary studies to estimate the effects of the herbicide on human health, accepting most of what is in its favor, but rejecting any that indicate risk. Moreover: not only that, Solomon and collaborators did not consult the complaint list (currently containing more than 8000 in the Public Advocate's Office)[b] that have been filed by different players in Colombian society on the environmental effects of the spraying. There they would certainly have found a large amount of data to verify.

Work in this direction was performed by Luengas (2005) who examined the databases of the Public Advocate's Office and the National Narcotics Department (DNE), finding that 87% of the complaints filed correspond to damage to plant life,[c] and 6.9% to human health and the rest to animals and bodies of water.

Furthermore, we believe that the variable selected to estimate the effects of Glyphosate on human health (Human Fertility, in particular Time to get Pregnant) is insufficient to evaluate the effect of the herbicide, because:

---

[a] See press releases, letter from the network of students abroad, public statements by the Minister of the Interior and the more than 3500 communications sent to presidents Uribe and Bush rejecting the imminent spraying in the National Parks of Colombia.

[b] Personal communications from officials at the Public Advocate's Office (April 2005).

[c] This result is to be expected due to the fact that glyphosate is an herbicide and its initial action occurs on the plant component.

- Those effects are evident in time periods greater than those contemplated in that study.
- The effects of chemical compounds of the type that are used in agriculture, are evident at the chromosome level in the exposed populations and by an increase in the proportion of genetic diseases in their descendents, which variable were not considered in the study by Solomón and collaborators.

It is for these reasons that the operators who handle these substances are obligated to use special clothing and additional safety measures, something that does not occur in people who, in one way or another, are exposed in the crop fields at the time of the aerial spraying of the herbicide.

On the studies that indicate health risks we must note the one that was recently performed by Maldonado (2003) which shows evidence of genetic damage in 36% of the cells of all women who were exposed to spraying of the herbicide on the Colombian – Ecuadorian border. Other evidence along the same line should have been consulted [see source for references].[d]

[PAGE 5]

Likewise, Richard *et al*, in recent research on the differential effects of glyphosate and Round-Up, prove that glyphosate is toxic to *JEG3* human placenta cells within 18 hours after exposure in concentrations lower than those used in agriculture and that this effect increases when the concentration and exposure time are increased or in the presence of the Round-Up coadjuvants.

A final reflection in this regard: human health is not only physical. It is also mental. It would have been interesting to explore what psychological affects aerial spraying has on the perceptions of children, men, and women who are affected by these actions in which, as admitted by the team of experts, combat aircraft and armed helicopters participate.

---

[d] "The toxicity of commercial glyphosate at a concentration of 48% shows a minimum average lethal dose (*amount required, in a single dose, to kill half of the* individuals in an experiment on a homogeneous group), orally of 4,900 to 5,000 milligrams per kilogram of live weight in female rats and it has been classified as Category IV toxicity (assigned by the FEDERAL, INSECTICIDE, FUNGICIDE AND RODENTICIDE ACT, FIFRA), Category III for inhalation toxicity, and Category IV for dermal toxicity. The Environmental Protection Agency, using the FIFRA criteria under identical conditions, assigned it Category II because of the eye irritation effect and corneal opacity in rabbits, these latter effects according to the manufacturer are caused by the tallow amine ethoxylate that is used as a surfactant which also has the ability to cause gastrointestinal irritation, nausea, vomiting, and diarrhea (…)." [see source for references]

Let us now move on to the general observations on the scientific procedures used:

3 In relation to the definition of the problem (pages 22 and 23).

The research problem is not clearly delimited in the text. Traditionally the definition of the research problems are stated in short paragraphs or in specific questions that must be answered (which include the variables to be studies as well as time and space references), which is not specified anywhere. A deduction is made, however, form that stated on page 23 of the document, that it is a question of "…evaluating the risk of using glyphosate and adjuvants to control illegal crops…." Because it is not clearly explained who will do the evaluation, under what conditions, nor based on what procedures … the document enters into the field of ambiguity, as shall be demonstrated in the following pages.

4 On the Methodology

The final text does not contain a specific chapter on the methodology and readers must look for the procedures used throughout the length of the text, which makes it difficult to read and understand. However, the principal methodological deficiency refers to the same general conception of the study.

For example, in relation to the ecosystemic components for which the effects of glyphosate are sought (which forms part of the methodological decisions), the authors did not hit the target: they sought effects where there might not be any or where minimum risks might be found, that also because of the deficient delimitation of the problem to be investigated.

Indeed, it is known that herbicides are principally toxic to plants and not to animals (as the authors indicate on page 25). Therefore, the effects to seek, estimate, and/or measure should have been as a priority those that are caused by its direct spraying on legal crops or on natural vegetation. We are certain that if that had been done, the study would have had other conclusions, because spraying the herbicide directly affects the plant biodiversity in these areas.

[PAGE 6]

One of the main criticisms in this regard is related to the fact that, according to the results of Solomon and collaborators, the glyphosate would specifically affect only the coca crops and in no way other plant species. However, as best we know, the principal active ingredient of glyphosate (isopropylamine) does not have species-specific effects, as can be seen from the results of the aforementioned work. Indeed, in the document: "Report on Matters Related to

the Aerial Eradication of Illegal Coca in Colombia," published by the Office of International Narcotics Affairs and Law Enforcement (INL) of the Department of State (September 2005),[e] it is acknowledged that "glyphosate is an effective broad-spectrum herbicide, and therefore a risk for non-target plants outside the area of application is expected."

Moreover, in relation to the soil, it was not urgent to detail the adsorption process of glyphosate molecules in the clay-humus complexes of the edaphic medium. It was sufficient to make estimates or take measurements on the erosion of the resource which, for humid tropical forest areas under clean cultivation has been estimated at amounts in excess of 25 tons / hectare / year. Mosquera (1985) from that time already stated that erosion greater than 25 t / ha / year was considered severe. Morgan (1986) states that on deforested surfaces in percentages near 35% then the erosion reaches in humid tropical forests rates as high as 15 t / ha.

It would have been very interesting for Colombia to see estimates on the loss of soil as a direct result of removing the plant coverage caused both by the spraying of Round-Up and by the introduction of the coca crop. We are also certain that the work her would have increased its usefulness for the country.

5 On the receiving environment

On page 33 of the report debatable information is given: the authors state that "…given that the critical points of diversity are associated directly with the highlands of the Andes and that coca is mostly grown at lower altitudes, *there is only a little superimposition* (the italics are ours) between the coca production areas and the regions of large biodiversity…."

Up to the point indicated by worldwide literature, the humid tropical forests that are the areas where coca is mostly grown, also represent the most sensitive areas (hotspots) of biodiversity, and therefore it's not that there is only a little superimposition, but entirely the opposite: spraying is being done in the most sensitive biodiversity areas on the planet (Sisk *et al*, 1994).

Humid tropical forests are characterized as being the ecosystems with the most complex structure, stratification, and species-diversity in the world. Around 50% of the world's described diversity of flora species is concentrated in these ecosystems (Gentry, 1993).

[e] **http://bogota.usembassy.gov/wwwfepag.pdf**

There is extensive work in Colombia on biodiversity and it has been done by various entities: The National Parks Unit of the Ministry of the Environment, Housing, and Territorial Development, the Alexander von Humboldt Institute, the Institute for Amazonian Research "Sinchi," Nongovernmental Organizations such as Prosierra, Natura, Tropenbos and several Universities (Nacional, Javeriana, Andes, Antioquia, Valle, among others) that have generated significant information from several disciplines on the subject of biodiversity and the pressures that exist on it, without mentioning international institutions such as the WWF, Conservation International, or National Toxic Network, entities and works that we suggest be consulted by researchers in future studies.

6 Deposits beyond the target

On page 38, information is presented that is attention-getting, concerning the spray that does not hit the targets (coca plants) and that winds up in other areas. Professor Solomon and his colleagues, citing Payne *et al* (1990), state that the effect is minimum although they agree that "…this estimation is based on visual observations of a relatively small number of crops…," which in the end means that this effect was not measured.

In all, the datum presented of 625.7 hectares affected by off-target deposits of glyphosate for 2002 is worrisome, as is the information given by the authors about 22 non-target areas that were affected with the herbicide of a total of 86 sites visited (that is to say, 25.6%). This implies that at least 1 in every four spray operations affects areas near the coca crops, which is no longer a minimum effect as suggested by Payne *et al (op. cit.)*.

This 25.6%, calculated by us based on the data presented in the Solomon report, contrasts with the low surface percentages that are indicated in the report ("…between 0.25% and 0.48% of the areas for coca production were damaged by deposits sprayed off the target site…"), which information we do not know how it was obtained given that the authors agree that there was no field proof.

Then, professor Solomon and his colleagues compare these areas with the entire surface area of Colombia and they conclude that they are small, which does not seem valid to us, because for the same reason it could be stated that the approximately 80,000 current hectares of coca in the country are also small if compared to the total surface area of Colombia (7.1%).

7 On the reference framework for evaluating risk (page 39 and subsequent)

The method chosen to rate the risk to human health is not adequately described. We do not know what ranges were adopted or the criteria for the 0 to 5 score that was used. Were they adopted in consensus in the group? What does in each case a rating of 1, of 0.5, or 3, mean, for example?[f]

[PAGE 8]

In Table 11 it is noted that 5 points were awarded (maximum effect on human health) to the slash and burn process. We ask: What are the effects of felling and burning a forest? Weren't the authors confused and wouldn't they classify the risk to biodiversity of that is in fact 5? In accordance with the foregoing, how were the recovery scores obtained? Why put the impacts of sowing and using fertilizers if their intensity scores are equal to zero?

Something similar occurs with the ecological risks (Table 12). Here the low scores assigned to sowing (1) and the use of pesticides (2) is noteworthy. Because the procedure for assigning these scores was not specified, we believe that they are overvalued. The sowing of coca as clean cultivation must have significant erosion effects on the soil in humid tropical forests., where the gradients and the high amount of precipitation drag large amount of edaphic material. The same thing happens with the use of pesticides. The authors presented lists of agrotoxins used by the coca farmers, which include category 1a and 1b substances which are highly toxic to non-target species. Then, why give such low risk intensities?

The conceptual model mentions that the toxicity data for glyphosate were obtained from the literature and on acute intoxication tests on laboratory animals performed with the glyphosate – Cosmoflux mixture, but the protocols were not present. Nor do they present how the processes of exposure via the food chain and drinking water were estimated. Likewise the protocols followed in the epidemiological studies and the toxicity tests on standard organisms were omitted (page 42).

The discussion on the effects of the POEA, which the authors acknowledge as important, were diluted in the text and were not presented as adjuvants that have toxic effects greater than technical glyphosate. The discussion thereof goes

[f] In this regard, it must be stressed that one of the recommendations from the study on the supposed effects of glyphosate on human health prepared by the Uribe Cualla toxicology clinic and requested by the United States Embassy is that, "to be able to determine whether there is an increase in the frequency of health problems and disease after aerial spraying with glyphosate and whether this supposed increase is related to that exposure, a prospective-type epidemiological-environmental study is required in practice. However, this was not possible given that the design and execution of this study was five (5) months after the aerial spraying."

unnoticed. The amounts of POEA used are not mentioned, when the DNE admitted, at least until 2002, that this coadjuvant was part of the mixture used. Nor is the appearance of Dioxane molecules mentioned, which are highly carcinogenic to animals, which commonly appear as impurities in the mixture.

8 In relation to the characterization of the exposure (chapter 3, page 44 and subsequent)

We are not certain that the group of sprayers has a greater probability of exposure to glyphosate as stated on page 44, given the safety measures that they take. We believe that the most vulnerable group are the coca producers (persons present in the area).

[PAGE 9]

In relation to the exposure of those in the area ([Tr.: *circunstantes* =] name given in the study to those who are exposed in the crop field or areas surrounding the crop), the extrapolation of the information from the bibliography to reality is worrisome (pages 46 to 50).

The authors state that, "…it is uncommon for there to be people present among a coca crop during the application of the pesticide and it is possible that *one* person might be directly in the spray corridor and that he receives a direct application…," but that is pure speculation. No one has counted the number of people present at the time of spraying in Colombia nor how they are exposed to the herbicides (naked torsos). Nor have the real conditions under which Colombian coca farmers work been evaluated: heat and humidity influence the human metabolism and could substantially change the cutaneous adsorption patterns for coca farmers through sweat and with pores open wider. To that must be added the nutrition conditions (which is assumed to be low in these areas) and the immunological defense of these workers, which variables are unknown.

In this regard, it is good to cite the recommendations made by the United States EPA (Environmental Protection Agency) to the then-Secretary of State Colin Powel, regarding spraying in Colombia: "…Detailed information on the time of application, the history of exposure, and the medical documentation of the symptoms related to exposure to the glyphosate mixture was not available (page 17)…." "…During those spray operations it is recommended that there be monitoring of health complaints, documentation of the exposure times, and the start of symptoms to be able to evaluate the health effects and be able to reduce or prevent their occurrence" (EPA, 2002). These recommendations by the EPA were not followed, in the study by Solomon and collaborators.

For exposure to glyphosate through diet an drinking water there is speculation with data from several parts of the world (using examples from North American and Denmark), but here equality of conditions can also not be assumed, because the Colombian fields that have coca are located in tropical rainforests (with rain precipitation near 3000 mm /year, relative humidity of 100%, air temperature greater than 28º C and oxisol-type soil, among other factors) where the dynamics of the chemical molecules are certainly very different from those that occur in temperate regions.

Therefore, it is not pertinent, to say the least, to ascribe exposure values to coca farmers by direct spraying, reentry or inhalation, estimated just from a review of the literature.

Given the importance of the study and its undeniable consequences on decision-making, the authors thousand have considered the possibility of studying the many complaints filed by affected producers (more than 8 thousand at present), which are in the files of the National Narcotics Department and the Public Advocate's Office and from that design a methodology that could establish, *in vivo*, the parameters that were found in the bibliography. Colombia is, perhaps, the only country in the world that can offer "science" real testimony from thousands of people affected by spraying and it is the duty of science to base itself on that testimony to verify or discard it. The rest is speculation.

[PAGE 10]

Then, as shall be seen later, the authors did not describe the "experimental" conditions for justifying the statement on page 50 that literally states, "…exposures from consumption from untreated surface water are considered low and infrequent, in areas where spraying is done for eradication."

9 In relation to environmental exposures (page 50 and subsequent)

The authors prevent bibliographic evidence that tends to show that the concentrations of glyphosate in surface waters "…are relatively small…" but they acknowledge that that has not been measured in Colombia. They propose, as a result, a monitoring study to measure the concentrations of glyphosate, AMPA, and other pesticides in surface waters.

Unfortunately they did not describe the general conditions under which the study was performed, although they cite individual reports where further details are found on temperature, rain precipitation, and soil characteristics. In the absence

of greater information and only in relation to that contained in the report of Solomon and his collaborators it is possible, therefore, to ask the following questions (page 54):

- What were the criteria for selecting the five areas (Valle de Cauca, Boyacá, Sierra Nevada, Putumayo and Nariño), so dissimilar from each other, not only in terms of geology and geomorphology, soils, climate, vegetation, but also in relation to the production unit management systems?
- What were the internal soil parameters (morphology of the modal profile, texture, hydraulic conductivity, permeability, water table, mineralogy, and organic matter) that were used to differentiate the selected areas? Where these parameters characterized?
- What where the external parameters (drainage, slope) of the soil under study? What is its taxonomy?
- From what specific time after the glyphosate applications where the samples started?
- What doses of herbicide were used? Applied to what type of crops?
- What was the size of the areas sprayed with glyphosate in relation to the plant coverage of the microbasins studied?
- Where were the microbasins near the selected areas not used as controls?
- How far from or how near to the sprayed areas from the sample areas? What obstacles prevented or what factors favored the glyphosate's reaching the surface water?
- What were the criteria used to define the sampling frequencies?
- What were the baselines for the time and space comparison?

The preceding questions are important because the variable selected affect the interpretation of the results obtained.

[PAGE 11]

Therefore, it is inappropriate to state that, "…little or no glyphosate contamination of the surface water has occurred, in large concentrations, from the use of glyphosate in agricultural spraying or eradication in Colombia…." This statement, which is and of itself is a conclusion, cannot be obtained from studying five locations, with limited sampling and with so many uncertainties such as those noted. It goes beyond what can be proved in the field with the selected stations and it exaggerates the magnitude of the data obtained, that is to say, it is not consistent with the methodology employed.

In relation to the effects on the soil (number 3.1.4.3), the authors present Table 15 which contains some data that are not supported in the text. They agree, furthermore, that "there are no direct measurements of glyphosate and AMPA concentrations in the coca and poppy crops" and right there they conclude that the recolonization of plants is rapid and that "no adverse effects have been observed in terms of recolonization or resowing of the sprayed crops….

Such statements contradict others in the same text that speak of "reviews" once or twice a year of the coca fields.

But beyond these effects, the members of the IDEA insist that the direct effect of the herbicide on the soil should be sought more in the erosion rights than in their biological persistence. However, in this same regard, the literature offers examples that show that glyphosate can persist in the soil for months and even years and that the results of its alteration can be more toxic than the original molecule.

10 On the characterization of the effects

The document shows a varied sample of articles in favor and against the effects that glyphosate does or does not cause on mammals and humans. Almost all of the ones that show some link between glyphosate and negative effects on human health are strongly criticized and then discarded as invalid evidence. There is even a footnote (page 58) that discards two articles by Post (1999) and Cox (1998) as pamphleteers and as being fraudulent scientific publications.

What is curious is that almost half the citations the authors use to demonstrate the innocuousness of glyphosate refer to Williams (2000) and Williams *et al.* (2002) who are researchers whose work was done under the auspices of Monsanto, the company that produces glyphosate.

After each review of specific subjects, the authors wind up concluding that glyphosate is not toxic in any case, which is not consistent with the work that is cited (see second paragraph of page 63). Note that Solomon and collaborators here mention POEA as possible responsible for toxicity in suicides.

We celebrate, however, that the OEA experts admit that, "…exposures in the population studied is never measured directly and the use of substitutes is common … which is subject to significant errors … the consequences of this supposition could be a high rate of false positives in the classification of

exposure…*the impact of this error can be significant and only rarely has it been quantified. Until classification of exposure to pesticides in epidemiological studies has been improved, the results of the effects on health are subject to erroneous classification biases*...” (page 64).

This statement from the very authors of the OEA report summarizes the key to the debate.

Thereafter the authors state several examples of studies that link cancer to glyphosate but, in the same line as their analytical bias, they refute them to conclude that that does not occur, the same with the likely neurological effects or the effects on human reproduction.

11 On the effects of glyphosate in non-target environmental organisms (sic) (page 72 and subsequent)

Just as in the prior cases, the authors present evidence on the negative effects of the herbicide, but all accompanied by their respective footnotes or criticisms, at the end discrediting them for different reasons (unreal dosages studied, inadequate methodologies, small samples or number of cases) and rejecting their conclusions. This happens with soil invertebrates and microorganisms and with land vertebrates and invertebrates. When any negative effect of glyphosate is admitted (for example, on some birds) it states that those effects are relatively small or that the affected organisms recover rapidly (p. 76). At the end they admit some negative effects on frogs.

It would be recommendable for the authors to consider more seriously the reports that criticize both technical glyphosate and the coadjuvants and the commercial products (Round-Up). Because it is deemed of interest, Appendix A is attached which contains the analysis of the consultant Jerry Bigwood contracted by the Ecuadorian government in 2002 on the noxious youths [Tr.: *efebos = youths*; perhaps *efectos = effects*] of glyphosate and a bibliographic list of 207 references which the author himself compiled on the subject.

Although it is not the intention of this document to perform a detailed analysis of the existing bibliography (work that was given to the OEA experts) we transcribe the *Abstract* of a recent study performed by Relyea (2005) that describes deleterious effects of glyphosate on some aquatic species:

[…]

The full document of this article can be obtained in the journal and at the email address indicated. We transcribe it because it is a good example of a serious work on the negative effects of glyphosate. Works such as these could also have been used during the review of the literature that the authors performed.

[PAGE 14]

12 On the effect of glyphosate and Cosmo-Flux on mammals

The authors set out a series of well-designed and -controlled experiments with rats for acute oral toxicity, in a single dose, finding clinical abnormalities (p. 87) in some cases but not in others; for acute toxicity by inhalation in different times (with different results); for acute thermal toxicity (record of clinical abnormalities). Rabbits were used for skin irritation tests (contrasting results) and the eyes (contrasting results although it is accepted that the formulation studied is a skin and eye irritant to rabbits).

What is noteworthy is that, based on these tests performed on rats, rabbits and guinea pigs, the authors extrapolate the results and state that "…the risk to people from the application of glyphosate or from its presence in the spray target area is considered minimal…." With the data obtained, what they can indeed properly state is that those effects did or did not occur in rabbits, rats, and guinea pigs…but nothing further! It is not even proper to extrapolate that information for all mammals (page 100) or wild birds (page 104).

Even so, the authors accept "slight or moderate irritation of the skin and eyes…." Is that or is it not a risk to human health?

13 To summarize

- Several of the conclusions that the authors reach cannot be obtained from the very data presented by them, especially because they are suppositions and not actual field measurements. That is especially important insofar as human health.

- The OEA experts dismissed several studies and did not consult others in the abundant bibliography on the matter, which could have influenced their own conclusions.

- The authors focused their efforts on seeking effects in ecosystem compartments where it is assumed that they are smaller and not in the ecosystem compartments where those effects are direct and easy to study: destruction of biodiversity, elimination of legal plants, and soil erosion.

- By discarding the study of the economic and social effects, it is not proper for the authors to use the term "environmental," because the people have deliberately been excluded, who are the most important players in the environment. It is suggested, as a result, that the authors change the title of their study.

Colombia is perhaps the only country in the world where there are more than 8,000 people who have complained about the diverse effects of the spraying. It is with them and for them that studies on the noxious effects on health, pets, legal plants and ecosystems. The databases of the Public Advocate's Office and the National Narcotics Department contain

[PAGE 15]

abundant information that could be used in this case. Also, future studies should count on their participation, only in the definition and characterization of environmental impacts, but also in the joint search for solutions to this complex problem caused by illegal crops.

[…]

[PAGE 18]

A BRIEF SUMMARY OF THE SCIENTIFIC LITERATURE REGARDING THE NOXIOUS EFFECTS OF FORMULATIONS THAT CONTAIN GLYPHOSATE IN AQUATIC BIOTA AND SOIL

To the Ministry of the Environment of Ecuador

6 March 2002

Jeremy Bigwood, Technical Consultant

Background:

The Government of Ecuador has requested that the government of Colombia implement a 10 kilometer buffer zone next to the border in Colombian territory to protect Ecuador from the possible ecological damage that might result from the spraying (chemical sprays) under the eradication program that is currently being conducted by the governments of Colombia and the United States against illegal crops. The request by the Ecuadorian Government comes after a series of articles published in the press, individual and community complaints by citizens in the border area (and including a lawsuit in a United States federal court) that state that the Republic of Colombia's and the United States' air forces had sprayed in Ecuadorian territory or in areas very close. Among the reports of damages caused by the spraying in Colombia there are reports of the death of fishes and other aquatic life, as well as damages to legal crops, virgin forests and fauna, including, although still not proved, damage to human health. Give the fact that may rivers flow from Colombia to Ecuador, and that there are reports of spraying above bodies of water in Colombia, the Ecuadorian Government has stated its due concern about the possible noxious effects that could be caused in the Ecuadorian environment and the Ecuadorian people.

Members of the Ecuadorian government are also alarmed about that fact that before starting the spraying, neither the Government of Colombia nor the Government of the United States (which supplies the equipment and has a very active role in these operations) have done research on the environmental effects of the various formulations that have been used on the most diverse biosystems in Colombia. That massive unresearched use of herbicide formulations and the continuous replacing of one formulation with another would not be allowed in the United States nor in the majority of the countries in the world. AS a result of this massive use of an unstudied formulation and in the absence of research, Ecuador could be facing a danger of unknown proportions.

Although there have been no studies of the current formulations that are being used in the ecosystems and biota shared between the south of Colombia and the northern border region of Ecuador, there is a wide range of research in the scientific literature with respect to the toxicity of SOME of the compounds present in the formulations that the governments of Colombia and the United States tell us that they are using. This literature is divided into three sections: 1) the effects on the aquatic biota such as rivers; 2) the soil; and 3) insects. In this report we are not going to consider the possible noxious effects on human beings[39, 187, 188] given that Ecuador hopes that the governments of Colombia and the United States are going to

refrain from spraying within Ecuadorian territory and in areas near the border.

It must be stressed that there has been no scientific research in Colombia with respect to the formulations that they have been using in the past or the formulations they are currently using. We also know that they intend to change the current formulation in a few months and use another one that has also not been investigated. Given this situation, we can only analyze the effects of SOME of the ingredients of the formulations used today. Also, we must stress that, with the exception of a few studies, such as one in Nigeria,[128] most of the research has occurred in temperate regions such as northern Europe, Canada, and the United States. Even so, these studies show that some of the ingredients in the formulations that are currently being sprayed in Colombia can cause significant noxious effects on aquatic life, including fish, amphibians, in the content of soil, and in insects. Until impartial research has also been done by neutral agents on the current formulations (and those of the past, as well as the ones that have been proposed for the future), we can only conclude that the spraying represents a clear and present danger to the Ecuadorian environment.

Effects on aquatic systems

While the persistence of glyphosate in water is less than its persistence in soil, it has been extracted from soil some 12 up to 60 days after its application.[39, 67, 68] But formulations such as "Round-Up" which contains glyphosate – that also contain a surfactant – are more dangerous than glyphosate alone in aquatic systems. The effects of Round-Up (glyphosate and surfactant) in the aquatic biota are so serious that Monsant itself – the company that produces Round-Up – prohibits its use near or above bodies of water. In Colombia incidents have been recorded of pisciculture operations in lakes and ponds, projects that were undertaken with the support of the GTZ that were completely destroyed by spraying with glyphosate formulations. The toxicity of these glyphosate formulations in rivers is not only limited to fish, but to amphibians, insects, invertebrates (including crustaceans) and unquestionably other species found in rivers and other bodies of water.[2, 4, 19, 39, 205, 206, 207] One of the most serious problems with the glyphosate formulations used in Colombia is that some of the ingredients are in and of themselves more toxic to aquatic life than glyphosate itself. Also, in the combination they are used in spraying, the sum of them has the effect of increased toxicity.[2] Here we must cite the summary of Abdelghani *et al.*:[2]

"The acute toxicity of three herbicides alone and in mixtures (2,4-D, Garlon-3A, and Roundup) and a chemical additive (the surfactant Syndets) was evaluated using three freshwater aquatic organisms ("channel" catfish [catfish],

"bluegill," and freshwater river crab [crab]). Among the three herbicides, Roundup was the most toxic to catfish and bluegill than Garlon-3A and 2,4-D. The order of toxicity in fish (Roundup Garlon-3A 2,4-D) was reversed in biotests with freshwater river crabs (crab), respectively. For the surfactant "Syndets," the CL_{50} levels of 1.9 mg/L (bluegill), 2.3 mg/L (catfish), and 15.2 mg/L (freshwater river crab) were noted, indicating that this chemical additive was much more toxic than the three herbicides…"[2 g]

[PAGE 20]

Different species of fish have different degrees of vulnerability to glyphosate (and, of course, the other additives),[185] and the amount of minerals dissolved in the water,[206] and the water temperature[205] also play a role in their toxicity.

Research conducted in Australia has demonstrated that the Roundup formulation is very toxic to amphibians. In a study commissioned in 1995 by the Western Australia Department of Environmental Protection (DEP) led by Dr. Joseph Bidwell of the Curtin Exotoxicology Program, concluded that Roundup 360 (another Roundup formulation that contains glyphosate and surfactants) may be acutely toxic to adult frogs and tadpoles at the recommended application rates (1.8 to 5.4 kg/ha). Roundup 360 was more toxic to frogs and tadpoles than the technical grade of glyphosate alone. It was assumed that the Roundup surfactant, and not glyphosate itself, had caused the increase in toxicity.[4, 19] It must be noted that it is the same surfactant (POEA) as is found in the Roundup used in Colombia.

The toxicity of glyphosate formulations to the aquatic biota is very well established, and this is the most important matter for Ecuador because many rivers originating in Colombia flow south, entering Ecuadorian territory. In the absence of scientific research on, among other things, the concentrations and the effects of the glyphosate formulations in such a variety of ecosystems, the Republic of Ecuador must continue its cautious and moderate focus and continue requesting a 10-kilometer buffer zone within the Republic of Colombia.

Effects on the soil:

Soil is comprised of thousands of microbes and invertebrate organisms with more complex forms of animal life. Plant and tree roots, seeds, and several fungi are a large part of these microhabitats.

---

[g] We include the information on the surfactant Syndets because in the case of spraying in Colombia, there have been many changes in the formulations used, including changes in surfactants.

> The microorganisms in the soil play an extensive role in the decomposition of organic material and the production of humus, the recycling of nutrients and energy and element fixation, the metabolism of the soil and the production of compounds that cause the formation of aggregates. Many microorganisms are in symbiotic relations with plants and animals, fixing nitrogen for them in the first case and microbes of the intestines in the second. They function as a substantial part of the food network.
>
> Among the microorganisms that are found in the ground are bacteria, actinomycetes, fungus, microalgae, protozoa, nematodes, and other invertebrates (mostly arthropods).[51]

The effects of the surfactants and other additives used in the spray formulations apparently have not been investigated in soil, nor have the effects of

---

Currently it is stated that they are using one or two additional surfactants added to Roundup (which already contains a surfactant). One of these is called Cosmoflux IND. We do not precisely know the chemical nature of Cosmoflux, but we hope that it is not the same ingredient as is found in Syndets.

the formulations well known as "Roundup." But glyphosate as a separate chemical has in fact been investigated. Glyphosate was manufactured to be applied directly to the leaves of plants, but "although glyphosate is not directly applied to the soil, a significant concentration of the compound can reach the soil during an application."[74] The studies on the effects of glyphosate in soil can be divided into four categories: 1) nematodes (all sizes of worms); 2) an increase in pathogenic fungus; 3) interference with the mycorrhizal relationships among the funguses, nutrients, and plants; and 4) the effects on microbes.

Glyphosate has negative effects on nematodes and other invertebrate worms.[48, 156] Research in New Zealand shoed the glyphosate had significant effects on the growth and survival of common ground worms.[39, 200]

Glyphosate increases the growth of pathogenic fungi according to much research published in the scientific literature. As a result, these mushrooms predominate in an area to release their own toxins (micotoxins), which are toxic

to many other forms of life nearby, including mammals. That is, in this case, we are talking about a secondary effect of toxicity. One of the genera that tends to increase in the presence of glyphosate is the genus *Fusarium*,[47, 82, 101, 102, 103, 144, 157, 183, 186] which until September 2002 was going to be used by the government of the United States as a bioherbicide (mycoherbicide) in Colombia in order to eradicate the coca, but the proposal was rejected by the Andean Committee of Environmental Authorities (CAAAM) and President Clinton. Species of the *Fusarium* genus have been responsible throughout the world for serious damage to many crops, poisoned soil, birth defects in human beings, and in one documented case, the deaths of thousands of people caused by it micotoxins when they ate contaminated cereals during the last years of the Second World War.[199]

The interference of glyphosate in mycorrhizal relations among fungi, nutrients and plants was recently published in 1998. A mycorrhizal relationship is a symbiotic association between the mycelium (the cell body) of a fungus, especially a basidiomycete (mushroom) with the roots of some plants and trees where the fungus's mycelium forms a tight woven cover wrapping around the small roots or even penetrating the roots. This relationship provides an exchange of nutrients and water that benefits both the plant and the fungus. In research performed by a Canadian team led by the scientist M.T. Wan,[183], the noxious effect of glyphosate was almost as toxic in the symbiotic fungus *Glomus intraradices* in carrot roots as the recognized by now prohibited toxic fungicide benomyl (which was the subject of a successful lawsuit by an Ecuadorian company against the multinational DuPont). Given that many plants cannot grow without this mycorrhizal relationship, this is one possible effect of spraying with glyphosate that we must consider.

Glyphosate also has effects on microbes in the soil. Wan et al., working at Texas A&M University, reported that "the evolution of CO_2 increased when the rate of glyphosate was increased. The glyphosate significantly stimulated the microbial activity measured by the mineralization of Carbon and Nitrogen."[74, 165] It has also been shown that glyphosate can reduce the ability of certain bacteria to fix nitrogen.[39, 201]

In sum, there is a lot of documentation on the clear effects of glyphosate

in the biota and ecology of the soil that comes from studies already known in other parts of the world, and it is likely that more noxious effects are going to be presented while the matter continues to be studied.

Effects on beneficial insects:

One of the complaints that was presented with respect to the Roundup (plus surfactants) spraying program that the United States government undertook to eliminate poppy crops in Guatemala, was that the apiculture in the areas near the spraying was destroyed. "Although the spraying program had a minimum effect on the poppy crop, according to local peasants, the traditional basis of production in the region was destroyed, in particular tomatoes and bees."[202, 203] As a result of pressure by environmentalists and others, the spraying program was suspended and now the poppy crop in Guatemala is being controlled thanks to manual eradication. Research performed by the International Organization for Biological Control agrees with the effects reported in Guatemala on bees; it also shows that there are effects on other beneficial insects.

According to these studies, it was demonstrated that exposure by insects to one commercial formulation of Roundup (glyphosate plus surfactants) caused mortality rates in excess of 50% in beneficial insects, including parasitoid wasps, lacewings, and butterflies. The mortality level was even higher for one type of predator beetle.[204]

Monitoring and chemical analysis

Although there are several methodologies for collecting and analyzing SOME of the components in the formulations that are being sprayed in Colombia, in freshwater or on the soil, all need relatively advanced scientific equipment in combination with well-trained personnel. Also, this would require a system of monitoring stations throughout the border area, especially in the rivers that have their source in Colombia.[1, 2, 3, 7, 8, 16, 22, 23, 25, 27, 28, 30, 31, 37, 54, 59, 63, 67, 69, 70, 73, 79, 85, 86, 92, 107, 108, 109, 111, 124, 125, 126, 127, 132, 135, 136, 138, 139, 165, 166, 167, 171, 174, 178, 180, 181, 184, 185, 187]

To develop a system of this nature would require significant funds, and under current conditions this seems to be an unfeasible proposal. But, in the ideal case that financial support could be obtain for monitoring, apart from everything implied by doing the analyses of the water and soil, it would be necessary that the following "indicator organisms" be monitored:

Indicator organisms

Aquatic plants, such as green algae
Aquatic invertebrates, such as water bugs
Fish, such as Tilapia or catfish
Amphibians, such as frogs
Nitrogen-fixing soil bacteria

Soil invertebrates, such as worms
Land plants
Birds
Mammals

[PAGE 23]

Summary:

Based on the studies cited above, it is very likely that at least some of the ingredients in the formulations used in Colombia cause noxious effects on the aquatic biota, including fish, amphibians, and insects, as well as on the content and function of soil. Given that science has not yet been able to catalog most of the species or even a small percentage of the Colombian or Ecuadorian ecosystems, spraying pesticides can easily eliminate an entire new species without us even knowing that it ever existed. This fact can clearly threaten the future exploitation by Ecuador of its own wealth, in biota and biodiversity. Until there is irrefutable proof based on impartial scientific research by neutral players that proves beyond doubt that the massive aerial spraying currently used is innocuous to our shared ecosystems – not a very likely proposal – according to the research consulted – we can only conclude that there is a true possibility of noxious effects from spraying in the Ecuadorian environment. That said, Ecuador must protect itself with a buffer zone of at least ten kilometers to guarantee its citizens that the possible noxious effects generated as a result of the chemical herbicides massively sprayed by air dissipate in the Colombian territory.

[…]

UNIVERSIDAD NACIONAL DE COLOMBIA
SEDE BOGOTÁ
INSTITUTO DE ESTUDIOS AMBIENTALES -IDEA-

UNIVERSIDAD NACIONAL DE COLOMBIA

INSTITUTO DE ESTUDIOS AMBIENTALES (IDEA)

Observaciones al "Estudio de los efectos del programa de Erradicación de Cultivos Ilícitos mediante la aspersión aérea con el herbicida Glifosato (PECIG) y de los cultivos ilícitos en la salud humana y en el medio ambiente"

Tomás León Sicard
Agrólogo PhD.
Director Programa de Investigación en Impactos de Cultivos de Uso Ilícito (PIAC) IDEA – UN.
Director (e) Instituto de Estudios Ambientales IDEA – Universidad Nacional

Javier Burgos Salcedo
Biólogo candidato PhD.
Investigador - Profesor Programa de Maestría en Medio Ambiente y Desarrollo IDEA – UN.

Catalina Toro Pérez
Arquitecta candidata PhD.
Investigadora Programa de Investigación en Impactos de Cultivos de Uso Ilícito (PIAC) IDEA – UN.

César Luengas Baquero
Zootecnista Esp.
Investigador Programa de Investigación en Impactos de Cultivos de Uso Ilícito (PIAC) IDEA – UN.

Claudia Natalia Ruiz Rojas
Ingeniera Civil Ms.
Investigadora Programa de Investigación en Impactos de Cultivos de Uso Ilícito (PIAC) IDEA – UN.

Claudia Patricia Romero Hernández
Ingeniera Topógrafa Ms.
Investigadora Programa de Investigación en Impactos de Cultivos de Uso Ilícito (PIAC) IDEA – UN.

Bogotá, mayo 11 de 2005.

UNIVERSIDAD NACIONAL DE COLOMBIA
SEDE BOGOTÁ
INSTITUTO DE ESTUDIOS AMBIENTALES -IDEA-

PRESENTACIÓN

El documento citado, que ha sido elaborado por los doctores Keith Solomon, Arturo Anadón, Antonio Luiz Cerdeira, Jon Marshall y Luz Helena Sanín (en adelante Solomon y colaboradores), constituye una importante referencia nacional para los futuros trabajos de investigación que se realicen sobre el tema. Se acompaña de abundantes citas bibliográficas e información valiosa en algunos tópicos, con argumentaciones amplias en los temas seleccionados.

El documento, que se elaboró bajo el auspicio de la CICAD (Comisión Interamericana para el Control del Abuso de Drogas), división de la Organización de Estados Americanos (OEA), presenta deficiencias en la manera como está estructurado, dado que carece del orden deseado en este tipo de documentos científicos. Adolece de un hilo conductor que, partiendo de la definición clara de los problemas a evaluar y de las hipótesis de partida, presente los procedimientos utilizados (metodología), los resultados encontrados y la discusión final de los mismos. Tales ítems se encuentran mezclados a lo largo del texto, dificultando su lectura.

La tesis central del estudio es demostrar que " i)...las exposiciones al glifosato y sus adyuvantes tal y como se emplean en los programas de erradicación de amapola y coca no originan efectos adversos, agudos o crónicos en organismos no blanco, expuestos por diferentes rutas .y ...ii) que tales exposiciones no originan efectos adversos agudos o crónicos en organismos no blanco expuestos por diferentes rutas...". En este esfuerzo Solomon y colaboradores apelan esencialmente a revisión de literatura existente y, en ocasiones, a pruebas experimentales realizadas en laboratorio.

Con base en el texto presentado, se pueden hacer las siguientes observaciones:

1 Sobre el Prefacio (página 2)

En primera instancia es necesario llamar la atención sobre las argumentaciones de partida del estudio: los autores reconocen que "... el Programa de Erradicación de Cultivos Ilícitos es tema de intenso debate por razones políticas, sociales y de otra índole..." y por lo tanto ".... se excluyen del estudio específicamente todos los aspectos sociales, políticos y económicos y *el informe final se basa estrictamente en la ciencia y en argumentos basados en la ciencia..(*la cursiva es nuestra*).".*

Esta aseveración por parte de los autores es muy polémica, por lo menos por tres razones: primero, porque excluye a las ciencias sociales, humanas y económicas del análisis ambiental; segundo, porque coloca el acento solamente en las explicaciones que provengan de las ciencias naturales o ciencias "duras" en un fenómeno que, en realidad, toca muchos más de los aspectos considerados por ellos y tercero, porque es ineludible que este estudio, o cualquier otro de la misma índole realizado bien sea por investigadores del país o, como en el caso presente, por un grupo expresamente seleccionado a nivel internacional, se utilizará con fines políticos.

La ciencia no puede declararse neutra frente a la sociedad alegando que su método es puro e imparcial, cuando sus motivaciones y resultados se insertan en el debate social. Más aún cuando se trata de temas tan sensibles social, económica, política y

militarmente, como el que trata el estudio, que se encuentran en el centro de polémicas con repercusiones mundiales, y que se ligan con derechos humanos fundamentales, como el de la vida, el ambiente sano y la salud de los colombianos.

En lo que toca al primer aspecto señalado, es preciso insistir en que, desde hace más de treinta años, el mundo reconoce que la dimensión ambiental es, precisamente, la conjunción de las complejas dinámicas sociedad – naturaleza o ecosistema – cultura y ello se ha expresado en una innumerable literatura tanto desde las vertientes ecológicas como antropológicas, sociopolíticas y económicas (Tamames, 1980; PNUD, 1990; Angel, 1993 a y b; Tyler, 1994; Sachs, 1996; Angel, 1996; Carrizosa, 1999, 2003).

A pesar de su buena intención por delimitar el campo de estudio, que en sí mismo es una actitud legítima, los autores no pueden olvidar la complejidad del asunto, especialmente porque ello tiene efectos tanto en su metodología como en sus conclusiones.

En su metodología, porque olvidaron incluir los efectos económicos, institucionales, políticos o sociales que tiene la fumigación con herbicidas en los campos de los productores (pérdida y disminución de rendimientos en cultivos lícitos, afectación de animales domésticos, desplazamientos de población, cambios en las relaciones familiares de los agricultores afectados o agudización del conflicto armado en Colombia, por solo citar cinco ejemplos).

En sus conclusiones porque, como puede observarse en la página 107 los autores afirman que " los riesgos adicionales asociados con el programa de aspersión son pequeños.." cuando el estudio no consideró, o si lo hizo fue de manera tangencial, los riesgos directos o indirectos sobre ecosistemas o agroecosistemas vecinos, pérdidas de biodiversidad, desplazamientos de población o incremento en procesos erosivos como consecuencia del uso del herbicida.

En segundo lugar, la confianza total en la ciencia también es relativa. Las argumentaciones en contra del glifosato, también son abundantes en la literatura mundial y, sin embargo, no fueron suficientemente exploradas por los autores. Ello quiere decir que la ciencia enfrenta problemas cuando pretende ser objetiva, porque es un ejercicio humano. Aquí vale la pena anotar el famoso ejemplo del vaso que está hasta la mitad de su volumen ocupado con agua: para algunos observadores está medio lleno y para otros estará medio vacío. La pretendida objetividad científica de las ciencias positivas, también está en duda.

En relación con el tercer punto basta señalar que, desde el mismo día en que los autores expusieron públicamente sus resultados, las reacciones de la sociedad civil y del gobierno no se han hecho esperar, unas a favor y otras en contra del estudio, prueba fehaciente de su innegable importancia política[1].

[1] Ver comunicados de prensa, carta de la red de estudiantes en el exterior, declaraciones públicas del Ministro del Interior y las más de 3500 comunicaciones enviadas a los presidentes Uribe y Bush rechazando las inminentes fumigaciones en los Parques Nacionales de Colombia.

2 Sobre el enfoque del trabajo

El proyecto tiene una grave deficiencia: se basó en estudios secundarios para estimar los efectos del herbicida en la salud humana, acogiendo la mayor parte de los que juegan a su favor, pero desestimando aquellos que indican riesgos. Es más: no solo, Solomon y colaboradores no consultaron la lista de quejas (en la actualidad reposan más de 8000 en la Defensoría del Pueblo)[2] que han interpuesto diferentes actores de la sociedad colombiana sobre los efectos ambientales de las fumigaciones. Allí seguramente hubieran encontrado una gran cantidad de datos para verificar.

Un trabajo en esta dirección fue realizado por Luengas (2005) quien examinó las bases de datos de la Defensoría del Pueblo y de la Dirección Nacional de Estupefacientes (DNE), encontrando que el 87% de las quejas interpuestas corresponde a daños sobre la vegetación[3], el 6,9% a salud humana y el resto a animales y cuerpos de agua.

Además, consideramos que la variable seleccionada para estimar los efectos del Glifosato en la salud humana (Fertilidad Humana, en particular Tiempo Para Quedar En Embarazo) es insuficiente para valorar el efecto del herbicida, debido a que:

- Dichos efectos son evidentes en intervalos de tiempo superiores a los considerados en ese estudio.
- Los efectos de compuestos químicos del tipo de los que se usan en agricultura, son evidentes a escala cromosómica en las poblaciones expuestas y por un incremento en la proporción de enfermedades genéticas en sus descendientes, variables que no fueron consideradas en el estudio de Solomón y colaboradores.

Es por estas razones que los operarios que manipulan estas sustancias están obligados a utilizar ropa especial y medidas adicionales de seguridad, cosa que no ocurre en las personas que, de una u otra manera, se encuentran expuestas en los campos de cultivo en los momentos de la aspersión aérea del herbicida.

Sobre estudios que indican riesgos en la salud es necesario destacar el que realizó recientemente Maldonado (2003) y que presenta evidencias de lesiones genéticas en el 36% de las células de la totalidad de mujeres que estuvieron expuestas a fumigaciones con el herbicida en la frontera colombo – ecuatoriana. Otras evidencias en la misma línea debieron ser consultadas (Nivia, 2001; Warren, 2001; Kaczewer, 2002)[4].

---

[2] Comunicación personal de funcionarios de la Defensoría del Pueblo (abril de 2005).
[3] Este resultado es de esperarse debido a que el glifosato es un herbicida y su primera acción ocurre sobre el componente vegetal.
[4] "La toxicidad del glifosato comercial a la concentración del 48% presenta una dosis letal media mínima (*cantidad requerida, en una sola dosis, para matar a la mitad de los* individuos en experimentación de un grupo homogéneo), por vía oral de 4.900 a 5.000 miligramos por kilogramo de peso vivo en ratas hembras y se ha clasificado como Categoría IV de toxicidad (asignada por la FEDERAL, INSECTICIDE, FUNGICIDE AND RODENTICIDE ACT,, FIFRA), Categoría III para toxicidad inhalatoria, y Categoría IV para la toxicidad dérmica. La Environmental Protection Agency, EPA., según criterios de la FIFRA y en igualdad de condiciones, le asignó Categoría II por el efecto ocular irritante y la opacidad corneal en conejos, efectos, estos últimos que según el fabricante son originados por la seboamina etoxilada que se utiliza como surfactante y que también tiene la capacidad de causar irritación gastrointestinal, nauseas, vómito y diarrea (..). ." Defensoría del Pueblo, Informe Evaluativo No. 3010-04, cuaderno 6, folios 18 a 31".

Igualmente, Richard *et al.*, en una reciente investigación sobre los efectos diferenciales del glifosato y el Round-up, demuestran que el glifosato es tóxico para las células placentarias humanas *JEG3* dentro de las 18 horas siguientes a la exposición en concentraciones más bajas que las usadas en agricultura y que este efecto se incrementa con el aumento en la concentración y el tiempo de exposición o en presencia de coadyuvantes del Round-up.

Una reflexión final en este sentido: la salud de los seres humanos no es solamente física. También es mental. Hubiera sido interesante explorar qué efectos sicológicos tiene la fumigación aérea en las percepciones de niños, hombres y mujeres que se ven afectados por estas acciones en donde participan, como lo admite el equipo de expertos, aviones de combate y helicópteros artillados.

Pasemos ahora a las observaciones generales sobre los procedimientos científicos utilizados:

3 En relación con el planteamiento del problema (páginas 22 y 23).

El problema de investigación no está claramente delimitado en el texto. Tradicionalmente la definición de los problemas de investigación se expresan en párrafos cortos o en preguntas concretas que se deben resolver (las cuales incluyen las variables a estudiar al igual que referencias de tiempo y espacio), lo cual no se especifica en ninguna parte. Se colige, no obstante, de lo expuesto en la página 23 del documento, que se trata de " ... evaluar el riesgo en el uso del glifosato y de los adyuvantes para el control de los cultivos ilícitos....". Como no se explicita claramente sobre quiénes se hará la evaluación, en qué condiciones ni a partir de qué procedimientos.....el documento entra en el campo de la ambigüedad, como se demostrará en las páginas siguientes.

4 Sobre la Metodología

El texto final no presenta un capítulo específico de metodología y los lectores deben buscar los procedimientos utilizados en toda su extensión del texto, cosa que dificulta su lectura y comprensión. No obstante, la principal deficiencia metodológica se refiere a la misma concepción general del estudio.

Por ejemplo, en relación con los componentes ecosistémicos sobre los cuales buscar efectos del glifosato (que hace parte de las decisiones metodológicas), los autores no dieron en el blanco: buscaron efectos en donde posiblemente no los había o en donde era de esperar riesgos mínimos, ello en razón también a la deficiente delimitación del problema a investigar.

En efecto, se sabe que los herbicidas son tóxicos principalmente para las plantas y no para los animales (como bien lo señalan los autores en la página 25). De acuerdo con ello, los efectos a buscar, estimar y/o medir, deberían haber sido de manera prioritaria aquellos que provoca su aspersión directa sobre cultivos lícitos o sobre vegetación natural. Estamos seguros que de haberse ejecutado así, las conclusiones del estudio serían otras, porque la aspersión del herbicida afecta directamente la biodiversidad vegetal de estas áreas.

Una de las principales críticas en este sentido se relacionan con el hecho de que, de acuerdo con los resultados de Solomon y colaboradores, el glifosato afectaría de manera específica únicamente a los cultivos de coca y de ninguna manera a otras especies vegetales. Sin embargo, hasta donde se sabe, el principio activo del glifosato (la isopropil amina) no tiene efectos especie-específicos, como de desprende de los resultados del trabajo mencionado. Incluso, en el documento: "Informe de Temas Relacionados con la Erradicación Aérea de Coca Ilícita en Colombia" publicado por la Oficina para Asuntos Internacionales de Narcóticos y Ejecución de la Ley (INL) del Departamento de Estado (septiembre de 2002.)[5], se reconoce que "el glifosato es un herbicida efectivo de amplio espectro, y por lo tanto se espera un riesgo para las plantas no objetivo fuera de la zona de aplicación".

Es más: en relación con el suelo, no era urgente detallar el proceso de adsorción de las moléculas de glifosato a los complejos arcillo-húmicos del medio edáfico. Bastaba con realizar estimaciones o mediciones sobre la erosión del recurso que, para zonas de bosques húmedos tropicales bajo cultivos limpios se ha estimado en cantidades superiores a 25 toneladas / hectárea / año. Mosquera (1985) ya desde esa época afirmaba que erosiones superiores a 25 t / ha / año eran consideradas como severas. Morgan (1986) afirma que en superficies deforestadas en porcentajes cercanos al 35% ya la erosión alcanza en los bosques húmedos tropicales, tasas tan altas como 15 t / ha.

Hubiese sido realmente interesante para Colombia conocer estimaciones sobre la pérdida de suelos como efecto directo de la remoción de las coberturas vegetales causadas tanto por la aspersión del Round- Up como por la introducción de los cultivos de coca. También estamos seguros que acá el trabajo hubiera aumentado su utilidad para el país.

5 Sobre el ambiente receptor

En la página 33 del informe se consigna información discutible: los autores indican que "... dado que los puntos críticos de diversidad se asocian principalmente con las tierras altas de los Andes y que la coca se cultiva en su gran mayoría en altitudes más bajas, *existe tan sólo algo de superposición* (la cursiva es nuestra) entre las áreas de producción de coca y las regiones de gran biodiversidad....".

Hasta donde la literatura mundial indica, los bosques húmedos tropicales que son las zonas en donde mayoritariamente se cultiva la coca, representan también las áreas más sensibles (hot spots) de la biodiversidad, con lo cual no es que exista algo de superposición, sino todo lo contrario: se está fumigando en las zonas más sensibles de la biodiversidad planetaria (Sisk *et al*, 1994).

Los bosques húmedos tropicales se caracterizan por ser los ecosistemas de mayor complejidad estructural, estratificación y diversidad de especies del mundo. Alrededor del 50% de la diversidad mundial de especies de flora descritas se concentran en estos ecosistemas (Gentry, 1993).

[5] **http://bogota.usembassy.gov/wwwfepag.pdf**

Los trabajos sobre biodiversidad en Colombia son extensos y los han realizado varias entidades: la Unidad de Parques Nacionales del Ministerio del Ambiente, Vivienda y Desarrollo Territorial, el Instituto Alexander von Humboldt, el Instituto de Investigaciones Amazónicas "Sinchi", Organizaciones No Gubernamentales como Prosierra, Natura, Tropenbos y varias Universidades (Nacional, Javeriana, Andes, Antioquia, Valle entre otros), que han generado amplia información desde distintas disciplinas en torno al tema de la biodiversidad y a las presiones que sobre ella existen., sin mencionar instituciones internacionales como WWF, Conservación Internacional o Nacional Toxic Network, entidades y trabajos que sugerimos sean consultados por los investigadores en próximos estudios.

6 Depósitos fuera del objetivo.

En la página 38 se presenta información que llama la atención, concerniente a las aspersiones que se salen de los objetivos (plantas de coca) y van a parar a zonas por fuera de los mismos. El profesor Solomon y sus colegas, citando a Payne *et al*, (1990) afirman que el efecto es mínimo aunque aceptan que "...este estimativo está basado en observaciones visuales de un número de cultivos relativamente pequeño...", lo cual en últimas quiere decir que este efecto no se ha medido.

Con todo, el dato presentado de 625,7 hectáreas afectadas por depósitos de glifosato fuera del objetivo para el año 2002, es preocupante, al igual que la información consignada por los autores sobre 22 zonas no objetivo que fueron afectadas con el herbicida de un total de 86 sitios visitados (es decir, el 25,6%). Esto implica que por lo menos 1 de cada cuatro operaciones de fumigación afecta zonas aledañas a los cultivos de coca, lo cual ya no es un efecto mínimo como lo sugería Payne *et al* (*op. cit).*

Este 25,6 % calculado por nosotros con base en los datos presentados en el informe de Solomon, contrasta con los bajos porcentajes de superficie que se señalan en el informe ("..entre el 0,25% y el 0,48% de la áreas para la producción de coca se dañaron por depósito del rociado fuera de sitio...."), información que no se sabe cómo se obtuvo dado que los autores aceptan que no hubo comprobación de campo.

Por otra parte, el profesor Solomon y sus colegas comparan estas zonas con toda la superficie de Colombia y concluyen que son pequeñas, lo cual no nos parece válido, porque con la misma razón se podría decir que las aproximadamente 80.000 hectáreas actuales de coca en el país también son muy pocas si se comparan con la superficie total de Colombia (7.1%).

7 Sobre el marco de referencia para la evaluación del riesgo (página 39 y siguientes)

El método elegido para calificar los riesgos en la salud humana no está descrito adecuadamente. No se sabe cuáles fueron los rangos adoptados ni los criterios utilizados para los puntajes de 0 a 5 que se utilizaron ¿Se adoptaron ellos en consenso dentro del grupo? ¿A qué equivale en cada caso una calificación de 1, de 0,5 o de 3, por ejemplo?[6].

[6] En este sentido, cabe resaltar que una de las recomendaciones, del estudio de los supuestos efectos del glifosato en la salud humana elaborado por la clínica de toxicología Uribe Cualla y solicitado por la Embajada

En la tabla 11 es notorio que se adjudican 5 puntos (máximo efecto sobre la salud humana) al proceso de roza y quema. Preguntamos: ¿Cuáles son los efectos en la salud humana de tumbar y quemar bosque? ¿No se confundirían los autores y calificarían el riesgo sobre pérdida de biodiversidad que ese sí es de 5?. En concordancia con lo anterior...¿Cómo se obtuvieron los puntajes de recuperación?..¿Para qué colocar los impactos de siembra y uso de fertilizantes si sus puntajes de intensidad son iguales a cero?.

Algo similar ocurre con los riesgos ecológicos (tabla 12). Aquí llama la atención los bajos puntajes asignados para la siembra (1) y uso de plaguicidas (2). Como no se especificó el procedimiento de asignación de estos puntajes, nosotros creemos que están subvalorados. La siembra de coca en tanto que cultivo limpio debe generar efectos significativos de erosión de suelos en los bosques húmedos tropicales, en donde las pendientes y las altas precipitaciones arrastran altas cantidades de material edáfico. Lo mismo sucede con el uso de plaguicidas. Los autores presentaron listas de agrotóxicos utilizados por los cocaleros, que incluyen sustancias de categoría 1ª y 1b que son altamente tóxicas para especies no objetivo. ¿Luego, porqué colocar intensidades de riesgo tan bajas?.

En el modelo conceptual se menciona que los datos de toxicidad para el glifosato se obtuvieron de la literatura y de las pruebas de intoxicaciones agudas de animales de laboratorio realizadas con la mezcla glifosato – Cosmoflux, pero no se presentan los protocolos. Tampoco se presenta la manera como se estimaron los procesos de exposición por vía de la cadena alimenticia y del agua de consumo. De igual forma se omitieron los protocolos seguidos en los estudios epidemiológicos y en los ensayos sobre toxicidad en organismos estándar (página 42).

La discusión sobre los efectos del POEA, que los autores reconocen como importantes, se diluyen en el texto y no se presentan como adyuvantes que tienen efectos tóxicos superiores al glifosato técnico. Su discusión pasa desapercibida. No se mencionan las cantidades de POEA utilizadas, cuando la DNE admitía, por lo menos hasta el año 2002, que este coadyuvante era parte de la mezcla utilizada. Tampoco se menciona la aparición de moléculas de Dioxano, altamente cancerígenas en animales, que aparecen comúnmente como impurezas de la mezcla.

8 En relación con la caracterización de la exposición (capítulo 3, pagina 44 y siguientes)

No estamos muy seguros que el grupo de asperjadores tenga la mayor probabilidad de exposición al glifosato, como se afirma en la página 44, dadas las medidas de seguridad que se toman. Creemos que el grupo más vulnerable es el de los productores de coca (circunstantes).

Estadounidense es que, "para poder determinar si existe un aumento en la frecuencia de problemas de salud y enfermedad después de las aspersiones aéreas con glifosato y si este supuesto aumento está relacionado con dicha exposición, se requiere de la práctica de un estudio epidemiológico-ambiental de tipo prospectivo. Sin embargo, esto no fue posible puesto que el diseño y ejecución del presente estudio fue cinco (5) meses posterior a las aspersiones aéreas".

En relación con la exposición de los circunstantes (nombre dado en el estudio a quienes se encuentran expuestos en los campos de cultivo o zonas aledañas al cultivo), preocupa la extrapolación de información desde la bibliografía a la realidad (páginas 46 a 50).

Los autores afirman que "....es poco común que haya personas presentes en un cultivo de coca durante la aplicación del plaguicida y es posible que *una* persona pueda estar directamente en el corredor de rociado y que reciba una aplicación directa...", pero esto es pura especulación. Nadie ha contado el número de personas presentes en los momentos de fumigación en Colombia ni la manera en que se exponen al herbicida (torsos desnudos). Tampoco se han valorado las condiciones reales en que se desempeñan los cocaleros colombianos: el calor y la humedad influyen en el metabolismo humano y podrían modificar sustancialmente los patrones de adsorción por la piel vía sudor y mayor apertura de poros en los cocaleros. A ello habría que agregarle las condiciones de nutrición (que se supone bajas en estas áreas) y de defensa inmunológica de estos trabajadores, variables que no se conocen.

En este sentido, es conveniente citar las recomendaciones que hizo en el año 2002 la EPA (Environment Protection Agency) de los Estados Unidos al entonces Secretario de Estado Colin Powell, a propósito de las fumigaciones en Colombia: ".... No estaba disponible la información detallada sobre el momento de la aplicación, la historia de la exposición y la documentación medica de los síntomas relacionados con la exposición a la mezcla de glifosato" (página 17) .... "... Durante las operaciones de aspersión se recomienda que se haga un rastreo de las quejas de salud , se documenten los tiempos de exposición y el inicio de los síntomas para poder evaluar los efectos sobre la salud y poder aminorar o prevenir su ocurrencia" (EPA, 2002). Estas recomendaciones de la EPA no se realizaron, en el estudio de Solomon y colaboradores.

Para las exposiciones al glifosato vía dieta y agua de consumo se especula con datos de varias partes del mundo (utilizando ejemplos de Norteamérica y Dinamarca), pero aquí tampoco pueden presumirse condiciones de igualdad, porque los campos colombianos que poseen coca se ubican en bosques lluviosos tropicales (con precipitaciones pluviales cercanas a 3000 mm / año, humedades relativas del 100%, temperatura del aire superior a 28 ºC y suelos de tipo oxisol, entre otros factores) en donde seguramente las dinámicas de las moléculas químicas son muy diferentes a aquellas que ocurren en zonas templadas.

Por lo tanto, no resulta pertinente, por decir lo menos, adscribirle valores de exposición a los cocaleros por rociado directo, reingreso o inhalación, estimados solo a partir de revisión de literatura.

Dada la importancia del estudio y sus innegables consecuencias en la toma de decisiones, los autores debieron considerar la posibilidad de estudiar las múltiples quejas interpuestas por los productores afectados (más de 8 mil en el momento actual), que reposan en los archivos de la Dirección Nacional de Estupefacientes y en la Defensoría del Pueblo y a partir de allí diseñar una metodología que pudiera establecer *in vivo*, los parámetros que se buscaron en la bibliografía. Colombia es, quizás, el único país del mundo que puede ofrecer a la "ciencia", los testimonios reales de miles de personas afectadas por las fumigaciones y es deber de la ciencia basarse en tales testimonios para verificarlos o desecharlos. El resto es especulación.

Por otra parte, como se verá más adelante, los autores no describieron las condiciones "experimentales" para justificar la afirmación de la página 50 que dice textualmente: ".... las exposiciones por el consumo de agua superficiales no tratadas se consideran bajas y poco frecuentes, en áreas en donde se realiza la aspersión para erradicación..."

9 En relación con las exposiciones ambientales (página 50 y siguientes)

Los autores presentan evidencias bibliográficas que tienden a demostrar que las concentraciones de glifosato en aguas superficiales "...son relativamente pequeñas..." pero reconocen que ello no se ha medido en Colombia. Proponen, en consecuencia, un estudio de monitorización para medir las concentraciones de glifosato, AMPA y otros plaguicidas en aguas superficiales.

Lamentablemente no describieron las condiciones generales en que se desarrolló el estudio, aunque citan informes individuales en donde se encuentran mayores detalles sobre temperatura, precipitación pluvial y características del suelo. En ausencia de mayor información y solo en relación con lo consignado en el informe de Solomon y sus colaboradores es posible, por lo tanto, realizar las siguientes preguntas (página 54) :

- ¿Cuáles fueron los criterios para seleccionar las cinco zonas (Valle del Cauca, Boyacá, Sierra Nevada, Putumayo y Nariño), tan disímiles entre sí, no sólo en términos de geología, geomorfología, suelos, clima y vegetación sino en relación con los sistemas de manejo de las unidades productivas?.
- ¿Cuáles son los parámetros internos de suelo (morfología del perfil modal, textura, conductividad hidráulica, permeabilidad, nivel freático, mineralogía y materia orgánica) que se utilizaron para diferenciar las zonas seleccionadas?. ¿Se caracterizaron estos parámetros?.
- ¿Cuáles fueron los parámetros externos (drenaje, pendiente) de los suelos en estudio? ¿Cuál es su taxonomía?
- ¿A partir de qué momento específico posterior a las aplicaciones de glifosato se iniciaron los muestreos?.
- ¿Qué dosis del herbicida se utilizaron? ¿Aplicados a qué tipo de cultivos?
- Cuál era la extensión de las áreas en que se asperjó el glifosato en relación con las coberturas vegetales de las microcuencas estudiadas?
- ¿Porqué no se utilizaron como testigos las microcuencas aledañas a las zonas seleccionadas?
- ¿Qué tan lejos o qué tan cerca estaban las zonas fumigadas de las zonas de muestreo? ¿Qué obstáculos se oponían o qué factores favorecían la llegada del glifosato a las aguas superficiales?
- Cuáles fueron los criterios utilizados para definir las frecuencias de muestreo?
- Cuáles fueron las líneas base de comparación en el tiempo y el espacio?

Las anteriores preguntas son pertinentes en razón de que las variables señaladas afectan la interpretación de los resultados obtenidos.

Por lo tanto, no resulta apropiado afirmar que ".....se ha producido poca o ninguna contaminación con glifosato de las aguas superficiales, en concentraciones significativas, por el uso de glifosato en aspersiones de agricultura o erradicación en Colombia...". Esta afirmación, que es en sí misma una conclusión, no puede desprenderse del estudio de cinco lugares, con un muestreo limitado y con tantas incertidumbres como las anotadas. Desborda lo que pudo comprobarse en campo con las estaciones seleccionadas y exagera la magnitud de los datos obtenidos, es decir, no es coherente con la metodología empleada.

En relación con los efectos sobre el suelo (numeral 3.1.4.3), los autores presentan la tabla 15 en la que aparecen varios datos que no se sustentan en el texto. Aceptan, por otra parte, que " no hay disponibles mediciones directas de las concentraciones de glifosato y AMPA de los cultivos de coca y amapola.." y por allí mismo concluyen que la recolonización de plantas es rápida y que "no se han observado efectos adversos en términos de recolonización o resembrado de los cultivos asperjados...".

Tales afirmaciones contradicen otras en el mismo texto que hablan de "repasos" de una o dos veces al año de los cocales.

Pero más allá de estos efectos, los miembros del IDEA insisten en que los efectos directos del herbicida sobre los suelos se debieron haber buscado más en las tasas de erosión que en su persistencia biológica. No obstante, en este mismo aspecto, la literatura ofrece ejemplos que muestran que el glifosato puede persistir en el suelo por meses e incluso años y que sus productos de alteración en el mismo pueden resultar más tóxicos que la molécula original.

10 Sobre la caracterización de los efectos

El documento presenta una variada muestra de artículos a favor y en contra de los efectos que provoca o no el glifosato en mamíferos y en humanos. Casi todos los que demuestran algún vínculo entre glifosato y efectos negativos en la salud humana son criticados fuertemente y luego desechados como pruebas no válidas. Incluso existe un pie de página (página 58) en el que se descartan dos artículos de Post (1999) y Cox (1998) por panfletarios y por querer aparecer como publicaciones científicas.

Lo curioso es que casi la mitad de las citas que utilizan los autores para demostrar la inocuidad del glifosato, se refieren a Williams (2000) y a Williams *et al (* 2002) que son investigadores cuyos trabajos se realizaron al amparo de Monsanto, la empresa productora del glifosato.

Luego de cada revisión por temas específicos, los autores van concluyendo que el glifosato no es tóxico para ningún caso, no siendo coherentes con los trabajos que se exponen (ver segundo párrafo de la página 63). Nótese que Solomon y colaboradores mencionan acá al POEA como posible responsable de la toxicidad en suicidas.

Celebramos, sin embargo, que los expertos de la OEA admitan que "... las exposiciones en la población estudiada nunca se miden directamente y es común el uso de sustitutos.....que son susceptibles de errores significativos.....las consecuencias de esta suposición podría ser una alta tasas de falsos positivos en la clasificación de la

exposición.....*el impacto de este error puede ser profundo y rara vez se ha cuantificado. Hasta que no se haya mejorado la clasificación de la exposición a los plaguicidas en los estudios epidemiológicos, los resultados de los efectos en la salud estarán sujetos a sesgos de clasificación errónea..."* (página 64).

Esta declaración de los propios autores del informe de la OEA. resume la clave del debate.

De allí en adelante los autores exponen varios ejemplos de estudios que relacionan cáncer con glifosato pero, en la misma línea de su sesgo analítico, los rebaten para concluir que ello no se da, al igual que los probables efectos neurológicos o efectos en la reproducción de humanos.

11 Sobre los efectos del glifosato en organismos ambientales (sic) no objetivo (página 72 y siguientes).

Al igual que en los casos anteriores, los autores presentan evidencias sobre efectos negativos del herbicida, pero todas acompañadas de sus respectivas glosas o críticas y al final terminan desvirtuándolas por diferentes razones (dosis estudiadas irreales, metodologías inadecuadas, pocos muestreos o casos) y rechazando sus conclusiones. Así sucede con invertebrados y microorganismos del suelo y con vertebrados e invertebrados terrestres. Cuando se admite algún efecto negativo del glifosato (por ejemplo sobre algunas aves), se indica que tales efectos son relativamente pequeños o que los organismos afectados se recuperan rápidamente (p.76). Al final admiten algunos efectos negativos sobre ranas.

Sería recomendable que los autores consideraran con mayor seriedad los reportes que critican tanto al glifosato técnico como a los coadyuvantes y a los productos comerciales (Round – up). Por considerarlo de interés, se adjunta el Anexo A que contiene el análisis del consultor Jeremy Bigwood contratado por el gobierno ecuatoriano en 2002 sobre efebos nocivos del glifosato y un listado bibliográfico de 207 referencias que el mismo autor recopiló sobre el tema.

Aunque no es la intención de este escrito realizar análisis detallados sobre la bibliografía existente (trabajo que se les encomendó a los expertos de la OEA.) transcribimos el *Abstract* de un reciente estudio realizado por Relyea (2005) que describe efectos deletéreos del glifosato sobre algunas especies acuáticas:

UNIVERSIDAD NACIONAL DE COLOMBIA
SEDE BOGOTÁ
INSTITUTO DE ESTUDIOS AMBIENTALES -IDEA-

The Impact of Insecticides and Herbicides on the Biodiversity and Productivity of Aquatic Communities

RICK A. RELYEA /

Ecological Applications v.15, n.2 1 apr 2005

[More on Roundup | Response to Monsanto's Concerns on this Study by Dr. Relyea 1apr2005]

Abstract. Pesticides constitute a major anthropogenic addition to natural communities. In aquatic communities, a great majority of pesticide impacts are determined from single-species experiments conducted under laboratory conditions. Although this is an essential protocol to rapidly identify the direct impacts of pesticides on organisms, it prevents an assessment of direct and indirect pesticide effects on organisms embedded in their natural ecological contexts. In this study, I examined the impact of four globally common pesticides (two insecticides, carbaryl [Sevin] and malathion; two herbicides, glyphosate [Roundup] and 2,4-D) on the biodiversity of aquatic communities containing algae and 25 species of animals.

Species richness was reduced by 15% with Sevin, 30% with malathion, and 22% with Roundup, whereas 2,4-D had no effect. Both insecticides reduced zooplankton diversity by eliminating cladocerans but not copepods (the latter increased in abundance). The insecticides also reduced the diversity and biomass of predatory insects and had an apparent indirect positive effect on several species of tadpoles, but had no effect on snails. The two herbicides had no effects on zooplankton, insect predators, or snails. Moreover, the herbicide 2,4-D had no effect on tadpoles. However, **Roundup completely eliminated two species of tadpoles and nearly exterminated a third species, resulting in a 70% decline in the species richness of tadpoles.** This study represents one of the most extensive experimental investigations of pesticide effects on aquatic communities and offers a comprehensive perspective on the impacts of pesticides when nontarget organisms are examined under ecologically relevant conditions.

Key words: amphibian decline; Anax junius; Bufo americanus; Daphnia; Dytiscus; *frogs;* Hyla versicolor; Lestes; Pseudacris crucifer; Rana pipiens; Rana sylvatica; Tramea.

[1] E-mail: **relyea@pitt.edu** *Department of Biological Sciences, 101 Clapp Hall, University of Pittsburgh, Pittsburgh, Pennsylvania 15260 USA*

Key words: amphibian decline; *Anax junius*; *Bufo americanus*; *Daphnia*; *Dytiscus*; frogs; *Hyla versicolor*; *Lestes*; *Pseudacris crucifer*; *Rana pipiens*; *Rana sylvatica*; *Tramea.*
Manuscript received 27 October 2003; revised 11 June 2004; accepted 2 July 2004; final version received 30 July 2004. Corresponding Editor: J. A. Logan .

El documento completo de este artículo puede conseguirse en la revista y en la dirección electrónica indicada. Lo transcribimos porque resulta ser un buen ejemplo de un trabajo serio sobre los efectos negativos del glifosato. Trabajos como estos pudieron también haber sido utilizados en la revisión de literatura que realizaron los autores.

12 Sobre efectos del glifosato y el Cosmo –Flux en los mamíferos.

Los autores plantearon una serie de experimentos bien diseñados y controlados con ratas para toxicidad oral aguda, en dosis única, encontrando anormalidades clínicas (p.87) en algunos casos y en otros no; para toxicidad aguda por inhalación en distintos tiempos (con resultados diferentes); para toxicidad aguda térmica (registro de anormalidades clínicas). Se utilizaron conejos para las pruebas de irritación de la piel (resultados contrastantes) y de los ojos (resultados contrastantes, aunque se acepta que la formulación estudiada es irritante para piel y ojos de conejos).

Lo que llama la atención es que, con base en estas pruebas efectuadas sobre ratas, conejos y cobayos, los autores extrapolen los resultados y afirmen que "...el riesgo para personas por la aplicación del glifosato o por su presencia en el área objeto de aspersión se considera mínimo....". Con los datos obtenidos, lo que ellos sí pueden afirmar lícitamente es que tales efectos se presentaron o no en conejos, ratas y cobayos...pero nada más!. Ni siquiera es lícito extrapolar tal información para el conjunto de los mamíferos (página 100) o las aves silvestres (página 104).

Aún así, los autores aceptan "irritación ligera a moderada de piel y ojos...". ¿Es esto o no un riesgo para la salud humana?.

13 A manera de síntesis

- Varias de las conclusiones a las que llegan los autores no se pueden extraer de los mismos datos presentados por ellos, especialmente porque se trata de suposiciones y no de mediciones reales en campo. Ello es importante especialmente en lo que concierne a la salud humana.

- Los expertos de la OEA desestimaron varios estudios y no consultaron otros de la abundante bibliografía sobre el tema, que hubieran podido incidir en sus propias conclusiones.

- Los autores centraron sus esfuerzos en buscar efectos en compartimentos ecosistémicos en donde se supone que son menores y no en los compartimentos ecosistémicos en donde tales efectos son directos y fáciles de estudiar: destrucción de biodiversidad, eliminación de cultivos lícitos y erosión de suelos.

- Al desechar del estudio los efectos económicos y sociales, no es lícito que los autores utilicen el término "ambiental", porque se ha excluido deliberadamente a la población, que es el actor más importante de la dimensión ambiental. Se sugiere, en consecuencia, que los autores modifiquen el título de su estudio.

- Colombia es quizás, el único país del mundo en donde existen más de 8.000 personas que se han quejado por diversos efectos de las fumigaciones. Es con ellos y para ellos que se debieran realizar los estudios sobre efectos nocivos en salud, animales domésticos, cultivos lícitos y ecosistemas. Las bases de datos de la Defensoría del Pueblo y de la Dirección Nacional de Estupefacientes, contienen

abundante información que podría utilizarse en este caso. Además, los futuros estudios deberían contar con su participación, no sólo en la definición y caracterización de impactos ambientales, sino en la búsqueda conjunta de soluciones a este compleja problemática planteada por los cultivos de uso ilícito.

ANNEX 152

Bibliografía citada

Angel, M.A. 1993. La trama de la vida. Bases ecológicas del pensamiento ambiental. Ed. Dirección General de Capacitación del Ministerio de Educación Nacional - Instituto de Estudios Ambientales (IDEA) Universidad Nacional de Colombia. Bogotá. 77 p.

Angel, M.A. 1995. La fragilidad ambiental de la cultura. Ed. Universidad Nacional de Colombia. Bogotá. 127 p.

Angel, M.A. 1996. El reto de la vida. Ecosistema y cultura Una introducción al estudio del medio ambiente. Ed. Ecofondo. Bogotá. 109 p.

Carrizosa, J. 1996. La evolución del debate sobre el desarrollo sostenible. En: La Gallina de los huevos de oro: debate sobre el concepto de desarrollo sostenible. Libro ECOS No 5. Ed. CEREC - ECOFONDO. pp 44 - 68.

Carrizosa, J. 2003. Colombia de lo imaginario a lo complejo. Reflexiones y notas acerca de ambiente, desarrollo y paz. Universidad nacional de Colombia – Instituto de Estudios Ambientales. 203 p.

EPA, 2002. Informe de Temas Relacionados con la Erradicación Aérea de Coca Ilícita en Colombia. Respuesta del Administrador Asistente de la EPA Johnson al Secretario de Estado, 19 de agosto de 2002. Publicado por el la Oficina para Asuntos Internacionales de Narcóticos y Ejecución de la Ley (INL) del Departamento de Estado, septiembre de 2002. Agencia de Protección Ambiental de los Estados Unidos Washington, D.C. 20460 Oficina de Prevención, Pesticidas y Sustancias Tóxicas. http://bogota.usembassy.gov/wwwfepag.pdf

Gentry, A. H. 1993. El significado de la biodiversidad. En: Cárdenas, S. y H.D. Correa (Eds.) Nuestra Diversidad Biológica. Fundación Alejandro Escobar, Colección María Restrepo de Angel, CEREC. Bogotá.

Luengas, C. 2005. Análisis socioambiental de las quejas por daños debido a las fumigaciones aéreas con glifosato en el marco del programa de erradicación de cultivos de uso ilícito

Miller, T.G. 1994. Ecología y Medio Ambiente. Ed. Grupo Editorial Iberoamérica. México. D.F. 875 p.

Morgan, R.P.C. 1986. Soil erosion and conservation. Ed: Longman Scientific and technical. UK. 298 p.

Mosquera, L. 1985. Examen y descripción de los suelos en el campo. Instituto Geográfico "Agustín Codazzi". 95 p.

PROGRAMA DE NACIONES UNIDAS PARA EL DESARROLLO (PNUD). 1990. Nuestra Propia Agenda. Ed: Banco Interamericano de Desarrollo- PNUD. Bogotá. 103 p.

Richard, Sophi. *et al*. 2005. Differential effects of glyphosate and roundup on human placental sells and aromatase. The National Institute of Environmental Health Sciences. National Institutes of health. U.S. Department of Health and Human Services. Environmental Health Perspectives.

Sachs W. 1996. La anatomía política del desarrollo sostenible. En: La Gallina de los huevos de oro: debate sobre el concepto de desarrollo sostenible. Libro ECOS No 5. Ed. CEREC-ECOFONDO. pp 15-43.

Sisk, T. D. *et al.* 1994. Identifying extintion threats. BioScience (44): 592 – 604.

Tamames, R. 1980. Ecología y Desarrollo. La polémica sobre los límites al crecimiento. Ed: Alianza. Madrid. 207 p.

Uribe, G., Melo, O., Salcedo, M., Céspedes, J. Santodomingo, T. Gastelbando, Y., Hernández, C. 2001. Supuestos efectos del glifosato en la salud humana. Clínica de toxicología Uribe Cualla. 60 p.

ANNEX 152

UNIVERSIDAD NACIONAL DE COLOMBIA
SEDE BOGOTÁ
INSTITUTO DE ESTUDIOS AMBIENTALES -IDEA-

UN RESUMEN BREVE DE LA LITERATURA CIENTÍFICA CON RESPETO A LOS EFECTOS NOCIVOS DE FORMULACIONES QUE CONTIENEN GLIFOSATO EN BIOTAS ACUÁTICAS Y SUELOS.

Para el Ministerio del Ambiente del Ecuador

6 de marzo, 2002

Jeremy Bigwood, Asesor Técnico

Antecedentes:

El Gobierno del Ecuador ha solicitado al gobierno de Colombia implementar una franja de seguridad de 10 kilómetros al lado de la frontera dentro del territorio colombiano para proteger a Ecuador de posibles daños ecológicos que pueden resultar de las fumigaciones (aspersiones químicas) del programa de erradicación que actualmente está siendo conducido por los gobiernos de Colombia y los Estados Unidos en contra de cultivos ilícitos. La solicitud del Gobierno ecuatoriano resulta después de una serie de artículos publicados en la prensa, denuncias individuales y comunidades de ciudadanos de la zona fronteriza (e incluyendo una demanda en una corte federal en los Estados Unidos) que afirman que aviación de la República de Colombia y de los Estados Unidos habían fumigado en territorio ecuatoriano o en lugares muy cercanos. Entre los reportes de daños ocasionados por las fumigaciones en Colombia existen informes sobre la muerte de peces y otra vida acuática, así como daños a cultivos lícitos, bosques vírgenes y fauna, incluso, aunque todavía no probado, daño a la salud humana. Dado el hecho de que muchos ríos pasan desde Colombia a Ecuador, y que haya reportes de fumigaciones encima de cuerpos de agua en Colombia, el Gobierno ecuatoriano ha expresado su debida preocupación sobre los posibles efectos nocivos que podrían generarse en el medio ambiente y la población ecuatorianos.

Miembros del Gobierno ecuatoriano también están alarmados sobre el hecho de que antes de iniciar las fumigaciones, ni el Gobierno de Colombia ni el Gobierno de los Estados Unidos (el cual suministra los equipos y tiene un rol muy activo en estas operaciones) ha hecho investigaciones sobre los efectos ambientales de las varias formulaciones que han estado utilizando sobre los ecosistemas más diversos de Colombia. Tal uso masivo de unas formulaciones de herbicidas no investigadas y la continua substitución de una formulación por otra no estaría permitido en los Estados Unidos ni en la mayoría de los países del mundo. Como resultado de esta utilización masiva de una formulación no estudiada y la falta de investigación, Ecuador podría estar enfrentando un peligro de proporciones no conocidas.

Aunque no ha habido ningún estudio sobre las formulaciones actuales que están utilizando en los ecosistemas y biota compartidos por el sur de Colombia y la región norteña fronteriza de Ecuador, existe una amplia gama de investigaciones en la literatura científica con respecto a la toxicidad de ALGUNOS de los compuestos presentes en las formulaciones que los gobiernos de Colombia y los Estados Unidos nos afirman que están utilizando. Esta literatura puede estar dividida en tres secciones: 1) los efectos sobre biotas acuáticas como ríos; 2) los suelos; e 3) insectos. En este informe nosotros no vamos a considerar los posibles efectos nocivos en los seres humanos, [39, 187, 188] puesto que Ecuador espera que los gobiernos de Colombia y los Estados Unidos se van a

abstener de fumigar dentro del territorio ecuatoriano y zonas aledañas a la frontera.

Se debe recalcar que no han habido investigaciones científicas en Colombia con respecto a las formulaciones que han utilizado en el pasado ni a las formulaciones que emplean actualmente. Además sabemos que hay una intención de cambiar dentro de unos meses la formulación de ahora y utilizar otra que tampoco ha sido investigada. Dada esta situación, sólo podemos analizar los efectos de ALGUNOS de los ingredientes de las formulaciones usadas hoy en día. También, debemos destacar que, con la excepción de unos pocos estudios, como uno de Nigeria,[128] la mayoría de las investigaciones han sido producidas en zonas templadas como las del norte de Europa, Canadá, y Los Estados Unidos. Aún así, estos estudios muestran que algunos de los ingredientes de las formulaciones que están siendo actualmente asperjadas en Colombia pueden causar efectos nocivos significativos en la vida acuática, incluyendo peces, anfibios, en el contenido de los suelos, y en los insectos. Hasta que se hayan realizado investigaciones imparciales por actores neutrales sobre las formulaciones actuales (y las del pasado, así como las que han sido propuestas para el futuro), sólo podemos concluir que las fumigaciones representan una amenaza clara y presente para al medio ambiente ecuatoriano.

Efectos en sistemas acuáticos:

Mientras la persistencia de glifosato en agua es menor que su persistencia en suelos, éste ha sido extraído de suelos unos 12 hasta 60 días después de su aplicación.[39, 67, 68] Pero formulaciones como "Roundup" que contiene glifosato y -que también contienen un surfactante - son más peligrosos que glifosato en sí en sistemas acuáticos. Los efectos de Roundup (glifosato y surfactante) en biotas acuáticas son tan serios que la misma Monsanto - la compañía que produce Roundup - prohíbe el uso cerca o encima de cuerpos de agua. En Colombia han registrado incidentes de operaciones de piscicultura en lagos y estanques, proyectos que se desarrollan con el apoyo de la GTZ y que fueran completamente destruidos por las fumigaciones con formulaciones de glifosato. La toxicidad de estas formulaciones de glifosato en ríos no esta solamente limitada a peces, sino a anfibios, insectos, invertebrados (incluyendo crustáceos) y sin duda otras especies encontradas en ríos y otros cuerpos de agua. [2, 4, 19, 39, 205, 206, 207] Uno de los problemas más serios de las formulaciones de glifosato utilizadas en Colombia es que algunos de los ingredientes son por sí mismos más tóxicos a la vida acuática que el mismo glifosato. Además, en la combinación que se utiliza en las fumigaciones, la suma de éstos tienen un efecto aditivo de toxicidad. [2] Aquí debemos citar el sumario de Abdelghani *et al.*: [2]

"La toxicidad aguda de tres herbicidas como simples y mezclas (2,4-D, Garlon-3A, y Roundup) y un aditivo químico (el surfactante Syndets) fue evaluada utilizando tres especies de organismos acuáticos de agua dulce ("channel" siluro [bagre], Ojón "bluegill", y jaiba de río [cangrejo]). Entre las tres herbicidas, Roundup fue más tóxico a siluros (bagres) y Ojón "bluegill" que Garlon-3A y 2,4-D. El orden de toxicidad en peces (Roundup Garlon-3A 2,4-D) fue invertido en los bioensayos con jaibas de río (cangrejo), respectivamente. Para el surfactante "Syndets," las CL_{50} valores de 1.9 mg/L ("bluegill" Ojón), 2.3mg/L (siluro [bagre]), and 15.2 mg/L (jaiba de río [cangrejo]) fueron notados, indicando que este aditivo químico fue mucho más tóxico que los tres herbicidas..."[2 a]

[a] Incluimos la información sobre el surfactante Syndets porque en el caso de la fumigación en Colombia, han habido muchos cambios en las formulaciones utilizados, incluyendo cambios en los surfactantes.

Distintas especies de peces tienen distintos grados de vulnerabilidad a glifosato (y por supuesto, los otros aditivos),[185] y la cantidad de minerales disueltos en el agua,[206] y la temperatura del agua [205] también juega un rol en la regulación de su toxicidad.

En investigaciones conducidas en Australia, la formulación Roundup han demostrado una seria toxicidad a anfibios. En un estudio comisionado en 1995 por el Western Australian Department of Environmental Protection (DEP) y dirigido por el Dr. Joseph Bidwell del Curtin Exotoxicology Program concluyó que Roundup 360 (otra formulación de Roundup que contiene glifosato y surfactantes) puede ser agudamente tóxico a ranas adultas y renacuajos en las tasas de aplicación recomendadas (1.8 to 5.4kg/ha). Roundup 360 fue más tóxico a ranas y renacuajos que el grado técnico de glifosato solo. Fue asumido que el surfactante de Roundup, y no glifosato en sí, hubo causado el incremento en toxicidad.[4,19] Hay que notar que es precisamente el mismo surfactante (POEA) que se encuentra en el Roundup utilizado en Colombia.

La toxicidad de formulaciones de glifosato a biotas acuáticas está muy bien establecida, y éste es el tema más importante para Ecuador pues muchos ríos de origen colombiano fluyen al sur, entrando en territorio ecuatoriano. En la ausencia de investigación científica sobre, entre otras cosas, las concentraciones y los efectos de las formulaciones de glifosato en tanta variedad de ecosistemas, la República del Ecuador debe continuar su cauteloso y moderado enfoque y seguir solicitando una franja de seguridad de 10 kilómetros dentro de la República de Colombia.

Efectos en los suelos:

Los suelos están formados por miles de microbios y organismos invertebrados con formas de vida animal más complejas. Raíces de plantas y árboles, semillas y varios hongos son una gran parte de estos microhábitats.

> "Los microorganismos de los suelos juegan un papel extensivo en la descomposición de materia orgánica y la producción de humus, el reciclaje de nutrientes y energía y la fijación elemental, metabolismo de los suelos y la producción de compuestos que causan la formación de agregados. Muchos microorganismos están en relaciones simbióticas con plantas y animales, sirviéndoles como fijadores de nitrógeno en el primer caso y microbios del los intestinos en el segundo. Ellos funcionan como una parte substancial de la red alimenticia.
>
> Entre los microorganismos que se encuentra en el suelo son bacterias, actinomicetes, hongos, micro-algas, protozoos, nemátodos, y otros invertebrados (más que todo artrópodos)."[51]

Los efectos de los surfactantes y otros aditivos utilizados en las formulaciones de aspersión aparentemente no han sido investigados en suelos, ni tampoco los efectos de

---

Actualmente, se afirma que se están utilizando uno o dos surfactantes adicionales agregados al Roundup (que ya contiene un surfactante). Uno de estos se llama Cosmoflux IND. Desconocemos exactamente cuál es la naturaleza química de Cosmoflux, pero esperamos que no sea el mismo ingrediente que se encuentra en Syndets.

las formulaciones bien conocidas como "Roundup". Pero el glifosato como químico aparte sí ha sido investigado. El glifosato ha sido fabricado para ser aplicado directamente a las hojas de las plantas, pero "aunque el glifosato no está directamente aplicado a los suelos, una concentración significativa del compuesto puede llegar al suelo durante una aplicación."[74] Los estudios de efectos de glifosato en suelos pueden ser divididos en cuatro categorías: 1) nemátodos (lombrices de todo tamaño); 2) el aumento de hongos patogénicos; 3) la interferencia con las relaciones micorrizales entre los hongos, nutrientes y plantas; y, 4) los efectos en los microbios.

El glifosato tiene efectos negativos en nemátodos y otras lombrices e invertebrados. [48, 156] Una investigación en Nueva Zelandia mostró que el glifosato tenía efectos significativos en el crecimiento y sobrevivencia de lombrices comunes del suelo.[39, 200]

El glifosato aumenta el crecimiento de hongos patogénicos según muchas investigaciones publicadas en la literatura científica. Como resultado, éstos hongos predominan en una área para liberar sus propias toxinas (micotoxinas), que son tóxicas para muchas de las otras formas de vida cercanas, incluso mamíferos. O sea, en este caso, estamos hablando de un efecto secundario de toxicidad. Uno de los géneros que tiende a aumentarse en presencia de glifosato es el género *Fusarium*, [47, 82, 101, 102, 103, 144, 157, 183, 186] el cual hasta septiembre 2002, iba a ser utilizado por el gobierno de los Estados Unidos como un bioherbicida (micoherbicida) en Colombia con el fin de erradicar la coca, pero esta propuesta fue rechazada por el Comité Andino de Autoridades Ambientales (CAAAM) y el presidente Clinton. Especies del género *Fusarium* han sido responsables en todo el mundo por daños serios a muchos cultivos, suelos envenenados, defectos de nacimientos en seres humanos, y en un caso documentado, la muerte de miles de personas causadas por sus micotoxinas cuando éstas comieron cereales contaminados durante los últimos años de la Segunda Guerra Mundial.[199]

La interferencia de glifosato en las relaciones micorrizales entre hongos, nutrientes y plantas fue publicado recientemente en 1998. La relación micorrizal es una asociación simbiótica entre el micelio (el cuerpo celular) de un hongo, especialmente un basidiomicete (champiñón) con las raíces de algunos plantas y árboles donde el micelio del hongo forma una estrecha cobertura tejida envolviendo las raicillas o hasta penetrando las células de las raíces. Esta relación provee un intercambio de nutrientes y agua que beneficia tanto a la planta como al hongo. En una investigación hecha por un equipo canadiense dirigido por el científico M.T. Wan,[183] el efecto nocivo de glifosato fue casi tan tóxico en el hongo simbiótico *Glomus intraradices* en raíces de zanahoria como el reconocido pero ya prohibido fungicida tóxico benomyl (lo cual fue el tema de una demanda exitosa de una compañía Ecuatoriana en contra de la multinacional Dupont). Dado que muchas plantas no pueden crecer sin esta relación micorrizal, este es un efecto posible de las fumigaciones con glifosato que debemos considerar.

El glifosato también tiene efectos sobre los microbios de los suelos. Wan et al., trabajando en Texas A & M University reportaron que "la evolución de CO_2 incrementó cuando se incrementaba la tasa de glifosato... El glifosato estimuló de una manera significativa la actividad microbial medida por la mineralización de Carbono y Nitrógeno." [74, 165] También se ha mostrado que el glifosato puede reducir la habilidad de ciertas bacterias para fijar nitrógeno.[39, 201]

Para resumir, existe bastante documentación sobre los claros efectos de glifosato

en la biota y ecología de los suelos que viene de estudios ya conocidos en otras partes del mundo, y es probable que más efectos nocivos van a ser presentados mientras que el tema siga siendo estudiado.

Efectos sobre insectos benéficos:

Una de las quejas que se presentaron con respeto al programa de fumigación con Roundup (más surfactantes), que el gobierno de los Estados Unidos llevó a cabo para eliminar cultivos de amapola en Guatemala, fue que se había destruido la apicultura en las zonas cercanas a las aspersiones. "Aunque el programa de fumigación tuvo un efecto mínimo en los cultivos de amapola, según los campesinos locales, se destruyó la base tradicional de la producción en la región, en particular tomates y abejas." [202, 203] Como resultado de las presiones de ambientalistas y otros, el programa de fumigación fue suspendido y ahora el cultivo de amapola en Guatemala está controlado gracias a la erradicación manual. Investigaciones realizadas por la International Organization for Biological Control coinciden con los efectos reportados en Guatemala sobre las abejas; también muestran que existen efectos sobre otros insectos benéficos.

Según estos estudios, se demostró que la exposición de los insectos a una formulación comercial de Roundup (glifosato más surfactantes), provocó tasas de mortalidad mayores al 50% en insectos benéficos, incluyendo avispas parasítoides, crisopos, y mariquitas. El nivel de mortalidad fue aún más alto para un tipo de escarabajo depredador.[204]

Monitoreo y análisis químico:

Mientras que existen varias metodologías para la recolección y análisis de ALGUNOS de los componentes de las formulaciones que están siendo asperjadas en Colombia, en agua dulce o suelos, sin embargo todas requieren equipos científicos relativamente avanzados en combinación con personal bien entrenado. Además, esto requeriría un sistema con estaciones de monitoreo a lo largo de la zona fronteriza, especialmente en los ríos que tienen sus orígenes en Colombia.[1, 2, 3, 7, 8, 16,22, 23, 25, 27, 28, 30, 31, 37, 54, 59, 63, 67, 69, 70, 73, 79, 85, 86, 92, 107, 108, 109, 111, 124, 125, 126, 127, 132, 135, 136, 138, 139, 165, 166, 167, 171, 174, 178, 180, 181, 184, 185, 187] Para desarrollar un sistema de esta naturaleza se necesitaría contar con bastantes fondos, y bajo las condiciones actuales esta parece ser una propuesta poco viable. Pero, en el caso ideal que se logre conseguir el apoyo financiero para un monitoreo, aparte de todo lo que implica hacer los análisis de aguas y suelos, sería preciso que los siguientes "organismos indicadores" sean monitoreados:

Organismos indicadores

Plantas acuáticas, tales como algas verdes
Invertebrados acuáticos, tales como chinches de agua
Peces, tales como Tilapia o siluro
Anfibios, tales como ranas
Bacterias de suelos, fijadoras de nitrógeno
Invertebrados del suelo, tales como las lombrices
Plantas terrestres
Aves
Mamíferos

UNIVERSIDAD NACIONAL DE COLOMBIA
SEDE BOGOTÁ
INSTITUTO DE ESTUDIOS AMBIENTALES -IDEA-

Resumen:

Basándose en los estudios antes referenciados, es muy probable que por lo menos algunos de los ingredientes de las formulaciones utilizadas en Colombia causen efectos nocivos en las biotas acuáticas, incluyendo peces, anfibios e insectos, así como en el contenido y función de los suelos. Dado que la ciencia todavía no ha podido catalogar la mayoría de las especies ni aún en un pequeño porcentaje de los ecosistemas colombianos o ecuatorianos, la fumigación fácilmente puede eliminar toda una nueva especie sin darnos cuenta siquiera de que han existido. Este hecho claramente puede amenazar la futura explotación del Ecuador de su propio patrimonio , en biota y biodiversidad. Hasta que haya pruebas contundentes basadas en investigaciones científicas imparciales por actores neutrales que demuestren sin duda alguna que las aspersiones aéreas masivas usadas actualmente son inocuas para nuestros ecosistemas compartidos - una proposición no tan probable, -de acuerdo a las investigaciones consultadas- sólo podemos concluir que existe una verdadera posibilidad de efectos nocivos de las fumigaciones en el medio ambiente ecuatoriano. Expuesta ésta situación, Ecuador debe protegerse con una franja de seguridad de al menos diez kilómetros para garantizar a sus ciudadanos que los posibles efectos nocivos generados como resultado de los herbicidas químicos asperjadas masivamente vía aérea se disipan dentro territorio Colombiano.

Referencias:

1) Abdel-Hamid, M.I. Development and application of a simple procedure for toxicity testing using immobilized algae. Hazard assessment and control of environmental contaminants in water: selected proceedings of the 2nd IAWQC International Specialized Conference on Hazard Assessment and Control of Environmental Contaminants in Water held in Lyngby, Denmark, 29-30 June 1995 /1996 Water science and technology 0273-1223; v. 33, no. 6 p. 129-138.

2) Abdelghani, A.A. Toxicity evaluation of single and chemical mixtures of Roundup, Garlon-3A, 2,4-D, and Syndets surfactant to channel catfish (*Ictalurus punctatus*), bluegill sunfish (*Lepomis michochirus*), and crawfish (*Procambarus* spp.). Environmental toxicology and water quality. 1997. v. 12 (3) p. 237-243.

3) Abdullah, M.P. Improved method for the determination of glyphosate in water. Journal of Chromatography. A. Apr 21, 1995. v. 697 (1/2) p. 363-369.

4) Acute toxicity of a herbicide to selected frog species: final report / prepared by Joseph R. Bidwell and John R. Gorrie. Perth [W.A.] : Western Australian Dept. of Environmental Protection, 1995, p. 9

5) Adkins, S.W. The influence of soil moisture content on glyphosate efficacy for the control of annual grasses in fallow land. Weed Research. April 1998. v. 38 (2) p. 119-127.

6) Adkins, S.W. Influence of environmental factors on glyphosate efficacy when applied to *Avena fatua* or *Urochloa panicoides*. Weed Research. Apr 1998. v. 38 (2) p. 129-138.

7) Alferness, P.L. Determination of glyphosate and (aminomethyl)phosphonic acid in soil, plant and animal matrices, and water by capillary gas chromatography with mass-selective detection. Journal of Agricultural and Food Chemistry. Dec 1994. v. 42 (12) p. 2751-2759.

8) Anton, F.A. Degradational behavior of the pesticides glyphosate and diflubenzuron in water. Bulletin of environmental contamination and toxicology. Dec 1993. v. 51 (6) p. 881-888.

ANNEX 152

9) Arnaud, L. Physiological behavior of two tobacco lines expressing EPSP synthase resistant to glyphosate. Pesticide biochemistry and physiology Oct 1998. v. 62 (1)p. 27-39.

10) Arnaud, L. Penetration and effects of glyphosate in isolated potato mitochondria. Phytochemistry. Jan 1993. v. 32 (1) p. 9-14.

11) Atkinson, P.R. Associations between host-plant nitrogen and infestations of the sugarcane borer, *Eldana saccharina* Walker (Lepidoptera: Pyralidae). Sept 1989. v. 79 (3) Bulletin of entomological research. p. 489-506.

12) Aust, W.M. Removal of floodwater sediments by a clearcut tupelo-cypress wetland. Jan/Feb 1991. v. 27 (1) Water resources bulletin. p. 111-116.

13) Aust, W.M. Soil temperature and organic matter in a disturbed forested wetland. Nov/Dec 1991. v. 55 (6) Soil Science Society of America journal. p. 1741-1746.

14) Bailey, B.A. Factors influencing the herbicidal activity of Nep1, a fungal protein that induces the hypersensitive response in *Centaurea maculosa*. Weed Science Nov/Dec 2000. v. 48 (6)p. 776-785.

15) Barron, P.P. Second-year weed control for direct seeding of *Eucalyptus porosa* in a low rainfall environment. Australian forestry. June 1998. v. 61 (2)p. 155-158.

16) Bauer, K.H. Analysis of polar organic micropollutants in water with ion chromatography-electrospray mass spectrometry. Journal of chromatography. A.Apr 2, 1999. v. 837 (1/2)p. 117-128.

17) Bell, G.P. Ecology and management of Arundo donax, and approaches to riparian habitat restoration in southern California. Plant invasions : studies from North America and Europe / p. 103-113.

18) Bergvinson,-D.J.; Borden,-J.H. Enhanced colonization by the blue stain fungus *Ophiostoma clavigerum* in glyphosate-treated sapwood of lodgepole pine. Can-J-For-Res-J-Can-Rech-For. Ottawa, Ont. : National Research Council of Canada. Feb 1992. v. 22 (2) p. 206-209.

19) Bidwell,-Joseph-R.; Gorrie,-John-R. Western Australia. Dept. of Environmental Protection. Acute toxicity of a herbicide to selected frog species : final report. Technical series no. 79. Perth [W.A.] : Western Australian Dept. of Environmental Protection, 1995. 9 p.

20) Blackshaw, R.E. Species, herbicide and tillage effects on surface crop residue cover during fallow. Canadian Journal of Soil Science. Nov 1995. v. 75 (4)p. 559-565.

21) Blum, U. Effects of clover and small grain cover crops and tillage techniques on seedling emergence of some dicotyledonous weed species. American journal of alternative agriculture.1997. v. 12 (4)p. 146-161.

22) Borjesson,-E.; Torstensson,-L. New methods for determination of glyphosate and (aminomethyl) phosphonic acid in water and soil. J-Chromatogr-A. Amsterdam ; New York : Elsevier, 1993-. July 21, 2000. v. 886 (1/2) p. 207-216.

23) Bowmer, K.H. Glyphosate--sediment interactions and phytotoxicity in turbid water. Pesticide science. Apr 1986. v. 17 (2) p. 79-88.

24) Brandt, S.A. Management practices for black lentil green manure for the semi-arid Canadian prairies. Canadian journal of plant science. Jan 1999. v. 79 (1)p. 11-17.

25) Buhler,-D.D.; Burnside,-O.C. Effect of water quality, carrier volume, and acid on glyphosate phytotoxicity Post-emergence herbicides. Weed-Sci. Champaign : Weed Science Society of America. Mar 1983. v. 31 (2) p. 163-169. ill.

26) Bullied, W.J. Soil water dynamics after alfalfa as influenced by crop termination technique. Agronomy Journal. Mar/Apr 1999. v. 91 (2) p. 294-305.

27) Burns, V. F. A. D. Kelley Responses and residues in certain crops irrigated with water containing glyphosate Pullman : College of Agriculture Research Center, Washington State University, 1975.

Washington State University. College of Agriculture Research Center. Bulletin ; 812

28) Burns,-V-F Responses and residues in certain crops irrigated with water containing glyphosate / V. f. burns, A. D. Kelley. -- Washington State University. College of Agriculture Research Center. bulletin; 812 Pullman : College of Agriculture Research Center, Washington State University, 1975. 5, [1] p.

29) Busse,-M.D.; Ratcliff,-A.W. Non-target effects of glyphosate on soil microbes.
Proc-Annu-Calif-Weed-Sci-Soc. Fremont, CA: The Society, 1994-. 2000. (52nd) p. 146-150.

30) Carlisle, S.M. Effect of the herbicide glyphosate on respiration and hydrogen consumption in soil. Water, air, and soil pollution. Feb 1986. v. 27 (3/4) p. 391-401.

31) Carlisle, S.M. Effect of the herbicide glyphosate on nitrification, denitrification, and acetylene reduction in soil. Water, air, and soil pollution. June 1986. v. 29 (2) p. 189-203.

32) Carlson, K.L. Comparative phototoxicity of glyphosate, SC-0224, SC-0545, and HOE-00661. Weed science. Nov 1984. v. 32 (6) p. 841-844.
33) Carson, D.B. Biodegradation of N-phosphonomethyliminodiacetic acid by microorganisms from industrial activated sludge. Canadian Journal of Microbiology. Jan 1997. v. 43 (1) p. 97-101.

34) Chakravarty, P.; Chatarpaul,-L. Non-target effect of herbicides. I. Effect of glyphosate and hexazinone on soil microbial activity. Microbial population, and in-vitro growth of ectomycorrhizal fungi. Pestic-Sci. Essex : Elsevier Applied Science Publishers. 1990. v. 28 (3) p. 233-241.

35) Clegg, B.S. Development of an enzyme-linked immunosorbent assay for the detection of glyphosate. Journal of Agricultural and Food Chemistry. Dec 1999. v. 47 (12)p. 5031-5037.

36) Cogliastro, A. Effet des sites et des traitements sylvicoles sur la croissance, l'allocation en biomasse et l'utilisation de l'azote de semis de quatre especes feuillues en plantations dans le sud-ouest du Quebec. Canadian journal of forest research = Revue Canadienne de Recherche Forestiere. Feb 1993. v. 23 (2) p. 199-209.

37) Comes,-R-D; Bruns,-V-F; Kelley,-A-D Residues and persistence of glyphosate [N-(phosphonomethyl)glycine] in irrigation water [Herbicides] Weed-Sci, Jan 1976, 24 (1): 47-50.

38) Coret,-J.M.; Chamel,-A.R. Influence of some nonionic surfactants on water sorption by isolated tomato fruit cuticles in relation to cuticular penetration of glyphosate.
Pesticide Science. Essex: Elsevier Applied Science Publishers. 1993. v. 38 (1) p. 27-32.

39) Cox, C. Glyphosate. 2. Human Exposure and ecological effects.
Journal of pesticide reform: a publication of the Northwest Coalition for Alternatives to Pesticides. Winter 1995. v. 15 (4) p. 14-20.

40) Cuomo, G.J. Management of warm-season annual grass residue on annual ryegrass establishment and production. Agronomy Journal. July/Aug 1999. v. 91 (4) p. 666-671.

41) D'Anieri, P. Effect of water stress and phenology on glyphosate efficacy in forest trees. Proceedings - Southern Weed Science Society. 1987. (40) p. 208-215.

42) D'Anieri, P. Glyphosate translocation and efficacy relationships in red maple, sweetgum, and loblolly pine seedlings. June 1990. v. 36 (2) Forest Science. p. 438-447.

43) Dall'Armellina, A.A. Effect of watering frequency, drought, and glyphosate on growth of field bindweed (Convolvulus arvensis). Weed science. May 1989. v. 37 (3) p. 314-318.

44) Daniels, M.B. Water use efficiency of double-cropped wheat and soybean. May/June 1991. v. 83 (3) Agronomy Journal. p. 564-570.

45) Darkwa, E.O. Weed management on Vertisols for small-scale farmers in Ghana. International Journal of Pest Management. Oct/Dec 2001. v. 47 (4) p. 299-303.

ANNEX 152

46) Derr, J.F. Biological assessment of herbicide use in apple production. I. Background and current use estimates. Hort Technology. Jan/Mar 2001. v. 11 (1)p. 11-19.

47) Descalzo,-R.C.; Punja,-Z.K.; Levesque,-C.A.; Rahe,-J.E. Identification and role of Pythium species as glyphosate synergists on bean (*Phaseolus vulgaris*) grown in different soils. Mycol-res. [Cambridge : Cambridge University Press], 1989-. Aug 1996. v. 100 (pt.8) p. 971-978.

48) Dewar,-A.M.; Haylock,-L.A.; May,-M.J.; Beane,-J.; Perry,-R.N. Glyphosate applied to genetically modified herbicide-tolerant sugar beet and 'volunteer' potatoes reduces populations of potato cyst nematodes and the number and size daughter tubers. Ann-Appl-Biol. Warwick: Association of Applied Biologists. June 2000. v. 136 (3) p. 179-187.

49) Dick, R.E. Glyphosate-degrading isolates from environmental samples: occurrence and pathways of degradation. Applied microbiology and biotechnology. July 1995. v. 43 (3)
p. 545-550.

50) Dickson, R.L. Effect of water stress, nitrogen, and gibberellic acid on fluazifop and glyphosate activity on oats (*Avena sativa*). Jan 1990. v. 38 (1) Weed science. p. 54-61.

51) Dindal (ed.) Soil Biology Guide. 1990 John Wiley & Sons and Soil Microbial Ecology, F. Blaine Metting Jr. (ed.) 1993

52) Dissanayake,-N.; Hoy,-J.W.; Griffin,-J.L. Herbicide effects on sugarcane growth, *Pythium* root rot, and *Pythium arrhenomanes*. Phytopathology. St. Paul, Minn. : American Phytopathological Society, 1911-. June 1998. v. 88 (6) p. 530-535.

53) Donaldson, R.A. The effects of post-treatment moisture stress and varying amounts of applied nitrogen on the ripening responses of sugarcane to glyphosate and ethrel. 1986. (60th) Proceedings of the annual congress - South African Sugar Technologists' Association. p. 223-227.

54) Drinking water criteria document for glyphosate. Washington, D.C. : Health and Ecological Criteria Division, Office of Science and Technology, Office of Water, U.S. Environmental Protection Agency, [1992]

55) Eason, J.R. Reversal of glyphosate inhibition of Sandersonia aurantiaca flower senescence with aromatic amino acids. Postharvest Biology and Technology. Jan 2000. v.18(1)p. 81-84.

56) Eberlein, C.V. Corn growth and yield in an alfalfa living mulch system. July/Sept 1992. v. 5 (3) Journal of Production Agriculture. p. 332-339.

57) Elmore, R.W. Glyphosate-resistant soybean cultivar response to glyphosate. Agronomy Journal.Mar/Apr 2001. v. 93 (2)p. 404-407.

58) Estok,-D.; Freedman,-B.; Boyle,-D. Effects of the herbicides 2,4-D, glyphosate, hexazinone, and triclopyr on the growth of three species of ectomycorrhizal fungi. Bull-Environ-Contam-Toxicol. New York, N.Y. : Springer-Verlag. June 1989. v. 42 (6) p. 835-839.

59) Feller, M.C. Effects of forest herbicide applications on streamwater chemistry in southwestern British Columbia. June 1989. b v. 25 (3) Water resources bulletin. p. 607-616. maps.

60) Feng, P.C.C. Resistance to glyphosate in *Lolium rigidum*. II. Uptake, translocation, and metabolism. Weed Science July/Aug 1999. v. 47 (4)p. 412-415.

61) Feng, P.C.C. Analysis of surfactant leaf damage using microscopy and its relation to glyphosate or deuterium oxide uptake in velvetleaf (Abutilon theophrasti). Pesticide Science Mar 1999. v. 55 (3)p. 385-386.

62) Forlani,-G.; Mangiagalli,-A.; Nielsen,-E.; Suardi,-C.M. Degradation of the phosphonate herbicide glyphosate in soil: evidence for a possible involvement of unculturable microorganisms. Soil-Biol-Biochem. Oxford : Elsevier Science Ltd. July 1999. v. 31 (7) p. 991-997.

63) Friestad, H.O. Improved polarographic method for determination of glyphosate herbicide in crops, soil, and water. Journal of the Association of Offical Analytical Chemists. Jan/Feb 1985. v. 68 (1) p. 76-79. ill.

64) Gallagher, J.E. Irrigation pond weed control. Oct 1991. v. 26 (10) Grounds maintenance. p. 26, 28, 30, 50.

65) Gardner, S.C. Effects of Rodeo and Garlon 3A on nontarget wetland species in central Washington. Environmental toxicology and chemistry /Apr 1996. v. 15 (4) p. 441-451.

66) Gianfreda, L. Activity of free and immobilized urease in soil: effects of pesticides. Soil Biology & Biochemistry. June 1994. v. 26 (6) p. 777-784.

67) Goldsborough, L.G. Dissipation of glyphosate and aminomethylphosphonic acid in water and sediments of boreal forest ponds. Environmental Toxicology and Chemistry /July 1993. v. 12 (7) p. 1139-1147.

68) Goldsborough,-L.G.; Beck,-A.E. Rapid dissipation of glyphosate in small forest ponds.
Arch-Environ-Contam-Toxicol. New York, N.Y. : Springer-Verlag. July/Aug 1989. v. 18 (4) p. 537-544.

69) Green, J.M. Effect of nonylphenol ethoxylation on the biological activity of three herbicides with different water solubilities. Weed technology : a journal of the Weed Science Society of America.Oct/Dec 1999. v. 13 (4)p. 840-842.

70) Grunewald, K. Behavior of glyphosate and aminomethylphosphonic acid (AMPA) in soils and water of reservoir Radeburg II catchment (Saxony/Germany). Journal of Plant Nutrition and Soil Science = Zeitschrift fürPflanzenernΣhrung und Bodenkunde. Feb 2001. v. 164 (1) p. 65-70.

71) Haag, K.H. Effects of herbicide application on mortality and dispersive behavior of the water hyacinth weevils, *Neochetina eichhorniae* and *Neochetina bruchi* (Coleoptera: Curculionidae). Environmental entomology. Dec 1986. v. 15 (6) p. 1192-1198.

72) Hall, G.J. Plants as sources of cations antagonistic to glyphosate activity. Pest management Science. Apr 2000. v. 56 (4)p. 351-358.

73) Hallas, L.E. Glyphosate degradation by immobilized bacteria: field studies with industrial wastewater effluent. Apr 1992. v. 58 (5) Applied and environmental microbiology.
p. 1215-1219.

74) Haney,-R.L.; Senseman,-S.A.; Hons,-F.M.; Zuberer,-D.A. Effect of glyphosate on soil microbial activity. Proc-S-Weed-Sci-Soc. Raleigh, N.C., etc. Southern Weed Science Society. 1999. v. 52 p. 215.

75) Harvey, B.M.R. Pre-harvest retting of flax: effects of water stress on uptake and efficacy of glyphosate. Annals of Applied Biology. Aug 1988. v. 113 (1) p. 61-68.

76) Haughton, A.J. The effect of the herbicide glyphosate on non-target spiders. I. Direct effects on *Lepthyphantes tenuis* under laboratory conditions. Pest management science. Nov 2001. v. 57 (11) p. 1033-1036.

77) Hawkins, C. Artificial regeneration of spruce on cold, wet soil: 10 years along. Water, air, and soil pollution May 1995. v. 82 (1/2)p. 115-124.

78) Hetherington, E.D. Carnation Creek floodplain hydrology: September 1985 - September 1985. Mar 1989. (063) FRDA report. p. 27-44. ill.

79) Holmstrom, D. Residue management for potato rotation in Prince Edward Island. Journal of Soil and Water Conservation. First Quarter 1999. v. 54 (1) p. 445-448.
80) Hunter, J.H. Effect of nitrogen on the glyphosate-induced inhibition of rhizome bud growth in quackgrass (Elytrigia repens). Weed Science July/Sept 1993. v. 41 (3) p. 426-433.

81) Jean Legris ... [et al.] Concentrations résiduelles de glyphosate dans l'eau de surface en milieu forestier, suite α des pulvérisations terrestres, 1985. Québec: Gouvernement du Québec, Ministere de l'Énergie et des ressources, Direction de la Conservation, Service des Études environnementales, [1987]

82) Johal,-G.S.; Rahe,-J.E. Effect of soilborne plant-pathogenic fungi on the herbicidal action of glyphosate on

ANNEX 152

bean seedlings. Phytopathology. St. Paul, Minn.: American Phytopathological Society. Aug 1984. v. 74 (8) p. 950-955. ill.

83) Jordan, T.N. Enhanced postemergence herbicide efficacy with ultra-low volume.
Proceedings, Southern Weed Science Society.Southern Weed Science Society (U.S.) 1995. v. 48 p. 208-212.

84) Karakatsoulis, J. Comparison of the effects of chemical (glyphosate) and manual conifer release on conifer seedlings physiology and growth on Vedder Mountain, British Columbia.
Mar 1989. (063) FRDA report. p. 168-188. maps.

85) Kataoka,-H.; Ryu,-S.; Sakiyama,-N.; Makita,-M. Simple and rapid determination of the herbicides glyphosate and glufosinate in river water, soil and carrot samples by gas chromatography with flame photometric detection. J-Chromatogr-A. Amsterdam; New York: Elsevier, 1993-. Mar 1, 1996. v. 726 (1/2) p. 253-258.

86) Kataoka, H. Simple and rapid determination of the herbicides glyphosate and glufosinate in river water, soil and carrot samples by gas chromatography with flame photometric detection. Journal of chromatography. A. Mar 1, 1996. v. 726 (1/2) p. 253-258.

87) Kawate,-M.K.; Colwell,-S.G.; Ogg,-A.G.-Jr.; Kraft,-J.M. Effect of glyphosate-treated henbit (*Lamium amplexicaule*) and downy brome (Bromus tectorum) on *Fusarium solani* f.sp. *pisi* and *Pythium ultimum*. Weed-sci. Lawrence, KS : Weed Science Society of America. Sept/Oct 1997. v. 45 (5) p. 739-743.

88) Kawate,-M.K.; Kawate,-S.C.; Ogg,-A.G.-Jr.; Kraft,-J.M. Response of *Fusarium solani* f. sp. *pisi* and *Pythium ultimum* to glyphosate. Weed-Sci. Champaign, Ill.: Weed Science Society of America. July/Sept 1992. v. 40 (3) p. 497-502.

89) King, S.P. Herbicide tolerance in relation to growth and stress in conifers. Weed Science. July 1985. v. 33 (4) p. 472-478.

90) Klevorn, T.B. Effect of leaf girdling and rhizome girdling on glyphosate transport in quackgrass (Agropyron repens). Weed Science. Nov 1984. v. 32 (6) p. 744-750. ill.

91) Kneer, R. Characterization of the elicitor-induced biosynthesis and secretion of genistein from roots of *Lupinus luteus* L. Journal of Experimental Botany. Oct 1999. v. 50 (339) (p. 1553-1559.

92) Knyr, L.L. Transl: Determination of glyphosate in the water and soil by the methods of photometry and thin layer chromatography. Agrokhimiia. June 1984. (6) p. 109-112. ill.

93) Kreutzweiser, D.P. Drift response of stream invertebrates to aerial applications of glyphosate. Mar 1989. v. 42 (3) Bulletin of environmental contamination and toxicology. p. 331-338. maps.

94) Krzysko-Lupicka,-T.; Strof,-W.; Kubs,-K.; Skorupa,-M.; Wieczorek,-P.; Lejczak,-B.; Kafarski,-P. The ability of soil-borne fungi to degrade organophosphonate carbon-to-phosphorus bonds. Appl-microbiol-biotechnol. Berlin, Germany : Springer Verlag. Oct 1997. v. 48 (4) p. 549-552.

95) Krzysko-Lupicka,-T.; Orlik,-A. The use of glyphosate as the sole source of phosphorus or carbon for the selection of soil-borne fungal strains capable to degrade this herbicide.
Chemosphere. Kidlington, Oxford, U.K. : Elsevier Science Ltd. June 1997. v. 34 (12) p. 2601-2605.

96) Laroche, F.B. Managing melaleuca (*Melaleuca quinquenervia*) in the Everglades. Weed technology : a journal of the Weed Science Society of America.Oct/Dec 1998. v. 12 (4)p. 726-732.

97) Lautenschlager, R.A. Electrical conductivity of five concentrations of two glyphosate-containing herbicides. May 1991. v. 15 (2) Southern journal of applied forestry. p. 85-88.

98) Legris, Jean. Bilan des contr∫les environnementaux, suite α des pulvérisations de glyphosate en milieu forestier sur les terres publiques québécoises.[Québec] : Gouvernement du Québec, Ministére de l'Énergie et des ressources, Direction de la conservation, [1989]
99) Léveillé, Pierre et Jean Legris, Giséle Couture. Bilan des vérifications ponctuelles en milieu lotique et la suite de pulvΘrisations de glyphosphate en milieu forestier [Québec] : Service du suivi environnemental,

Ministére des foréts, [1993]

100) Levesque, C.A. Fungal colonization of glyphosate-treated seedlings using a new root plating technique. Mycological research. Mar 1993. v. 97 (pt.3) p. 299-306.

101) Levesque,-C.A.; Rahe,-J.E.; Eaves,-D.M. The effect of soil heat treatment and microflora on the efficacy of glyphosate in seedlings. Weed-Res. Oxford : Blackwell Scientific Publications. Oct 1992. v. 32 (5) p. 363-373.

102) Levesque,-C.A.; Rahe,-J.E.; Eaves,-D.M. Fungal colonization of glyphosate-treated seedlings using a new root plating technique. Mycol-Res. Cambridge : Cambridge University Press. Mar 1993. v. 97 (pt.3) p. 299-306.

103) Levesque,-C.A.; Beckenbach,-K.; Baillie,-D.L.; Rahe,-J.E. Pathogenicity and DNA restriction fragment length polymorphisms of isolates of Pythium spp. from glyphosate-treated seedlings. Mycol-Res. Cambridge : Cambridge University Press. Mar 1993. v. 97 (pt.3) p. 307-312.

104) Liu, L. Altered root exudation and suppression of induced lignification as mechanisms of predisposition by glyphosate of bean roots (*Phaseolus vulgaris* L.) to colonization by *Pythium* spp. Physiological and molecular plant pathology. Aug 1997. v. 51 (2)p. 110-127.

105) Mietkiewski,-R.T.; Pell,-J.K.; Clark,-S.J. Influence of pesticide use on the natural occurrence of entomopathogenic fungi in arable soils in the UK: field and laboratory comparisons. Biocontrol-sci-technol. Abingdon, Oxfordshire : Carfax Publishing Co,. Dec 1997. v. 7 (4) p. 565-575.

106) Mitchell, D.G. Seawater challenge testing of coho salmon smolts following exposure to Roundup herbicide. Environmental toxicology and chemistry. 1987. v. 6 (11) p. 875-878.

107) Mogadati, P.S. Determination of glyphosate and its metabolite, (aminomethyl) phosphonic acid, in river water. Journal of AOAC International.Jan/Feb 1996. v. 79 (1) p. 157-162.

108) Mogadati,-P.S.; Louis,-J.B.; Rosen,-J.D. Determination of glyphosate and its metabolite, (aminomethyl) phosphonic acid, in river water. J-AOAC-Int. Gaithersburg, MD : AOAC International. Jan/Feb 1996. v. 79 (1) p. 157-162.

109) Monnig, Edward [et al.] Treatability studies of pesticide manufacturing wastewaters : glyphosate. Research Triangle Park, N.C. : Industrial Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency ; Springfield, Va. : National Technical Information Service, 1980.

110) Msiska, H.D.C. Effects of seed treatment and environmental stress on germination of 'Sabine' Illinois bundleflower. 1989. v. 3 (Texas journal of agriculture and natural resources : a publication of the Agricultural Consortium of Texas. p. 2-5.

111) Munoz-Rueda, A. Effects of glyphosate N-(phosphonomethyl)-glycine on water potential, and activities of nitrate and nitrite reductase and aspartate aminotransferase in lucerne and clover. Journal of plant physiology. 1986. v. 123 (2) p. 107-115.

112) Nalewaja, J.D. 2,4-D and salt combinations affect glyphosate phytotoxicity. Apr/June 1992. v. 6 (2) Weed Technology: a journal of the Weed Science Society of America. p. 322-327.

113) Nalewaja, J.D. Optimizing adjuvants to overcome glyphosate antagonistic salts. Weed Technology : a journal of the Weed Science Society of America. Apr/June 1993. v. 7 (2)
p. 337-342.

114) Nalewaja, J.D. Spray carrier salts affect herbicide toxicity to kochia (Kochia scoparia).
Weed Technology : a journal of the Weed Science Society of America. Jan/Mar 1993. v. 7 (1)
p. 154-158.

115) Nalewaja,-J.D.; Matysiak,-R.; Freeman,-T.P. Spray droplet residual of glyphosate in various carriers. Weed-Sci. Champaign, Ill. : Weed Science Society of America. Oct/Dec 1992. v. 40 (4) p. 576-589.

116) Nalewaja, J.D. Influence of diammonium sulfate and other salts on glyphosate phytotocity. Pesticide science1993. v. 38 (2/3) p. 77-84.

117) Nalewaja, J.D. Spray droplet residual of glyphosate in various carriers. Oct/Dec 1992. v. 40 (4) Weed Science. p. 576-589.

118) Nalewaja,-J.D.; Matysiak,-R. Optimizing adjuvants to overcome glyphosate antagonistic salts. Weed-technol. Champaign, Ill. : The Weed Science Society of America. Apr/June 1993. v. 7 (2) p. 337-342.

119) Newton, M. Dissipation of glyphosate and aminomethylphosphonic acid in North American forests. Journal of agricultural and food chemistry. Aug 1994. v. 42 (8)p. 1795-1802.

120) Nilsson, U. Water uptake by planted *Picea abies* in relation to competing field vegetation and seedling rooting depth on two grass-dominanted sites in southern Sweden. Scandinavian Journal of Forest Research.1999. v. 14 (4) p. 312-319.

121) O'Sullivan, P.A. Influence of non-ionic surfactants, ammonium sulphate, water quality and spray volume on the phytotoxicity of glyphosate. Apr 1981. v. 61 (2) Canadian journal of plant science = Revue Canadienne de Phytotechnie. p. 391-400.

122) O'Sullivan,-P.A.; O'Donovan,-J.T.; Hamman,-W.M. Influence of non-ionic surfactants, ammonium sulphate, water quality and spray volume on the phytotoxicity of glyphosate.
Can-J-Plant-Sci-Rev-Can-Phytotechnie. Ottawa : Agricultural Institute of Canada. Apr 1981. v. 61 (2) p. 391-400.

123) Obenshain, K.R. Spatial analysis of herbicide decay rates in Louisiana. Environmental monitoring and assessment.--Dec 1997. v. 48 (3) p. 307-316.

124) Ogner, Gunnar. The effect of glyphosate application on brook water quality in a nutrient-rich forest = Effekten av glyfosatspr°yting pσ vannkvaliteten i skogsbekker i n£ringsrik skog / Gunnar Ogner. ┼s : Norsk Institutt for Skogforskning, Institutt for Skogfag, 1993.

125) Ogner, G. Glyphosate application in forest-ecological aspects. II. The quality of water leached from forest soil lysimeters. Scandinavian journal of forest research. 1987. v. 2 (4) p. 469-480.

126) Ogner, G. Glyphosate application in forest-ecological aspects. V. The water quality of forest brooks after manual clearing or extreme glyphosate application. Scandinavian journal of forest research. 1987. v. 2 (4) p. 509-516. maps.

127) Ogner, G. Glyphosate application in forest-ecological aspects. IV. The water quality of forest brooks after routine application. Scandinavian journal of forest research. 1987. v. 2 (4) p. 499-508.

128) Olaleye, V.F. Effect of a glyphosate (N-Phosphonomethyl) glycine) application to control *Eichhornia crassipes* Mart. on fish composition and abundance in Abiala creek, Niger Delta, Nigeria. Journal of environmental management June 1996. v. 47 (2) p. 115-122.

129) Oleskevich,-C.; Shamoun,-S.F.; Vesonder,-R.F.; Punja,-Z.K. Evaluation of *Fusarium avenaceum* and other fungi for potential as biological control agents of invasive *Rubus* species in British Columbia. Can-J-plant-pathol. Guelph, Ont. : Canadian Phytopathological Society. Mar 1998. v. 20 (1) p. 12-18.

130) Oliveira, M.T. Soil physical conditions in a New York orchard after eight years under different groundcover management systems. Plant and soil. July 2001. v. 234 (2)p. 233-237.

131) Olson, B.M. Soil microbial activity under chemical fallow conditions: effects of 2,4-D and glyphosate. 1991. v. 23 (11) Soil biology and biochemistry. p. 1071-1075.

132) Oppenhuizen, M.E. Liquid chromatographic determination of glyphosate and aminomethylphosphonic acid (AMPA) in environmental water: collaborative study. Mar/Apr
1991. v. 74 (2) Journal of the Association of Official Analytical Chemists. p. 317-323.

133) Pankey,-J.H.; Griffin,-J.L.; Colyer,-P.D.; Schneider,-R.W. Relationship between preemergence herbicides and seedling disease in roundup ready cotton. Proc-S-Weed-Sci-Soc. Raleigh, N.C., etc. Southern Weed Science Society. 1999. v. 52 p. 33-34.

134) Paveglio, F.L. Use of Rodeo and X-77 spreader to control smooth cordgrass (Spartina alterniflora) in a southwestern Washington estuary. 1. Environmental fate. Environmental toxicology and chemistry /June 1996. v. 15 (6) p. 961-968.

135) Payne, N.J. Off-target deposits and buffer zones required around water for aerial glyphosate applications. 1990. v. 30 (2) Pesticide science. p. 183-198.

136) Payne, N. Off-target deposit measurements and buffer zones required around water for various aerial applications of glyphosate. Information report FPM-X - Forest Pest Management Institute. 1987. (80) 23 p. ill., maps.

137) Payne, N.J. Off-target glyphosate from aerial silvicultural applications, and buffer zones required around sensitive areas. Pesticide science. 1992. v. 34 (1) p. 1-8.

138) Payne, N. Off-target deposit measurements and buffer zones required around water for various aerial applications of glyphosate. Mar 1989. (063) FRDA report. p. 88-109.

139) Pfeifer, R.A. Evaluation of alternative cropping practices under herbicide use/soil loss restrictions. Clean water, clean environment, 21st century : team agriculture, working to protect water resources : conference proceedings, March 5-8, 1995, Kansas City, Missouri /
v. 1 p. 145-148.

140) Pittaway,-P.A. Opportunistic association between Pythium species and weed residues causing seedling emergence failure in cereals. Aust-j-agric-res. Melbourne : Commonwealth Scientific and Industrial Research Organization, 1950-. 1995. v. 46 (3) p. 655-662.

141) Ponte-Freitas, A. Penetration of isoproturon and inhibition of photosynthesis after droplet deposition on leaf fragments. Pesticide biochemistry and physiology. p. 54-61.

142) Porazinska,-D.L.; Duncan,-L.W.; McSorley,-R.; Graham,-J.H. Nematode communities as indicators of status and processes of a soil ecosystem influenced by agricultural management practices. Agric,-ecosyst-environ,-Appl-soil-ecol. Amsterdam : Elsevier Science B. V., c1994-. Sept 1999. v. 13 (1) p. 69-86.

143) Powers, R.F. Intensive management of ponderosa pine plantations: sustainable productivity for the 21st century. Journal of sustainable forestry.2000. v. 10 (3/4)p. 249-255.

144) Rahe,-J.E.; Levesque,-C.A.; Johal,-G.S. Synergistic role of soil fungi in the herbicidal efficacy of glyphosate. A-C-S-Symp-Ser-Am-Chem-Soc. Washington, D.C. : The Society. 1990. (439) p. 260-275.

145) Reynolds, P.E. Alternative conifer release treatments affect below- and near-ground microclimate. The Forestry Chronicle. Jan/Feb 1997. v. 73 (1)p. 75-82.

146) Reynolds, P.E. Gas exchange for managed ponderosa pine stands positioned along a climatic gradient. Journal of sustainable forestry.2000. v. 10 (3/4)p. 257-265.

147) Reynolds, P.E. Alternative conifer release treatments affect microclimate and soil nitrogen mineralization. Forest ecology and management. Aug 1, 2000. v. 133 (1/2)p. 115-125.

148) Reynolds, P.E. Microclimate changes following alternative conifer release treatments continued through three post-treatment growing seasons. Journal of sustainable forestry. 2000. v. 10 (3/4)p. 267-275.

149) Richard, E.P. Jr. Sensitivity of sugarcane (*Saccharum* sp.) to glyphosate. Jan/Mar 1991. v. 39 (1) Weed Science. p. 73-77.

150) Roblin, E. Chemical control of Japanese knotweed (*Reynoutria japonica*) on river banks in South Wales. 1988. v. 16 Aspects of applied biology. p. 201-206.

ANNEX 152

151) Romo, J.T. Wolf plant effects on water relations, growth and productivity in crested wheatgrass. Canadian Journal of Plant Science. Oct 1994. v. 74 (4)p. 767-771.

152) Rosemond, J.M. Control of water hyacinth and water lettuce with glyphosate. Proceedings - Southern Weed Science Society. Jan 17-19, 1984. (37th) p. 292-299. ill.

153) Ruiter, H. de Influence of water stress and surfactant on the efficacy, absorption, and translocation of glyphosate. Weed Science May/June 1998. v. 46 (3)p. 289-296.

154) Sahid, I.B. Effects of watering frequency, shade and glyphosate application on *Paspalum conjugatum* Berg (sour grass). Crop protection. Crop protection (Guildford, Surrey)Feb 1996. v. 15 (1) p. 15-19.

155) Sancho, J.V. Rapid determination of glufosinate, glyphosate and aminomethylphosphonic acid in environmental water samples using precolumn fluorogenic labeling and coupled-column liquid chromatography. Journal of Chromatography. A.June 14, 1996. v. 737 (1) p. 75-83.

156) Sanderson,-J.B.; MacLeod,-J.A.; Kimpinski,-J. Glyphosate application and timing of tillage of red clover affects potato response to N, soil N profile, and root and soil nematodes.
Can-j-soil-sci. Ottawa : Agricultural Institute of Canada, 1957-. Feb 1999. v. 79 (1) p. 65-72.

157) Sanogo,-S.; Yang,-X.B.; Scherm,-H. Effects of herbicides on *Fusarium solani* f. sp. *glycines* and development of sudden death syndrome in glyphosate-tolerant soybean. Phytopathology. St. Paul, Minn. : American Phytopathological Society, 1911-. Jan 2000. v. 90 (1) p. 57-66.

158) Schoenholtz,-S.H.; Burger,-J.A.; Torbert,-J.L. Natural mycorrhizal colonization of pines on reclaimed surface mines in Virginia. J-Environ-Qual. Madison, Wis. : American Society of Agronomy. Apr/June 1987. v. 16 (2) p. 143-146.

159) Sharon,-A.; Amsellem,-Z.; Gressel,-J. Glyphosphate suppression of an elicited defence response: increased susceptibility of Cassia obtusifolia to a mycoherbicide.
Plant-Physiol. Rockville, Md. : American Society of Plant Physiologists. Feb 1992. v. 98 (2) p. 654-659.

160) Shea, P.J. Reversal of cation-induced reduction in glyphosate activity with EDTA. Weed science. Nov 1984. v. 32 (6) p. 802-806.

161) Shilling, D.G. Interactive effects of diluent pH and calcium content on glyphosate activity on *Panicum repens* L. (torpedograss). Dec 1989. v. 29 (6) Weed research. p. 441-448.

162) Shiver, B.D. Comparison of herbicide treatments for controlling common coastal plain flatwoods species. Nov 1991. v. 15 (4) Southern journal of applied forestry. p. 187-193.

163) Somervaille, A.J. The effects of pre-harvest sorghum spraying with glyphosate on the accumulation of soil water in fallow. Non-tillage crop production in northern N.S.W. : proceedings of the project team meeting, Tamworth, 17, 18 April 1985 / edited by R.J. Martin and W.L. Felton. p. 74-77.

164) Stallings,-W.C.; Abdel-Meguid,-S.S.; Lim,-L.W.; Shieh,-H.S.; Dayringer,-H.E.; Leimgruber,-N.K.; Stegeman,-R.A.; Anderson,-K.S.; Sikorski,-J.A.; Padgette,-S.R.; Kishore,-G.M. Structure and topological symmetry of the glyphosate target 5-enol-pyruvylshikimate-3-phosphate synthase: A distinctive protein fold. Proc-Natl-Acad-Sci-U-S-A. Washington, D.C.: The Academy. June 1, 1991. v. 88 (11) p. 5046-5050.

165) Stratton,-G.W.; Stewart,-K.E. Glyphosate effects on microbial biomass in a coniferous forest soil. Environ-Toxicol-Water-Qual. New York, N.Y. : John Wiley & Sons. Aug 1992. v. 7 (3) p. 223-236.

166) Stratton, G.W. Glyphosate effects on microbial biomass in a coniferous forest soil. Aug 1992. v. 7 (3) Environmental toxicology and water quality. p. 223-236.

167) Sundaram, A. Solubility products of six metal-glyphosate complexes in water and forestry soils, and their influence on glyphosate toxicity to plants. Journal of environmental science and health. Part B: Pesticides, food contaminants, and agricultural wastes. 1997. v. B32 (4) p. 583-598.

168) Takahashi,-S.; Nakajima,-M.; Kimoshita,-T.; Haruyama,-H.; Sugai,-S.; Honma,-T.; Sato,-S.; Haneishi,-T.

Hydantocidin and cornexistin: new herbicidal antibiotics.
ACS-symp-ser. Washington, D.C.: American Chemical Society, 1974-. 1994. (551) p. 74-84.

169) Tanipipat, S. Influence of selected environmental factors on glyphosate efficacy when applied to awnless barnyard grass (*Echinochloa colona* (L.) Link). Australian journal of agricultural research.1997. v. 48 (5) p. 695-702.

170) Tenuta, M. Denitrification following herbicide application to a grass sward. Canadian Journal of Soil Science. Feb 1996. v. 76 (1) p. 15-22.

171) Thelen, K.D. The basis for the hard-water antagonism of glyphosate activity. Weed Science Oct/Dec 1995. v. 43 (4) p. 541-548.

172) Thomas, K.D. Vegetation management using polyethylene mulch mats and glyphosate herbicide in a coastal British Columbia hybrid poplar plantation: four-year growth response. Western journal of applied forestry. Jan 2001. v. 16 (1) p. 26-30.

173) Tiffin, P. Response of corn grain yield to early and late killed red clover green manure and subirrigation. Journal of Production Agriculture. Jan/Mar 1998. v. 11 (1)p. 112-121.

174) Trotter, D.M, M. P. Wong, and R. A. Kent. Canadian water quality guidelines for glyphosate Ottawa, Ont. : Inland Waters Directorate, 1990. 27 p.

175) Tucker, D.P.H. Middles management methods in citrus affect soil retention and vegetation species. Proceedings of the ... annual meeting of the Florida State Horticultural Society. Florida State Horticultural Society. Meeting. June 1998. v. 110p. 39-43.

176) Turkington, T.K. The impact of soil incorporation of canola residues and stubble application of chemicals on decomposition and inoculum production by Leptosphaeria maculans. Canadian journal of plant pathology = Revue Canadienne de phytopathologie.June 2000. v. 22 (2)p. 155-159.

177) Tworkoski, T.J. Effect of moisture stress and glyphosate on adventitious shoot growth of Canada thistle (Cirsium arvense). Weed Science Jan/Feb 1998. v. 46 (1)p. 59-64.

178) United States. Environmental Protection Agency. Office of Science and Technology. United States. Environmental Protection Agency. Office of Water. Drinking water criteria document for glyphosate. Washington, D.C.: Health and Ecological Criteria Division, Office of Science and Technology, Office of Water, U.S. Environmental Protection Agency, [1992] 1 v. (various pagings)

179) United States. Agricultural Research Service. Cropping Systems and Water Quality Research Unit. Cropping Systems and Water Quality Research Unit [computer file]. Columbia, Mo. : USDA, ARS, The Unit, [2001]-

180) V.F. Burns, A.D. Kelley. Responses and residues in certain crops irrigated with water containing glyphosate. Pullman: College of Agriculture Research Center, Washington State University, 1975.

181) Villa, M.V. Hydrotalcites and organo-hydrotalcites as sorbents for removing pesticides from water. Journal of environmental science and health. Part B: Pesticides, food contaminants, and agricultural wastes.1999. v. B34 (3)p. 509-525.

182) Wan, M.T. Acute toxicity to juvenile Pacific Northwest salmonids of Basacid Blue NB755 and its mixture with formulated products of 2,4-D, glyphosate, and triclopyr. Sept 1991. v. 47 (3) Bulletin of environmental contamination and toxicology. p. 471-478.

183) Wan,-M.T.; Rahe,-J.E.; Watts,-R.G. A new technique for determining the sublethal toxicity of pesticides to the vesicular-arbuscular mycorrhizal fungus Glomus intraradices.
Environ-Toxicol-Chem. Pensacola, Fla. : SETAC Press. July 1998. v. 17 (7) p. 1421-1428.

184) Wan, Y.S. Dissipation of 2,4-D glyphosate and paraquat in river water. Water, air, and soil pollution Jan 1994. v. 72 (1/4) p. 1-7.

ANNEX 152

185) Wan, M.T. Effects of different dilution water types on the acute toxicity to juvenile Pacific salmonids and rainbow trout of glyphosate and its formulated products. Bulletin of environmental contamination and toxicology. Sept 1989. v. 43 (3) p. 378-385.

186) Wan, Michael T., Rahe, James E., and Watts, Ronald G. A New Technique for Determining the Sublethal Toxicity of pesticides to the Vesicular-Arbuscular Mycorrhizal Fungus GLOMUS INTRARDICES Environmental Toxicology and Chemistry, Vol. 17, No. 7. 1998 pp 14211428

187) Wang, Y.S. Accumulation of 2,4-D and glyphosate in fish and water hyacinth. Water, Air, and Soil Pollution Apr 1994. v. 74 (3/4) p. 397-403.

188) Wardle,-D.A.; Parkinson,-D. The influence of the herbicide glyphosate on interspecific interactions between four soil fungal species.
Mycol-Res. Cambridge: Cambridge University Press. Mar 1992. v. 96 (pt.3) p. 180-186.

189) Wester, R.C. Glyphosate skin binding, absorption, residual tissue distribution, and skin decontamination. May 1991. v. 16 (4) Fundamental and applied toxicology: official journal of the Society of Toxicology. p. 725-732.

190) Wester, R.C. In vitro percutaneous absorption of model compounds glyphosate and malathion from cotton fabric into and through human skin. Food and chemical toxicology: an international journal published for the British Industrial Biological Research Association.Aug 1996. v. 34 (8) p. 731-735.

191) Wicks, G.A. Effect of rainfall on glyphosate plus 2,4-D performance on *Echinochloa crus-galli*. Weed Science Oct/Dec 1995. v. 43 (4) p. 666-670.

192) Wiese, A.F. Effect of tillage timing on herbicide toxicity to field bindweed. Journal of production agriculture. July/Sept 1997. v. 10 (3)p. 459-461.

193) Wigfield, Y.Y. A modified clean-up for the determination of glyphosate and its metabolite residues in lentils using high pressure liquid chromatography and post-column fluorogenic labelling. Pesticide science. 1991. v. 33 (4) p. 491-498.

194) Willoughby, I. Control of coppice regrowth in roadside woodlands. Forestry : the journal of the Society of Foresters of Great Britain. Forestry (London, England)1999. v. 72 (4)p. 305-312.

195) Wittwer, R.F. Direct seeding of bottomland oaks in Oklahoma. Feb 1991. v. 15 (1) Southern Journal of Applied Forestry. p. 17-22.

196) Wong, P.K. Effects of 2,4-D, glyphosate and paraquat on growth, photosynthesis and chlorophyll-a synthesis of *Scenedesmus quadricauda* Berb 614. Chemosphere July 2000. v. 41 (1/2)p. 177-182.

197) Yeiser, J.L. Growth and physiological response of four shortleaf pine families to herbicidal control of herbaceous competition. Nov 1991. v. 15 (4) Southern journal of applied forestry. p. 199-204.

198) Zaranyika, M.F. Degradation of glyphosate in the aquatic environment: an enzymatic kinetic model that takes into account microbial degradation of both free and colloidal (or sediment) particle adsorbed glyphosate. Journal of agricultural and food chemistry. May 1993. v. 41 (5) p. 838-842.

199) Marassas, W.F.O, Nelson, P.E., and Tousson, T.A. Toxigenic Fusarium species: Identity and Mycotoxicology Pennsylvania State University press, 1984

200) Springett, JA and Gray, R.A.J. Effect of repeated low doses of biocides on the earthworm *Aporrectodea caliginosa* in laboratory culture. Soil. Biol. Biochem, 24 (12) 1992: pp. 1739-1744.

201) Hutchinson, G.I. Nitrogen Cycle Interactions with Global Change Processes. In Niertenberg, W.I. (Ed) Encyclopedia of Environmental Biology. Volume 2 1995, San Diego, Academic press. Pp. 583-587

202) Kenneth Freed "Anti-drug Effort Sows Bad Blood; Guatemala: Farmers Complain That Legitimate Crops Are Being Damaged by a U.S. Spraying Program Designed to Cut into Heroin Production." Los Angeles Times, October 15, 1989, Sunday, Home Edition

203) U.S. Department of State cable from Guatemala to Washington, DC: 1991GUATEM00643
204) Hassan, S.A et al. Results of the fourth joint pesticide testing programme carried Out by the ICBC-WPRS-Working Group "pesticides and beneficial Organisms." J Appl. Ent 105 1988, 321-329

205) Folmar, L.C., Sander, H.O., and Julin, A.M. Toxicity of the Herbicide Glyphosate and several of its formulations on fish and aquatic invertebrates. Arch. Environ. Contam. Toxicol. 8 1979. 269-278

206) Hartman, WA and Martin, D.B. Effect of suspended bentonite clay on the acute toxicity of glyphosate to *Daphnia pulex* and *Lemna minor*. Bull. Environ. Contam. Toxicol. 33 1984 pp. 355-361

207) Servizi, J.A., Gordon, R.W. and Martens, D.W. Acute Toxicity of Garlon 4 and Roundup herbicides in salmon, *Daphnia*, and trout. Bull. Environ. Contam. Toxicol 39 1987 pp. 15-22.

ANNEX 153

Ecuadorian Scientific-Technical Commission,
Technical Report from the CCTE on the CICAD Document on the Study of the Effects Produced by Spraying Glyphosate (within the coca crop eradication program) on the Border Between Ecuador and Colombia (2 June 2005)

General Department of Border Relations with Colombia

From: ECOTOXICOLOGY [ceea.uqa@andinanet.net]
Sent: Thursday, 02 June 2005 16:34
To: General Department of Border Relations with Colombia
Subject: Re: Circular Note No. 076/05-SSNDF-DGRFC

Dear Messrs. General Department of Border Relations with Colombia

Attached review of the document sent by you.

Sincerely,

Ramiro Castro
Ecuadorian Atomic Energy Commission

03/06/2005

[PAGE 2]

TECHNICAL REPORT FROM THE CCTE ON THE CICAD DOCUMENT ON THE STUDY OF THE EFFECTS PRODUCED BY SPRAYING GLYPHOSATE (Within the coca crop eradication program) ON THE BORDER BETWEEN ECUADOR AND COLOMBIA.

1 Background

The Ministry of Foreign Relations Department of National Sovereignty and Border Development – DGRFC issued to the CCTE, through Circular Note 16375 of 17 May 2005, the CICAD study called "Study of the effect of the Program to Eradicate Illegal Crops by Aerial Spraying with the herbicide Glyphosate (PECIG) and illegal crops on human health and in the environment." Likewise the Chancellery of Ecuador – SSNDF-DGRFC sent to the CCTE, through Circular Note 074-05, of 23 May 2005, as an additional reference, a study performed by the National University of Colombia on the same subject, called "Report by the National University of Colombia Institute of Environmental Studies (IDEA), Remarks on the 'Study of the effect of the Program to Eradicate Illegal Crops by Aerial Spraying with the herbicide Glyphosate (PECIG) and illegal crops on human health and in the environment.'" On the latter, the CCTE will issue a separate document.

The Document was prepared by a panel of international experts in human, animal, and environmental toxicology; in epidemiology in agronomy and ecology which was called the Scientific Evaluation Team – ECE. The members of this team were Drs. Keith R. Solomón, Arturo Anadón, Antonio Luiz Cerdeira, Jon Marshal, Luz Helena Sanin (hereinafter the "panel of experts"). This report was prepared for the Inter-American Commission for the Control of Drug Abuse (CICAD) a Division of the Organization of States (OEA).

In general, the report contains valuable information with supporting documents on the selected subjects and abundant bibliography citations. It will unquestionably constitute an important reference for future research work related to risk evaluation in the program to eradicate illegal crops by spraying glyphosate formulations and other pesticides. However, the document lacks adequate ordering which affects its order but not its content.

2. Objectives

The CCTE analyzed the text of the study prepared by CICAD, in its entirety and especially the partial and total results, as well as the methodology applied, sources, and practical experiments, and data collection performed to prepare that report.

The comments and remarks issued by the CCTE are institutional in nature as a function of the representation their members have of their respective national and international institutions. This technical report was reviewed by each of the members of the CCTE and duly signed.

3. Summary of the characterization of exposure and effects on human health and the environment.

The document indicates the definition of the problem as a key step in the risk-evaluation process. Initially, it takes into account all the activities and consequences related to spraying, coca production, and

coca processing. It acknowledges that the growth in crops as well as the coca refining process implies significant repercussions on health and the environment, from the felling of forests, the use of chemicals to care for the crops, and processing the drug. However, it acknowledges that the risks cannot be estimated given that the logistics of collecting data on exposure to persons and the

environment is very difficult. With this fact, the "panel of experts" performs the risk evaluation focusing on human health and the environment of the effects caused by the aerial spraying of glyphosate and the adjuvants used in controlling illegal crops.

To evaluate the risk of using glyphosate "the conceptual model applied" is the one used in the agricultural application of pesticides wherein the danger and the risk are directly related to the toxicity and exposure to the pesticide. Therefore for human health, the toxicity data are compared to the estimated exposure for the worst-case data and also for the most realistic data obtained in other uses of glyphosate.

For acute Exposures, the risks are compared with the acute intoxication data. The toxicity data for the active ingredient glyphosate is obtained from the literate and from acute intoxication tests of laboratory animals undertaken with a mixture of glyphosate and cosmoflux such as the one used in the spraying program.

It is also acknowledged that the glyphosate used in the eradication program can contribute to exposure through the food chain and drinking water; these are estimated and compared with the toxicity data and exposure guidelines based on chronic intoxication by glyphosate.

When evaluating the ecological risks a similar farming-based mechanism is used. The exposures are estimated from the worst-case models, the measures made in other locations and measurements based on samples collected in the Colombian environment. Due to the frequency of application in the eradication program (prolonged periods between applications), the ecological exposures resulting from the spraying operations are acute and are compared with acute intoxication data.

The toxicity data were obtained from the literature and from tests performed in the laboratory on standard organisms.

As a human health risk hypothesis it is stated that "Exposures to glyphosate and its adjuvants do not cause acute adverse effects on persons exposed by different routes."

For effects in ecological environments, the hypothesis is that "Exposures to glyphosate and its adjuvants as employed in the poppy and coca eradication programs do not cause acute or chronic adverse effects in non-target organisms exposed by different routes."

To characterize exposure in the risk evaluation, the risk behaviors identified in general are related to the frequency of use of pesticides in agriculture, washing the equipment in water sources used by people, improper disposal of empty containers, consumption of food during application, and the improper use of protection suits. This behavior is different from the aerial application of glyphosate.

[PAGE 4]

There are two human groups exposed: Sprayers (Applicators) and those present. "The panel of experts" indicates that in Colombia there were no available measurements of the exposure of sprayers; however, they estimate that it is similar to that of sprayers in other situations (forestry and agriculture). According to the document, the maximum estimated exposure in applicators through all routes is 0.056 mg/kg body weight. For those present, body exposure in the worst of cases would be 0.08 mg/kg of body weight approximately. All the measurements of these exposures are considerably below those estimated as rational values in the case.

For environmental exposures, the chemical glyphosate is important to determine its use in the environment. Its presence in the air is unlikely due to the physiochemical properties duly documented and established in the literature, glyphosate is not very volatile. In the ground it is absorbed significantly by organic matter therefore it possesses little motility. It is very soluble in water.

In Colombia a study was performed to monitor surface water in five locations to characterize the concentrations of glyphosate and AMPA in a 24-week period. The samples were sent to Canada for analysis, the results obtained indicated that only two samples had limits in excess of the quantification limit of the analysis method which was 25 ug/L. These data suggest that little or no contamination with glyphosate has occurred in surface waters, the concentrations found were for the most part below the method's detection limit.

In the characterization of effects, there is little epidemiological evidence that associates glyphosate with any specific illness in humans. The effect of glyphosate on non-target environmental organisms, on aquatic animals, shows zero risk for glyphosate. However the risk on fish and other aquatic organisms is increased with the presence of the surfactant in the formulation more than with the glyphosate itself.

4.0 Summary of the Conclusions Proposed by "The panel of experts"

Relevance for human health: According to the report, the risks for people and for human health from the use of glyphosate and Cosma-flux are minimal. The acute toxicity of the formulated product and Cosmo-flux for experimental animals is very low, the likely exposures are low and the frequency of exposure is low. When these risks are compared with other risks associated with the production and processing of cocaine raw material, they are essentially negligible.

Ecological Relevance: The risks of the direct effects on ground wildlife such as mammals and birds was deemed negligible as well as for beneficial insects such as bees. However, they note that there could be moderate risks for some wild aquatic animals in some locations where there are static bodies of surface water located near coca crops when they are sprayed accidentally. When taken within the context of the environmental risks of other activities associated with the production of cocaine, the risks associated with the spraying program are slight.

According to the report, the applications of glyphosate are well characterized. Latest-generation equipment is used. The application sites and areas are well documented. The mixture and application rates are well characterized and the

[PAGE 5]

likelihood that greater quantities of glyphosate and Cosmo-flux than those specified is slight. The resulting concentration in the soil and water which may result from accidental spraying is also very certain. The environmental behavior of glyphosate is well characterized and under the usage conditions in the eradication program in Colombia the glyphosate is not persistent, it will not accumulate, nor biomagnify in the environment. The analyses of the surface waters and sediments did not disclose the presence of significant concentrations of the compound, which confirms the conclusion based on its properties that it is immobile in the environments where it is applied, regardless of the pattern of usage.

The lack of information on the characterization of exposure rests on the lack of precise measurements in the fields sprayed near the surface waters.

Exposure by people: The exposures of people to glyphosate in the studies performed in other countries was estimated and it is believed that they are accurate with respect to the persons present who were sprayed directly. It was assumed that the exposures were slight and that in all cases they were considerably below the threshold of importance.

The glyphosate application rates used to eradicate coca are slightly higher than those used in conventional agriculture, which suggests that the exposures measured under these conditions might not be applicable to the exposures of those present in the eradication operations in Colombia. There is less information available on the likelihood of exposure in returning to the coca crops immediately after spraying. Exposures under these conditions have not been measured.

Environmental effects: According to the toxicity data provided by the literature glyphosate is in and of itself of low toxicity for non-target organisms; however, there are a certain number of formulations on the market that contain different surfactants and/or adjuvants that are more toxic. Due to this, the panel performed several toxicity tests with the formulated glyphosate product plus Cosmo.Flux® as used in the eradication program in Colombia. The recent studies have reported that amphibians such as frogs are among the aquatic organisms most sensitive to the glyphosate formulations such as Roundup and Vision. Toxicity studies have not been performed in amphibians with the glyphosate plus Cosmo-flux mixture and this is a source of some uncertainty on the ecological risks for frogs.

Effects on humans: There is significant evidence and data on the effects of glyphosate and its risks for humans. In all cases glyphosate has been deemed low-risk. However, some of these studies on which these evaluations were made were performed before the refining of the test guidelines and the availability of new and more sensitive methods of analyzing and characterizing effects, such as those based on changes in the concentrations of neurotransmitters and their metabolites in the central nervous system. Changes in the regulator state of glyphosate must be supervised and any new effect identified must be included in the update of the risk evaluation.

There is abundant literature on the epidemiology of pesticides and the possible effects on human health. As a result of the recent work, it is clear that many epidemiological studies are confounded by the use of improper, inexact studies of exposures to pesticides. The panel also performed a preliminary

epidemiological study to evaluate the possible associations between the use of glyphosate and the adverse effects on human health and it acknowledges that, for clear logistical reasons, there are no exposure measurements available for the different groups involved in the study other than those for using glyphosate for eradication operations in the region. The results of this study do not suggest that

there is any association between the use of glyphosate in the spraying program and the time to get pregnant as a result in reproduction.

Risk evaluation and confounding factors: The panel acknowledges that the substances used in the production and processing of cocaine represent a significantly greater hazard both for people and for the environment that the mixture of glyphosate and Cosmo-flux used in the eradication program in Colombia. The lack of information on these usage conditions for these substances exacerbated these dangers.

5.0 Conclusions of the members of the CCTE

This document is important in the field of science because it has contributions that should serve as a basis to continue with the more specific studies to evaluate the risks of using formulations of glyphosate in the spraying program taking into account other types of effects of exposure on human health (effects on chromosomes) and on aquatic organisms.

There is a contradiction in the presentation of CICAD's conclusions because when defining the problem the "panel of experts" indicates that is not possible to do a risk evaluation in planting and processing activities due to the inability to gather data. However, they conclude that the risks associated with the use of glyphosate and Cosmo-flux in the coca eradication program in Colombia are related to the total impact of coca product according to the definition of the problem stated in this study.

Mechanisms must be found that allow measurements to be taken of the formulation concentration of glyphosate and Cosmoflux near the fields where the spraying is done to characterize the degree of exposure both of people and in the surface waters.

In terms of the analysis of the effects of using glyphosate and Cosmo-flux, a question arises, it is that the actual concentration of the formulation in the spray application to eradicate the crop is not known. According to the conceptual risk-evaluation model, the degree of exposure is in relation to the formulation concentration, therefore the estimates of exposures of people in the studies performed in other countries lack validity in relation to the actual place of application.

The CICAD researchers recommend "performing more specific studies," which supports our asseveration that the aforementioned study must not in any manner

be deemed "conclusive." Moreover when parameters such as Genotoxicity have hardly been mentioned, without further analysis.

It would be very useful also to monitor in the northern Ecuador border area affected by the spraying that might serve as a reference for Ecuadorian authorities.

[PAGE 7]

An effect on crops from spraying is also evident with rapid recovery of the coca crops sprayed by successful replanting of coca, however the affected crops in Ecuador are not coca crops, but rather crops that are the daily food of the border population, which are not recovered.

Therefore we recommend performing studies in the directly affected populated areas, and whenever there is an effect on health, the risk analysis must be studied and proved scientifically.

Quito, 2 June 2005

Ecuadorian Atomic Energy Commission. Pesticide analysis Laboratory.

Ramiro Castro Palacios
Chemist

Central University of Ecuador

Dr. Luis Reinoso Garzón

Dr. Leonardo Lovato

Dr. Angelo Nicolalde

Ministry of Public Health
Inquieta Pérez Institute

Dr. Marcelo Chiriboga U.

Dr. Beatriz Vargas P.

Ministry of the Environment

Santiago Salazar

Carlos Valencia, Engineer

PS: This report does not contain contributions from the CCTE members representing the OMS-OPOS, or the SESA.

Direccion General de Relac Fronterizas con Colombia

De: ECOTOXICOLOGIA [ceea.uqa@andinanet.net]
Enviado el: Jueves, 02 de Junio de 2005 16:34
Para: Direccion General de Relac Fronterizas con Colombia
Asunto: Re: Nota Circular No. 076/05-SSNDF-DGRFC

Estimados señores Dirección General de Relaciones Fronterizas con Colombia,

Adjunto revisión de acta enviada por ustedes.

Atentamente

Ramiro Castro
Comisión Ecuatoriana de Energía Atomica

ANNEX 153

INFORME TÉCNICO DE LA CCTE SOBRE EL DOCUMENTO DEL CICAD EN TORNO AL ESTUDIO DE LOS EFECTOS PRODUCIDOS POR LAS ASPERSIONES CON GLIFOSATO (Dentro del programa de erradicación de cultivos de coca) EN LA FRONTERA ENTRE ECUADOR Y COLOMBIA.

1 Antecedente

El Ministerio de Relaciones Exteriores Subsecretaría de Soberanía Nacional y Desarrollo Fronterizo-DGRFC remitió a la CCTE, mediante Nota Circular 16375 de 17 de mayo 2005, el estudio de la CICAD denominado "Estudio de los efectos del Programa de Erradicación de Cultivos ilícitos mediante la aspersión aérea con el herbicida Glifosato (PECIG) y de los cultivos ilícitos en la salud humana y en el medio ambiente". De igual manera la Cancillería del Ecuador-SSNDF-DGRFC remitió a la CCTE, mediante la Nota Circular 074-05, de 23 mayo 2005, como referente adicional, un estudio realizado por la Universidad Nacional de Colombia sobre el mismo tema, denominado "Informe de la Universidad Nacional de Colombia Instituto de Estudios Ambientales (IDEA), Observaciones al "Estudio de los efectos del Programa de Erradicación de Cultivos ilícitos mediante la aspersión aérea con el herbicida Glifosato (PECIG) y de los cultivos ilícitos en la salud humana y en el medio ambiente". Sobre este último, la CCTE se pronunciará en documento separado.

El Documento ha sido elaborado por un panel de expertos internacionales en toxicología humana, animal y ambiental; en epidemiología en prácticas de agronomía y en ecología que se denominó el Equipo Científico de Evaluación – ECE. Como miembros de este equipo están los doctores Keith R. Solomón, Arturo Anadón, Antonio Luiz Cerdeira, Jon Marshal, Luz Helena Sanin (en adelante "el panel de expertos"). Este Informe se ha preparado para la Comisión Interamericana para el Control del Abuso de Drogas (CICAD) División de la Organización de Estados (OEA)

En forma general, el informe contiene información valiosa con argumentos de respaldo en los temas seleccionados y abundantes citas bibliográficas. Constituirá sin duda una importante referencia para futuros trabajos de investigación relacionados a la evaluación de riesgos en el programa de erradicación de cultivos ilícitos mediante aspersión con formulaciones de glifosato y otros plaguicidas. Sin embargo, el documento carece de un ordenamiento adecuado que afecta su forma más no su fondo.

2.- Objetivos

La CCTE analizó el texto del estudio elaborado por la CICAD, en su totalidad y de manera especial los resultados parciales y totales, así como la metodología aplicada, fuentes y experiencias prácticas y recolección de datos efectuados para la elaboración de dicho informe.

Los comentarios y observaciones emitidos por la CCTE son de carácter institucional en función de la representación que ejercen sus miembros de sus respectivas entidades nacionales e internacionales. El presente informe técnico ha sido revisado por cada uno de los integrantes de la CCTE y debidamente suscrito.

3.- Resumen de las caracterizaciones de las exposiciones y efectos en la salud humana y en el ambiente.

El documento indica el planteamiento del problema como paso clave en el proceso de evaluación del riesgo. Inicialmente, toma en cuenta todas las actividades y consecuencias relacionadas a la aspersión, producción de coca y al procesamiento de

coca. Reconoce que el crecimiento de cultivos al igual que el proceso de refinamiento de la coca implica apreciables repercusiones en la salud y en el medioambiente, en parte por la tala de los bosques, el uso de químicos para el cuidado del cultivo y el procesamiento de la droga. Sin embargo, reconoce que no se puede estimar los riesgos dado que la logística de la recolección de datos de las exposiciones a las personas y del ambiente es muy difícil. Con este antecedente, "el panel de expertos" realiza la evaluación de riesgo enfocado en la salud humana y el ambiente de los efectos causados por la aspersión aérea de glifosato y de los adyuvantes utilizados el control de cultivos ilícitos.

Para la evaluación de riesgo del uso de glifosato "el modelo conceptual aplicado" es el usado en la aplicación agrícola de plaguicidas en el cual el peligro y el riesgo se encuentran directamente relacionados con la toxicidad y la exposición al plaguicida. Por consiguiente para salud humana, los datos de toxicidad se comparan con las exposiciones estimadas de los datos de los peores casos y también de datos más realistas obtenidos en otros usos de glifosato.

Para Exposiciones agudas, los riesgos se comparan con los datos de intoxicaciones agudas. Los datos de toxicidad para el ingrediente activo el glifosato, se obtienen de la literatura y de las pruebas de intoxicación agudas de animales de laboratorio realizadas con una mezcla de glifosato y cosmoflux como la que se utiliza en el programa de aspersión.

Además se reconoce que el glifosato utilizado en el programa de erradicación puede contribuir a la exposición por vía de la cadena alimenticia y del agua de consumo; estos se estiman y se comparan con los datos de toxicidad y guías de exposición basados en la intoxicación crónica por glifosato.

Al evaluar los riesgos ecológicos se utiliza un mecanismo similar con base en la agricultura. Las exposiciones se estiman de los modelos de los peores casos, de mediciones realizadas en otras localidades y en mediciones basadas en muestras recolectadas del ambiente colombiano. Debido a la frecuencia de aplicación en el programa de erradicación (períodos prolongados entre las aplicaciones), las exposiciones ecológicas resultantes de las operaciones de aspersión resultan ser agudas y se comparan con datos de intoxicaciones agudas.
Los datos de toxicidad se obtuvieron de la literatura y de pruebas llevadas a cabo en el laboratorio en organismos estándar.

Como hipótesis de riesgo para la salud humana se afirma que "Las exposiciones al glifosato y sus adyuvantes no causan efectos adversos agudos en las personas expuestas por diferentes rutas".

Para efectos en medios ecológicos, la hipótesis es que "Las exposiciones al glifosato y sus adyuvantes tal y como se emplean en los programas de erradicación de la amapola y coca, no originan efectos adversos agudos o crónicos en organismos no blanco expuestos por diferente rutas".

Para la caracterización de la exposición en la evaluación de riesgo, los comportamientos de riesgo identificados en general están relacionados a la frecuencia de uso de plaguicidas en la agricultura, al lavado del equipo en fuentes de agua utilizadas por personas, a la disposición inadecuada de los recipientes vacíos, al consumo de comidas durante la aplicación y al uso inadecuado de trajes de protección. Este comportamiento es diferente a la aplicación aérea de glifosato.

Existen dos grupos humanos expuestos: Asperjadores (Aplicadores) y circunstantes. "El panel de expertos" indica que en Colombia no habia mediciones disponibles de las exposiciones de los asperjadores; sin embargo, estiman que sea similar a los asperjadores en otras situaciones (silvicultura y agricultura). Según el documento, la exposición máxima estimada en los aplicadores por todas las vías es de 0.056 mg/kg peso corporal. Para los circunstantes, la exposición corporal en el peor de los casos sería 0.08 mg/kg de peso corporal aproximadamente. Todas las medidas de estas exposiciones son considerablemente menores que las estimadas como valores racionales del caso.

En las exposiciones ambientales, la química del glifosato es importante para determinar su destino en el ambiente. En el aire es poco probable la presencia en virtud de las propiedades fisicoquímicas debidamente documentadas y establecidas en la literatura, el glifosato es poco volátil. En el suelo se adsorbe fuertemente a la materia orgánica por consiguiente posee poca movilidad. En el agua es muy soluble.

En Colombia se realizó un estudio de monitoreo de aguas superficiales en cinco localidades para caracterizar las concentraciones de glifosato y AMPA en un período de 24 semanas. Las muestras se enviaron a Canadá para su análisis, los resultados obtenidos indicaron que sólo dos muestras tenían cantidades superiores al límite de cuantificación del método de análisis que fue de 25 ug/L. Estos datos sugieren que se ha producido poca o ninguna contaminación con glifosato de las aguas superficiales, las concentraciones halladas estaban en su mayoría por debajo del límite de detección del método.

En la caracterización de efectos, existe poca evidencia epidemiológica que asocie al glifosato con alguna enfermedad específica en los humanos. El efecto del glifosato en organismos ambientales no objetivo, en animales acuáticos presenta un riesgo nulo para glifosato. Sin embargo, el riesgo en peces y otros organismos acuáticos se incrementa por la presencia del surfactante en la formulación más que con el glifosato mismo.

4.0 Resumen de las Conclusiones propuestas por "El panel de expertos"

Relevancia para la salud humana: De acuerdo al informe, los riesgos para las personas y para la salud humana del uso del glifosato y Cosma-flux son mínimos. La toxicidad aguda del producto formulado y Cosmo-flux para los animales de experimentación es muy baja, las probables exposiciones son bajas y la frecuencia de exposiciones es baja. Cuando estos riesgos se comparan con otros riesgos asociados a la producción y procesamiento de materia prima a cocaína, son esencialmente despreciables.

Relevancia Ecológica: Los riesgos de los efectos directos sobre la vida silvestre terrestre como mamíferos y aves se consideró despreciable así como para los insectos benéficos como las abejas. Sin embargo hacen notar que pueden existir riesgos moderados para algunos animales acuáticos silvestres en algunas localidades donde se encuentran cuerpos de agua superficiales y estáticos localizados en la vecindad de los cultivos de coca cuando éstos sean asperjados accidentalmente. Cuando se toman en el contexto de los riesgos ambientales de otras actividades asociadas con la producción de coca, los riesgos asociados al programa de aspersión son pequeños.

Según el informe, las aplicaciones de glifosato están bien caracterizadas. Se usa equipo que es el de última generación. Los sitios de las aplicaciones y las áreas están bien documentadas. Las tasas de mezcla y aplicación están bien caracterizadas y la

probabilidad que se usen cantidades mayores de glifosato y Cosmo-flux que las especificadas son pocas. Las concentraciones resultantes en suelo y agua que pueden resultar de una aspersión accidental también tienen gran certidumbre. El comportamiento ambiental del glifosato esta bien caracterizado y bajo las condiciones de uso en el programa de erradicación en Colombia el glifosato no es persistente, no se acumulará, ni se biomagnificará en el ambiente. Los análisis de las aguas superficiales y de los sedimentos no revelaron la presencia de concentraciones significativas del compuesto, lo cual confirma la conclusión basada en sus propiedades de que es inmóvil en los ambientes donde se aplica , sin importar el patrón de uso.

La carencia de información sobre la caracterización de la exposición radica en la falta de mediciones precisas en la proximidad de los campos asperjados a las aguas superficiales.

Exposiciones de personas: Se estimaron las exposiciones de personas al glifosato de los estudios realizados en otros países y se cree que son precisos con respecto a los circunstantes que recibieron directamente la aspersión. Se considero que las exposiciones eran pequeñas y que en todos los casos estuvieron considerablemente por debajo del umbral de importancia.

Las tasas de aplicación del glifosato utilizadas para la erradicación de la coca son ligeramente mayores a las usadas en la agricultura convencional, lo cual sugiere que las exposiciones medidas bajo estas condiciones pueden no ser aplicables a las exposiciones de los circunstantes en las operaciones de erradicación en Colombia. Hay menos información disponible sobre la probabilidad de exposición en el reingreso a los cultivos de coca inmediatamente después de la aspersión. No se han medido las exposiciones bajo estas condiciones.

Efectos ambientales: De acuerdo a los datos de toxicidad proporcionados por la literatura el glifosato en sí es de toxicidad baja para los organismos no objetivo; sin embargo, existe cierto número de formulaciones en el mercado que contienen surfactantes y/o adyuvantes diferentes los cuales son más tóxicos. Debido a esto, el panel adelantó varias pruebas de toxicidad con el producto formulado del glifosato más Cosmo.Flux® tal y como se utiliza en el programa de erradicación de Colombia. . Los estudios recientes han reportado que los anfibios, como las ranas, se encuentran entre los organismos acuáticos más sensibles a las formulaciones de glifosato como Roundup y Visión. No se han realizado estudios de toxicidad en anfibios con la mezcla de glifosato más Cosmo-flux y ésta es una fuente de cierta incertidumbre de los riesgos ecológicos para las ranas.

Efectos en humanos: Existe gran evidencia y datos de los efectos del glifosato y sus riesgos para los humanos. En todos los casos, se ha considerado que el glifosato es de bajo riesgo. Sin embargo, alguno de estos estudios en los cuales se basan estas evaluaciones se llevaron a cabo antes del refinamiento de las guías de pruebas y de la disponibilidad de métodos de análisis y caracterización de efectos, nuevos y más sensibles, tales como los basados en las alteraciones de las concentraciones de los neurotransmisores y sus metabolitos en el sistema nervioso central. Los cambios en el estado regulador del glifosato se deben supervisar y cualquier nuevo efecto identificado se debe incluir en la actualización de la evaluación de riesgo.

Existe abundante literatura sobre la epidemiología de los plaguicidas y los posibles efectos sobre la salud humana. Como resultado del trabajo reciente, es claro que muchos estudios epidemiológicos se confunden por el uso de substitutos inadecuados e inexactos para las exposiciones a plaguicidas. El panel también realizó un estudio

epidemiológico preliminar para evaluar las posibles asociaciones entre el uso de glifosato y los resultados adversos en la salud humana y reconoce que, por claras razones de logística, no existen disponibles mediciones de exposición para los diversos grupos involucrados en el estudio diferentes a las del uso del glifosato para operaciones de erradicación en la región. Los resultados de este estudio no sugieren que exista alguna asociación entre el uso de glifosato en el programa de aspersión y el tiempo para quedar en embarazo como resultado en la reproducción.

Evaluación del riesgo y factores de confusión: El panel reconoce que las substancias usadas en la producción y procesamiento de la cocaína representan un peligro significativamente mayor tanto para las personas como para el ambiente que la mezcla de glifosato y Cosmo-flux utilizadas en el programa de erradicación en Colombia. La falta de información sobre las condiciones de uso de estas substancias exacerba estos peligros.

5.0 Conclusiones de los miembros del CCTE

Este documento es importante en el campo de la ciencia porque tiene aportes que deben servir como base para continuar con los estudios más específicos de evaluación de riesgos del uso de formulaciones de glifosato en el programa de aspersión tomando en cuenta otro tipo de efectos de la exposición en la salud humana (efectos en los cromosomas) y en organismos acuáticos.

Existe una contradicción en la presentación de las conclusiones del CICAD ya que en el planteamiento del problema "el panel de expertos" indican que no es posible hacer una evaluación de riesgo en las actividades de cultivo y procesamiento debido a la imposibilidad de recolección de datos. Sin embargo, concluyen que los riesgos asociados con el uso de glifosato y Cosmo-flux en el programa de erradicación de la coca en Colombia se relacionan con los impactos totales de la producción de coca de acuerdo al planteamiento del problema expuesto en este estudio.

Debe encontrarse los mecanismos que permitan realizar mediciones de la concentración de formulación de glifosato y Cosmoflux en la proximidad de los campos donde se realizan las aspersiones para caracterizar el grado de exposición tanto en las personas como en aguas superficiales.

En cuanto al análisis de los efectos del uso de glifosato y Cosmo-flux, surge una interrogante, es que no se conoce la concentración real de la formulación en la aplicación por aspersión para erradicar el cultivo. De acuerdo al modelo conceptual de la evaluación de riesgo, el grado de exposición esta en relación con la concentración de la formulación, por lo tanto las estimaciones de las exposiciones de personas de los estudios realizados en otros países carecen de validez con relación al lugar real de aplicación.

Los investigadores de la CICAD recomiendan "realizar estudios más específicos", lo que apoya nuestra aseveración de que el mencionado estudio no debe considerarse de ninguna manera como "concluyente". Más aún cuando parámetros como la Genotoxicidad apenas han sido mencionados, sin mayor análisis.

Hubiera sido de mucha utilidad que el monitoreo también se realizara en la zona nor-fronteriza ecuatoriana afectadas por las aspersiones que puedan servir de referencia para autoridades ecuatorianas.

Además se evidencia un efecto a los cultivos por la aspersión con una rápida recuperación de los cultivos de coca aspergeados por medio de la resiembra exitosa de coca, sin embargo los cultivos afectados en el Ecuador no se refiere a cultivos de coca, si no a cultivos que son el sustento diario de la población fronteriza, los cuales no son recuperados.

Por lo tanto se recomienda realizar los estudios en las zonas poblacionales directamente afectadas y siempre que exista un efecto hacia la salud, la evaluación de riesgo debe ser estudiado y demostrado científicamente.

Quito, a 2 de junio de 2005

Comisión Ecuatoriana de Energía Atómica. Laboratorio de análisis de Plaguicidas

Ramiro Castro Palacios
Químico

Ministerio de Salud Pública
Instituto Inquieta Pérez

Dr. Marcelo Chiriboga U.

Dra. Beatriz Vargas P.

Universidad Central del Ecuador

Dr. Luis Reinoso Garzón

Dr. Leonardo Lovato

Dr. Angelo Nicolalde

Ministerio de Ambiente

Santiago Salazar

Ing. Carlos Valencia

P.D. Este informe no tiene los aportes de los miembros de la CCTE representantes del OMS-OPS, ni del SESA.

ANNEX 154

United States Environmental Protection Agency, Office of Pesticide Programs, *CICAD Environmental and Human Health Assessment of the Aerial Spray Program for Coca and Poppy Control in Colombia (Ecological Effects Assessment)* (26 Oct. 2005)

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D. C. 20460

OFFICE OF
PREVENTION, PESTICIDES
AND TOXIC SUBSTANCES

MEMORANDUM October 26, 2005

SUBJECT: CICAD Environmental and Human Health Assessment of the Aerial Spray Program for Coca and Poppy Control in Colombia (Ecological Effects Assessment)

FROM: Thomas Steeger, Ph.D., Senior Biologist
Environmental Fate and Effects Division 7507C
Office of Pesticide Programs

THROUGH: Steven Bradbury, Ph.D., Director
Environmental Fate and Effects Division 7507C
Office of Pesticide Programs

TO: Jay Ellenberger, Associate Director
Field and External Affairs Division 7506C
Office of Pesticide Programs

The Environmental Fate and Effects Division (EFED) has completed its review of the report entitled "*Environmental and Human Health Assessment of the Aerial Spray Program for Coca and Poppy Control in Colombia*"[1] prepared by the Inter-American Drug Abuse Control Commission (CICAD) section of the Organization of American States. The review is confined to those portions of the report that addressed the potential effects of the herbicide glyphosate (N-phosphonomethyl glycine; CAS 1071-83-6) and on the combined effects of glyphosate and the adjuvant/surfactant Cosmo-Flux® to non-target animals based on expected use of the active ingredient and formulated product in the field. The suggestions made by Dr. Keith Solomon (Center for Toxicology, University of Guelph) in a separate document entitled "*Glyphosate/Roundup and frogs*" to address uncertainties identified in the CICAD report were also reviewed.

[1] Solomon, K., A. Anadón, A. L. Cerdeira, J. Marshall, and L. Luz-Helena Sanin. 2005. *Environmental and Human Health Assessment of the Aerial Spray Program for Coca and Poppy Control in Colombia*. A report prepared for the Inter-American Drug Abuse Control Commission (CICAD) section of the Organization of American States (OAS).

CICAD Report Review

The CICAD report concludes that relative to the major environmental impacts incurred from clear cutting forested habitat for coca and poppy production in Colombia, the ecological effects of glyphosate applications to eliminate such production areas are low. However, there are uncertainties regarding the potential effects in nontarget organisms from formulations of glyphosate and formulations of glyphosate containing Cosmo-Flux®. According to the CICAD report, the toxicity of glyphosate alone to plants and animals is low; however, for formulations of glyphosate containing the surfactant polyethoxylated tallowamine (POEA) or formulations of glyphosate with POEA in combination with Cosmo-Flux®, a nonionic surfactant composed of linear and aryl ethoxylated alcohols and liquid isoparafins[2], toxicity to plants and some animals is enhanced. The potential toxicity of glyphosate plus POEA or glyphosate/POEA in combination with Cosmo-Flux® to amphibians and in particular to frogs (anurans) is uncertain. To address this uncertainty, the report recommends conducting additional studies on the toxicity of the glyphosate/POEA/Cosmo-Flux® to African clawed frogs (*Xenopus laevis*), a common laboratory test species, and to anuran species indigenous to Colombia. Should the combination of exposure to and toxicity from particular formulations of glyphosate prove likely, the report recommends that a less toxic herbicide be considered.

Based on environmental fate data reviewed in the CICAD report, the authors conclude that glyphosate is not expected to be highly mobile in the environment given its propensity to sorb to sediments. The authors also conclude that with two applications of 4.99 kg/ha for coca and up to 4 applications of 1.2 kg/ha for poppy plant control each year, concentrations of glyphosate/POEA plus Cosmo-Flux® are expected to be high in shallow surface waters that are over-sprayed during application of the herbicide.

Although the CICAD report states that concentrations of glyphosate/POEA plus Cosmo-Flux® are expected to be high in shallow surface waters that are over-sprayed during application of the herbicide, the extent to which shallow surface waters and/or ephemeral pools are located in coca and poppy production areas and are subjected to over-spray is unknown. Also, the extent to which the active ingredient, surfactants and adjuvant remain in the same proportion as the original tank mix following aerial application is uncertain since degradation and dissipation of the herbicide mixture under tropical conditions is not well known. A study by Thompson *et al.*[3] indicates that application of a formulation of glyphosate typically used in forestry results in measured residues well below model estimates. However, to the extent that shallow surface water are contaminated, there is concern that these waters serve as breeding habitat for amphibians and thus represent a potential route of exposure for these animals.

Although the report concludes that glyphosate, glyphosate/POEA, and glyphosate/POEA in combination with Cosmo-Flux® are not acutely toxic to terrestrial animals (mammals and birds), the potential for acute toxicity to reptiles and terrestrial-phase amphibians is uncertain. While EPA considers toxicity data on birds protective for potential effects on reptiles and terrestrial-phase amphibians, studies by Relyea[4]

---

[2] http://www.cosmoagro.com/

[3] Thompson, D. G., B. F. Wojtaszek, B. Staznik, D. T. Chartrand, and G. R. Stephenson. *Chemical and Biomonitoring to Assess Potential Acute Effects of Vision Herbicide on Native Amphibian Larave in Forest Wetlands.* Environmental Toxicology and Chemistry 23(4): 843 - 849.

[4] Relyea, R. A. 2005a. *The Lethal Impact of Roundup on Aquatic and Terrestrial Amphibians.* Ecological Applications. 15(4): 1118-1124.

suggest that terrestrial-phase amphibians may be more sensitive than surrogate species to glyphosate/POEA and this uncertainty is not adequately addressed in the CICAD report. The Relyea study indicates that terrestrial-phase amphibians treated with glyphosate/POEA at a level equivalent to a direct application rate of 0.016 kg/ha, resulted in a 64% decrease in survival across all of the species tested after 24 hours. Although there are major uncertainties in the Relyea study that limit its utility in ecological risk assessment, the data suggest that terrestrial-phase amphibians may be sensitive to glyphosate formulations containing POEA on an acute exposure basis.

Based on the information presented in the CICAD report, aquatic animals appear to be relatively insensitive to glyphosate alone; however, there is considerable range in the sensitivity of nontarget organisms to formulations of glyphosate containing polyethoxylated tallowamines. Studies by Relyea[5,6], Relyea *et al.*[7] and Howe *et al.*[8] suggest that formulations of glyphosate containing polyethoxylated tallowamines are toxic to aquatic-phase amphibians and that the toxicity appears to be related to the developmental stage of the larvae[9]. These studies contain a number of uncertainties that limit their utility in ecological risk assessment for regulatory purposes; however, the studies suggest that under the conditions tested, formulations of glyphosate may adversely affect amphibian larvae and that the effects are primarily associated with the POEA surfactant.

In addition, toxicity testing with glyphosate/POEA in combination with Cosmo-Flux®, discussed in the CICAD report, indicates acute 96-hour median lethal concentrations (LC_{50}) ranging from 1.85 to 4.6 mg/L for freshwater animals and plants. Since the LC_{50} values are between 1 and 10 mg/L, glyphosate in combination with Cosmo-Flux® would be classified by EPA as moderately toxic to freshwater organisms on an acute exposure basis. Given the importance of these data in establishing the toxicity of the glyphosate/POEA product in combination with an adjuvant, it would be helpful to review the actual studies used to generate the toxicity estimates presented in the CICAD report.

As discussed below, the means to evaluate the potential risks of the formulated product to amphibians in the areas of Colombia that will be treated requires information on the spatial and temporal location of amphibians and their habitats in the context of projected use sites and timing of application. If the magnitude and extent of exposure to amphibians or their habitat is determined to be low, the generation of additional toxicity or fate data would likely not provide a significant reduction in the risk assessment uncertainty. If the magnitude and extent of exposure of the formulated product to amphibians or their habitat (*i.e.*, shallow waterbodies) is considered significant, further refinement of risk estimates, if required, could potentially be gained with better understanding of the toxicity of the formulated product and/or the degradation rates of the active ingredient and the remaining components within the formulated product.

---

[5] *Ibid* Relyea, R. A. 2005a..

[6] Relyea, R. A., 2005b. The Impact of Insecticides and Herbicides on the Biodiversity and Productivity of Aquatic Communities. Ecological Applications 15(2): 618 - 627.

[7] Relyea, R. A, N. M. Schoeppner and J. T. Hoverman. 2005. Pesticides and Amphibians: the Importance of Community Context. Ecological Applications 15(2): 1125 - 1134.

[8] Howe, C. M, M. Berrill, B. D. Pauli, C. C. Helbing, K. Werry and N. Veldhoen. 2004. Toxicity of Glyphosate-based Pesticides to Four North American Frog Species. Society of Environmental Toxicology and Chemistry 23(8): 1928 - 1938.

[9] Ibid Howe *et al.* 2004.

Review of Glyphosate and Frogs Report by K. Solomon

With respect to the recommendations made by Dr. Keith Solomon in an accompanying document to address uncertainties regarding the potential effects of glyphosate/POEA in combination with Cosmo-Flux® on frogs, the approach appears reasonable; however, additional information would be helpful to more fully evaluate the proposed approach for performing bioassays with *Xenopus laevis*. Presumably, the proposed study is designed to examine potential acute toxicity; however, studies by Relyea[10] and Howe *et al.*[11] suggest that chronic developmental effects may also occur in amphibians exposed to glyphosate/POEA. Although testing using anurans indigenous to Colombia is proposed, the logistics of conducting toxicity studies of indigenous [untested] species can be daunting and no discussion on techniques for collection or holding of these species is provided.

Additionally, the work conducted by Relyea[12] suggests that terrestrial-phase amphibians may also be sensitive to glyphosate in combination with POEA, however, toxicity testing using terrestrial-phase juvenile and/or adult frogs is not discussed. It must be noted that there are no standard toxicity testing methods for adult amphibians and if any such testing was deemed necessary careful consideration should be placed on the ecological relevancy of the exposure methods used in any proposed testing protocol. Before initiating studies of terrestrial-phase amphibians, it would be important to first establish the extent to which terrestrial-phase amphibians rely on coca/poppy production areas, *i.e.*, potentially clear-cut areas. Presumably though, if aquatic-phase amphibians are present in surface waters, the adults that spawned them must be in relatively close proximity. Whether surrounding untreated forested areas would be sufficiently close to serve as a refuge for these animals, as the CICAD report suggests, is uncertain.

The CICAD report and the subsequent recommendations made for additional studies to address ecological uncertainties outline what may involve considerable time and resources to establish the extent of exposure to glyphosate and its potential effects on amphibians. Generating these data will not guarantee that the information provided by the studies will be sufficiently conclusive to reduce uncertainties in the assessment or to mitigate potential risk. An effort to collect existing published information on amphibian presence in likely treatment areas could provide useful insights on potential exposure scenarios with a reasonable investment of time and resources. Geographical Information System (GIS) coverages may be available to establish the extent in overlap between known species ranges and potential treatment sites. If there is no overlap between the occurrence of amphibians considered to be at risk and potential and/or existing treatment sites, then the need for determining exposure and effects to amphibians from the use of glyphosate to control coca and poppy production may not represent high priorities.

---

[10] *Ibid* Relya. R. A. 2005a.

[11] *Ibid* Howe *et al.* 2004.

[12] *Ibid* Relyea 2005a.

ANNEX 155

Inter-American Drug Abuse Control Commission (CICAD),
Interim Report on Follow-Up Studies: Environmental and Human Health Assessment of the Aerial Spray Program for Coca and Poppy Control in Colombia (July 2006)

INTERIM REPORT ON FOLLOW-UP STUDIES: ENVIRONMENTAL AND HUMAN HEALTH ASSESSMENT OF THE AERIAL SPRAY PROGRAM FOR COCA AND POPPY CONTROL IN COLOMBIA

July 2006

1 INTRODUCTION

There are several environmental and human health issues with respect to the production and eradication of coca in Colombia that were identified as needing further investigation to reduce uncertainty and to fill in data gaps. These issues relate to spray drift, which has not been measured under conditions of use in Colombia, toxicity to amphibians of glyphosate and other pesticides used by growers of illicit crops, risks to amphibians of production and eradication of illicit crops. The following are the proposals to address these research needs and a summary of the results.

The proposed studies are summarized in Table 1 and those that are underway or completed are described in more detail in the following sections. Progress to date is highlighted in ***bold italics***. The order of presentation is more or less chronologic.

Table 1. Summary of proposed follow-up studies related to the spray eradication program in Colombia

Study	Comment	Start	Likely completion
T1. Frog toxicity studies	This is an acute toxicity study of glyphosate+Cosmo-Flux® to *Xenopus laevis* at two rates, one for coca, and one for poppy. The good laboratory practice (GLP) study was conducted by Wildlife International and is partially completed. Hypothesis – the mixture is not differently toxic from formulated glyphosate alone. ***The results of toxicity studies with the spray mix show that some risks of adverse effects in frogs as sensitive as X. laevis in shallow waters. See below for further discussion of the results and their implication.***	Mar 20	Completed, May 26, 2006
T2. Toxicity of pesticides used by coca growers to amphibians and the effects of habitat alteration on amphibians.	This study is important to conduct as it will allow the potential effects of the eradication spraying on amphibians to be compared to the effects of the other pesticides used by growers, the effects of clear-cutting, the effects of a monoculture, the effects of reductions in food supply, and potential spread of diseases on frogs. Hypotheses – the risks to amphibians from eradication spraying are the same as those from all of the processes and procedures used by	Apr 15, 2006	Completed, May 30, 2006

Table 1. Summary of proposed follow-up studies related to the spray eradication program in Colombia			
Study	**Comment**	**Start**	**Likely com-pletion**
	growers of illicit crops. ***This study is underway and will be completed by the end of May. See below for initial conclusions.***		
M1. Preliminary feasibility study of mapping of shallow water habitat for amphibians in coca fields.	This study will require satellite images that can distinguish and identify shallow water with emergent vegetation. Hypothesis – all coca fields in all regions have shallow surface water that is suitable as frog habitat. It is a preliminary study to test the feasibility of using satellite imagery for this purpose. ***Initial analysis of satellite images in the study have been hampered by a lack of ground-based wetland data to calibrate the satellite images against. Field verification of specific locations with high enough GPS resolution has been difficult because of the difficulties of linking GPS data to images taken from helicopters.***	Mar 1 2006	Apr 30 2006
M2. Mapping of shallow water habitat for amphibians in coca fields.	This study will be a follow-up to the above preliminary study. Hypothesis – all coca fields in all regions have shallow surface water that is suitable as frog habitat. This study will use satellite imagery, or if this is not feasible, will require that the Gyrocam is operational and is being used to evaluate efficacy of the spray program. It will also require that the operators and evaluators are able to identify potential habitat. Once all fields have been categorized once, only new fields will have to be evaluated as these are established. ***This process will require that the location data of the images on the Gyrocam be directly linked to GPS locations of the image rather than the location of the aircraft. It is not known how long this will take to implement.***	Jun 2006	????
M3. Distribution of Colombian frogs in relation to spray programs	Will require person(s) in Colombia with local knowledge. Hypothesis – populations of rare, threatened, and endangered frogs in Colombia are only found in areas where coca is being produced and is sprayed for eradication purposes. Discussions are underway to identify the appropriate people. ***This work is important as it will allow the association between the growing of coca and poppy and adverse effects on amphibians to be better characterized.***	Sep 1, 2006	Mar31, 2007
T3. Toxicity of glyphosate to	Will require a person in Colombia with local knowledge and the ability to raise frogs in the	Dec 1, 2006	Dec 31, 2007

Table 1. Summary of proposed follow-up studies related to the spray eradication program in Colombia

Study	Comment	Start	Likely com-pletion
Colombian frogs (tadpoles and terrestrial juveniles).	laboratory. Hypotheses – frogs from Colombia are not differently sensitive to glyphosate and Cosmo-Flux® than frogs from other countries. ***We now know that the glyphosate-Cosmo-Flux® mixture as used in Colombia is toxic to the most sensitive frog species (X. laevis) and that the spray mixtures would present a risk to frogs as sensitive as this species. However, other frogs are less sensitive than X. laevis and it is necessary to further characterize the toxicity of the mixture and allow testing of the hypothesis that Colombian frogs and frogs from other countries have similar sensitivity to glyphosate as well as to characterize toxicity to adult frogs, an issue that has particular relevance to Colombian frogs. Potential collaborators have been identified and study plans are being discussed.***		
T4. Field studies where frogs are exposed under field conditions to a direct overspray in a coca field	Will require person in Colombia with local expertise and availability of a test species of frog that has also been tested in the laboratory. In addition, a test field plot will be needed. Hypothesis – frogs are equally sensitive to glyphosate and Cosmo-Flux® in the field as in the laboratory. ***The initiation of this study would depend on the results of T3, above but could be important as it would give information on responses under realistic conditions where adsorption to sediments will reduce biologically available concentrations and may negate risks to amphibians.***	Jan 2007	Jun 2007
E1. Testing of other adjuvants for formulated glyphosate that are equally efficacious but are less toxic to aquatic organisms.	Will require mature coca plants in a secure site in Colombia and potential products selected for likely low toxicity. Hypothesis – other adjuvants are as efficacious for coca control as is Cosmo-Flux®. Products that are as good as or better than Cosmo-Flux® will be further tested to identify products less hazardous to aquatic organisms. This study will require a field site. It is assumed that the test plots will be ready in Jan 2007. ***This study will allow us to identify mixtures of glyphosate and adjuvants that allow a reduction in the amounts of glyphosate needed in the eradication program. This would allow reductions in application rates would reduce risks of off-target effects and reduce the overall risk of the program. A site***	Jan 1 2007	Jun 30 2007

Table 1. Summary of proposed follow-up studies related to the spray eradication program in Colombia			
Study	**Comment**	**Start**	**Likely com-pletion**
	for the project is available at Pijaos (in Tolima) and preparations for the field work have been started.		
T 5. Toxicity testing of new adjuvants.	If more effective adjuvants are identified, these will be tested with formulated glyphosate to determine toxicity to the standard suite of aquatic test organisms (fathead minnow, rainbow trout, *Daphnia*, algae) and to the African clawed frog, *Xenopus laevis*. Hypothesis – there is no difference in toxicity between glyphosate + Cosmo-Flux® and glyphosate + other formulants and adjuvants. ***The need for this study is dependent on the results of E1, above.***	Jun 2007	Dec 2007
S1. Spray drift study – spray droplet spectrum.	This study will be conducted in a wind-tunnel in Australia to characterize the spray droplet spectrum for the nozzles and speed of spraying in Colombia. These data will be used to better model spray drift under conditions of use in Colombia and to determine whether a surrogate for spray can be used to measure spray drift under actual conditions of use in Colombia. ***This study will proceed as soon as the contract has been finalized.***	Aug 2006	Nov 2006
S2. Spray drift study in Colombia.	A field experiment will be conducted with aerial application of a surrogate mix for glyphosate + Cosmo-Flux® under conditions in Colombia to determine spray drift. Water-sensitive paper and/or a spray dye will be used to assess off-target drift. Hypothesis – modeled spray drift is the same as measured spray drift. ***This study requires the completion of S1.***	Jan 2007	Apr 2007
Human health effects of eradication spraying using the "comet" assay on human lymphocytes	A protocol has been developed and will assess genotoxicity using the comet assay on lymphocytes from people in 5 areas previously identified in the 2004 epidemiology study. Blood samples will be taken prior to, about 5 days after, and 5 months after spraying. Other areas of Colombia will be used as control regions. Hypotheses – genetic effects in human lymphocytes in people from areas of coca spraying are not different from those in areas where no spraying is undertaken and there is no correlation between genetic effects in lymphocytes and closeness to the sprayed fields. ***The training of personnel as begun and the study will be initiated in August.***	Aug 2006	Aug 2007

2 FROG TOXICITY STUDIES

2.1 TOXICITY TESTS WITH XENOPUS LAEVIS

The toxicity of the spray mix as used in Colombia was tested in *Xenopus laevis* tadpoles. Previous studies had shown that larvae of *X. laevis* were the most sensitive frog species to formulated glyphosate (Edginton et al. 2004) and suggested that they may be a good indicator organism for this purpose. Tests were conducted by Wildlife International (2006a, 2006b) under GLP. Acute toxicity of Glyphosate-Cosmo-Flux® - coca and poppy mixtures as taken from the tanks of spray aircraft were determined in African clawed-frog (*X. laevis*) tadpoles during a 96-hour exposure period under static-renewal test conditions. African clawed frog tadpoles used in the test were obtained from *Xenopus* One, Dexter, Michigan and were tested at Gosner stage 25. Before and during testing, frogs were held at 22 ± 1°C with 16 h light, 8 h darkness. Test concentrations were 1.3, 2.5, 5.0, 10, and 20 mg Spray Mixture/L and were renewed every 24 h during the 96 h test. Test solutions were sampled at 0, 24 (just prior to renewal), and 96 h at the completion of the test and analyzed for glyphosate using standard methods. Tadpoles were observed at 4, 24, 48, 72, and 96 hours after test initiation for signs of distress and mortality. Measured concentrations of the glyphosate in the mix were close to nominal values. Most of the mortality occurred in the first 24 h of exposure and the concentration-response curves were steep, an observation consistent with the literature (Edginton et al. 2004, Perkins 1997).

The toxicity of the spray mix as used in Colombia to *X. laevis* and margins of safety over a number of estimated worst-case field concentrations used in the initial risk assessment (Solomon et al. 2005) are shown in Tables 2 and 3. The most likely scenario is shown in Bold in both Tables.

Table 2. Estimates of worst case concentrations of glyphosate in surface water of various depths and scenarios after a spray application to coca (sprayed at 4.992 kg/ha = 3.69 kg AE/ha), toxicity values for *X. laevis* larvae (Gosner stage 25) to the spray mixture, and margins of exposure.

Scenario	Exposure concentration in µg AE/L	Margin of exposure (safety) for 96-h LC50	Margin of exposure (safety) for 96-h NOEC
Toxicity of the spray mixture (median lethal concentration, LC50) over 96 h).	1,100		
Toxicity of the spray mixture (96-h no-observed effect concentration, NOEC).	140		
Surface water, 2 m deep, rapid mixing and no absorption to sediments, no flow.	185	5.9	0.8

Table 2. Estimates of worst case concentrations of glyphosate in surface water of various depths and scenarios after a spray application to coca (sprayed at 4.992 kg/ha = 3.69 kg AE/ha), toxicity values for *X. laevis* larvae (Gosner stage 25) to the spray mixture, and margins of exposure.

Scenario	Exposure concentration in µg AE/L	Margin of exposure (safety) for 96-h LC50	Margin of exposure (safety) for 96-h NOEC
Surface water, 0.3 m deep, rapid mixing and no absorption to sediments, no flow.	1,229	0.9	0.1
Surface water, 0.15 m deep, rapid mixing and no absorption to sediments, no flow.	2,473	0.4	0.1
Surface water, 0.15 m deep, rapid mixing and 50% absorption to sediments, no flow.	**1,237**	**0.9**	**0.1**

Table 3. Estimates of worst case concentrations of glyphosate in surface water of various depths and scenarios after a spray application to poppy (sprayed at 1.2 kg/ha = 0.89 kg AE/ha), toxicity values for *X. laevis* larvae (Gosner stage 25) to the spray mixture, and margins of exposure.

Scenario	Exposure concentration in µg AE/L	Margin of exposure (safety) for 96-h LC50	Margin of exposure (safety) for 96-h NOEC
Toxicity of the spray mixture (median lethal concentration, LC50) over 96 h).	1,300		
Toxicity of the spray mixture (96-h no-observed effect concentration, NOEC).	440		
Surface water, 2 m deep, rapid mixing and no absorption to sediments, no flow.	44	29.5	10.0
Surface water, 0.3 m deep, rapid mixing and no absorption to sediments, no flow.	296	4.4	1.5
Surface water, 0.15 m deep, rapid mixing and no absorption to sediments, no flow.	595	2.2	0.7
Surface water, 0.15 m deep, rapid mixing and 50% absorption to sediments, no flow.	**297**	**4.4**	**1.5**

Toxicity values for the spray mixture were somewhat less than those reported for the glyphosate formulation, Vision®, by Edginton et al. (2004). The coca mix was somewhat more toxic (lower LC50) than the poppy mix; however, the difference between the two in terms of glyphosate AE was not large.

For coca application rates, for estimated exposure scenarios (Solomon et al. 2005) suggested low hazards for water bodies ≥2m deep but margins of exposure were <1 for estimated worst-case concentrations in water bodies of smaller depths (Table 2). The most likely scenario is judged to be water 0.15 m deep, rapid mixing and 50% absorption to sediments, no flow. This suggests that under worst case exposure conditions, some hazards exist for frogs as sensitive as or more sensitive than *X. laevis*. However, exposures to both the glyphosate and the surfactants under field conditions would likely be shorter and smaller as they have been shown to adsorb strongly to sediments with half-lives in the water column of the order of ½ day (Giesy et al. 2000, Wang et al. 2005). Hazards would also be smaller in flowing waters where dilution would reduce exposure concentration and duration.

For poppy application rates, margins of exposure existed for all estimated exposure concentrations for both the LC50 and the NOEC, except for the surface water scenario, 0.15 m deep with no flow, rapid mixing, and no absorption to sediments, where the margin of safety was <1. Overall, these data do not suggest hazards for frogs from poppy spraying unless these species are very much more sensitive than *X. laevis*. These hazards would be further reduced by adsorption to sediments (the likely scenario) and by flow dilution.

In summary, the results of toxicity tests in tadpoles of *Xenopus laevis*, the most sensitive frog species to formulated glyphosate, do not suggest adverse effects on amphibians from spraying poppy with the mixture of glyphosate and Cosmo-Flux®. For the spraying of coca, there is a possibility of adverse effects in amphibians that are more sensitive than *X. laevis*. This uncertainty can be addressed by conducting toxicity tests with Colombian species under laboratory and field conditions.

Neither coca nor opium poppy grows in wet soil such as that found in wetlands, marshes, and ponds used by the aquatic stages of amphibians. The spray mixture would therefore pose very little risk to these amphibians when accurately applied. Risk only occurs to the degree that 1) amphibian habitat is located in close proximity, or among, sprayed areas; and 2) accidental overspray or spray drift causes contamination of aquatic area used by amphibians. How often these two factors coincide is not well known, but anecdotal evidence such as the dry topography of typical crop growing regions, the environmental protocol of the spray program (which only allows spraying in low wind conditions - <8 km/h), the lack of mobility of glyphosate in the environment, and the accuracy of the spray program, all suggest that it is likely not common. Leaf-litter breeding frogs will likely be protected from the spray by the litter and organic matter covering of the eggs.

Nevertheless, for the purposes of conducting an assessment of the worst possible case exposures, we must assume that these factors do coincide, however rarely, and that Colombian frogs are exposed to the spray mixture at concentrations ranging from near zero to the worst case concentrations shown in Tables 2 and 3. By employing the frog species most sensitive to glyphosate (*Xenopus laevis*), and exposing this species to the spray mixture for 96 hours at its most sensitive life stage, we are studying conditions which would likely occur infrequently in the environment but which provide a useful benchmark for determining maximum possible risk. Several of the projects listed in Table 1 will add additional data and reduce our uncertainty about both toxicity to frogs and their distribution in relation to the frog program.

2.2 *HAZARDS OF GLYPHOSATE, OTHER PESTICIDES, AND OTHER HUMAN ACTIVITIES TO FROGS*

The potential toxic effects of glyphosate on frogs and other amphibians should be considered in the context of the effects of other pesticides and activities involved with the production of the coca and the poppy crops. The following is a summary of a separate, more detailed report (Brain 2006).

2.2.1 Direct effects of other pesticides

Several pesticides are used in the production of coca and poppy in Colombia (CICAD/OAS 2005). A search of the ECOTOX database and other literature showed that several of these pesticides are more toxic to frogs than formulated glyphosate or the glyphosate-Cosmo-Flux® mixture as used in Colombia ((CICAD/OAS 2006). These data are summarized in **Figure 1**.

The data show that several of the pesticides used in the production of coca and poppy are as toxic or more toxic to amphibians than the glyphosate-Cosmo-Flux® mixture used in Colombia. Endosulfan and diazinon are several orders of magnitude more toxic to frogs than the mixture and the detection of endosulfan in surface waters from coca-growing regions in Colombia show that it is being used and may have significant direct adverse effects on amphibians.

Reports from the literature provide support for the possible adverse effects of these insecticides on frogs. Analysis of historical pesticide application data has linked organophosphorus and carbamate insecticides with the declines of four Californian amphibians (Davidson 2004).

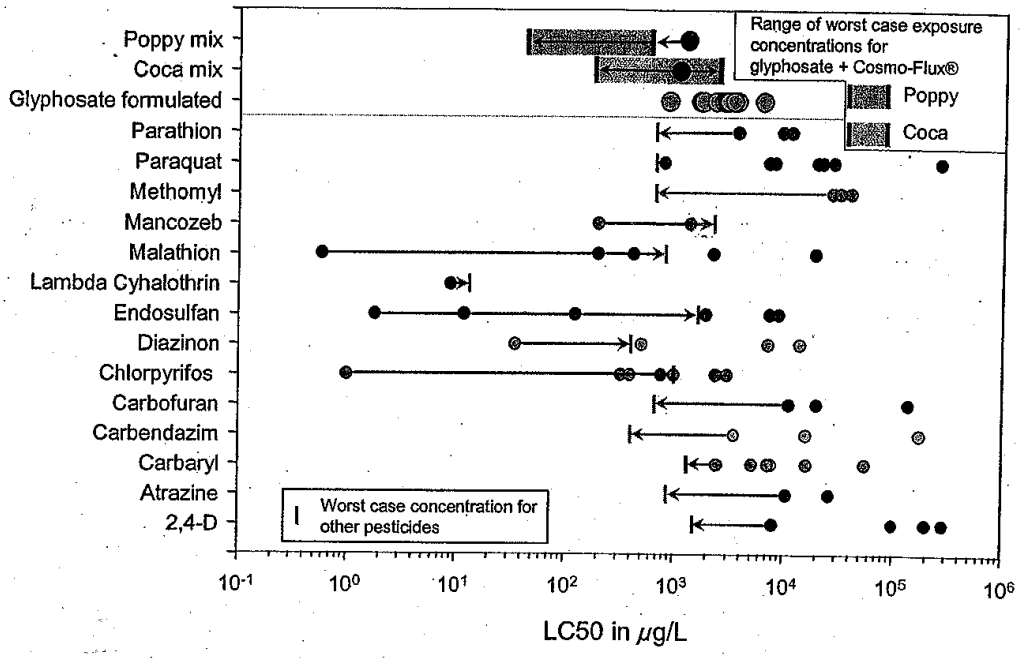


Figure 1. Toxicity of glyphosate and Cosmo-Flux® spray mixture, glyphosate, and other pesticides used in the production of coca and poppy to amphibians. The data for the two mixtures of glyphosate and Cosmo-Flux® are from tests in *Xenopus laevis*, those for formulated glyphosate (mostly Roundup® and Vision®) and the other pesticides are from several species of frogs and other amphibians. Each point on the graph is a different species of amphibian. Glyphosate data are all normalized to acid equivalents (AE), other data are given as active ingredient (AI). Green horizontal arrows indicate margins of safety between LC50 concentrations for *X. laevis* (glyphosate) or the most sensitive species (other products) and estimated exposure, red arrows, lack of margin of safety.

2.2.2 Indirect effects of other pesticides

Many of the pesticides used in the production of poppy and coca are insecticides (CICAD/OAS 2004, 2005). Use of these insecticides to protect coca and poppy from insect damage will kill insects that are also food items for adult frogs that utilize the coca and poppy fields as habitat. Thus, while some of the insecticides have little direct toxicity to the frogs, they may have adverse effects through reducing the availability of food.

2.2.3 Effects of habitat alteration on amphibians

There are many factors that may adversely affect frogs and be the cause of the reported declines in populations and extinctions. Several of these are discussed in more detail in a separate report (Brain 2006). A recent Global Amphibian Assessment suggests that as many as a third of amphibian species (> 5,700) have undergone severe declines or extinction with many species on the brink of extinction (Stuart et al. 2004). Historical data indicate that amphibian declines began in the 1970s in Northern Australia (Blaustein et al. 2003), Western United States (Drost and Fellers 1996, Sherman and

Morton 1993) and Puerto Rico (Burrowes et al. 2004). Many extinctions and declines took place in seemingly pristine and often montane areas (Pounds and Crump 1994, Pounds et al. 1997, Young et al. 2001).

The production of coca and poppy has significant effects on habitat. In many cases, fields are located in pristine areas where natural tropical forest has been cleared by slash and burn techniques. Loss of habitat has resulted in several species of frogs being driven to the brink of extinction. For example, loss of migration routes has been implicated as a major cause for the reductions in the populations of two north American frogs (*Bufo baxteri* and *Bufo houstonensis*) to single populations (United States Fish and Wildlife Service 1984, 2001).

Other human activities have been suggested as being partly responsible for the extinction of frogs. These range from increased exposure to ultraviolet radiation resulting from the release of substances which deplete stratospheric ozone through the spread of diseases and the interaction of these with climate change. Of these, one fungal disease, chytridiomycosis, has been associated with extinctions of frogs. This disease was first described from dead and dieing frogs at sites of mass deaths in Australia and Panama from 1993 to 1998 (Berger et al. 1998). The chytrid that infected the Australian and Central American amphibians was identified as *Batrachochytrium dendrobatidis*, which has low host specificity and is likely to infect any species of amphibian. Infections have been detected in 15 amphibian families that include 94 species (Speare 2001). Amphibian chytridiomycosis is an emerging infectious disease of amphibians and has been recognized as such on a global scale (Daszak et al. 1999, Daszak et al. 2003), has been identified as a key threatening process under the Environment Protection and Biodiversity Conservation Act 1999 of New Zealand (Speare 2001), and further discussed in the development of an Amphibian Conservation Action Plan (Mendelson et al. 2006).

While chytridiomycosis has not been described from frogs in coca-growing areas of Colombia, humans are potential vectors of the disease though the carrying of spores on clothing and equipment (Krajick 2006). Thus, human activities in the growing of coca and poppy in remote areas may increase the spread of this disease to new areas of Colombia. The effects of this on rare or endangered species of amphibians in Colombia are potentially serious.

In summary, there are a number of human activities associated with the production of coca and poppy that present greater risks to amphibians than the glyphosate + Cosmo-Flux® mixture used in the aerial eradication spraying. This must be considered in the assessment of the overall risk and risk benefit analysis.

3 REFERENCES

Berger L, Speare R, Daszak P, Green DE, Cunningham AA, Goggin CL, Slocombe R, Ragan MA, Hyatt AD, McDonald KR, Hines HB, Lips KR, Marantelli G, Parkes H. 1998. Chytridiomycosis causes amphibian mortality associated with population

declines in the rain forests of Australia and Central America. *Proceedings of the National Academy of Science of the United States of America* 95:9031-9036.

Blaustein AR, Romansic JM, Kiesecker JM, Hatch AC. 2003. Ultraviolet radiation, toxic chemicals and amphibian population declines. *Diversity and Distributions* 9:123–140.

Brain RA. 2006. Hazards of Glyphosate, Other Pesticides, and Other Human Activities to Amphibians. Guelph, ON, Canada: Centre for Toxicology, University of Guelph. OAS/CICAD 2006-6-1.

Burrowes PA, Joglar RL, Green DE. 2004. Potential causes for amphibian declines in Puerto Rico. *Herpetologica* 60:141-154.

CICAD/OAS. 2004. The Toxicology of Chemicals Used in the Production and Refining of Cocaine and Heroin: A Tier-one Assessment. Washington, DC, USA: CICAD, Organization of American States. OAS/CICAD 2004-01. 536 p

CICAD/OAS. 2005. The Toxicology of Selected Chemicals Used in the Production and Refining of Cocaine and Heroin: A Tier-two Assessment. Washington, DC, USA: CICAD, Organization of American States. OAS/CICAD 2005-01. x + 35 + 427 p http://www.cicad.oas.org/Desarrollo_Alternativo/ENG/Projects%20By%20Country/Colombia/OAS_CICAD_Tier_2_Hazard_Assessment_July_2005%5B1%5D.pdf

CICAD/OAS. 2006. The Toxicity of Pesticides Used in the Production of Cocaine and Heroin to Amphibians: A Review. Washington, DC, USA: CICAD, Organization of American States. OAS/CICAD 2005-01.

Daszak P, Berger L, Cunningham AA, Hyatt AD, Green DE, Speare R. 1999. Emerging infectious diseases and amphibian population declines. *Emerging Infectious Diseases* 5:745-748.

Daszak P, Cunningham AA, Hyatt AD. 2003. Infectious disease and amphibian population declines. *Diversity and Distributions* 9:141-150.

Davidson C. 2004. Declining downwind: Amphibian population declines in California and historical pesticide use. *Ecological Applications* 14:1892-1902.

Drost CA, Fellers GM. 1996. Collapse of a regional frog fauna in the Yosemite area of the California Sierra Nevada, USA. *Conservation Biology* 10:410-425.

Edginton AN, Sheridan PM, Stephenson GR, Thompson DG, Boermans HJ. 2004. Comparative effects of pH and Vision herbicide on two life stages of four anuran amphibian species. *Environmental Toxicology and Chemistry* 23:815-822.

Giesy JP, Dobson S, Solomon KR. 2000. Ecotoxicological risk assessment for Roundup® herbicide. *Reviews of Environmental Contamination and Toxicology* 167:35-120.

Krajick K. 2006. The lost world of the Kihansi toad. *Science* 311:1230-1232.

Mendelson JR, III, Lips KR, Gagliardo RW, Rabb GB, Collins JP, Diffendorfer JE, Daszak P, Ibáñez D R, Zippel KC, Lawson DP, Wright KM, Stuart SN, Gascon C, da Silva HR, Burrowes PA, Joglar RL, La Marca E, Lötters S, du Preez LH, Weldon C, Hyatt A, Rodriguez-Mahecha JV, Hunt S, Robertson H, Lock B, Raxworthy CJ, Frost DR, Lacy RC, Alford RA, Campbell JA, Parra-Olea G, Bolaños F, Domingo JJC, Halliday T, Murphy JB, Wake MH, Coloma LA, Kuzmin SL, Price MS, Howell KM, Lau M, Pethiyagoda R, Boone M, Lannoo MJ,

Blaustein AR, Dobson A, Griffiths RA, Crump ML, Wake DB, Brodie ED, Jr. 2006. Confronting amphibian declines and extinctions. *Science* 313:48.

Perkins MJ. 1997. Effects of two formulations of glyphosate and triclopyr on four non-target species: *Xenopus laevis, Myriophyllum sibericum, Lemna gibba and Tubifex tubifex.* [MSc thesis]. Guelph: University of Guelph. 93 p.

Pounds JA, Crump ML. 1994. Amphibian declines and climate disturbance: The case of the golden toad and the harlequin frog. *Conservation Biology* 8:72-85.

Pounds JA, Fogden MPL, Savage JM, Gorman GC. 1997. Tests of null models for amphibian declines on a tropical mountain. *Conservation Biology* 11:1307-1322.

Sherman CK, Morton ML. 1993. Population declines of Yosemite toads in the eastern Sierra Nevada of California. *Journal of Herpetology* 27:186-198.

Solomon KR, Anadón A, Cerdeira A, Marshall J, Sanin L-H. 2005. Environmental and human health assessment of the aerial spray program for coca and poppy control in Colombia. Washington, DC, USA: Inter-American Drug Abuse Control Commission (CICAD) section of the Organization of American States (OAS). 121 p http://www.cicad.oas.org/en/glifosateFinalReport.pdf.

Speare R. 2001. Recommendations from Workshop in Getting the Jump on Amphibian Disease. In: Speare R, editor. Getting the Jump on Amphibian Disease Developing management strategies to control amphibian diseases: Decreasing the risks due to communicable diseases. Townsville, NZ: School of Public Health and Tropical Medicine, James Cook University. p 131-147.

Stuart SN, Chanson JS, Cox NA, Young BE, Rodrigues ASL, Fischman DL, Waller RW. 2004. Status and trends of amphibian declines and extinctions worldwide. *Science* 306:1783-1786.

United States Fish and Wildlife Service. 1984. Houston Toad Recovery Plan. Albuquerque, NM: United States Fish & Wildlife. 72 p

United States Fish and Wildlife Service. 2001. Wyoming Toad (*Bufo baxteri*) Population and Habitat Viability Assessment (PHVA). Laramie, WY, USA: United States Fish and Wildlife Service. 7 p

Wang N, Besser JM, Buckler DR, Honegger JL, Ingersoll CG, Johnson BT, Kurtzweil ML, MacGregor J, McKee MJ. 2005. Influence of sediment on the fate and toxicity of a polyethoxylated tallowamine surfactant system (MON 0818) in aquatic microcosms. *Chemosphere* 59:545-551.

Wildlife International. 2006a. Glyphosate-Cosmo-Flux® - Coca Mix: A 96-Hour Static-Renewal Acute Toxicity Test with the African Clawed-Frog Tadpole (*Xenopus laevis*). Final Report. Easton, MD, USA: Wildlife International. 628A-101. 42 p

Wildlife International. 2006b. Glyphosate-Cosmo-Flux® - Poppy Mix: A 96-Hour Static-Renewal Acute Toxicity Test with the African Clawed-Frog Tadpole (*Xenopus laevis*). Final Report. Easton, MD, USA: Wildlife International. 628A-102. 42 p

Young BE, Lips KR, Reaser JK, Ibáñez R, Salas AW, Cedeño JR, Coloma LA, Ron S, La Marca E, Meyer JR, Muñoz A, Bolaños F, Chaves G, Romo D. 2001. Population declines and priorities for amphibian conservation in Latin America. *Conservation Biology* 15:1213-1223.

ANNEX 156

United States Department of State,
Report to Congress: A Preliminary Evaluation of the Risk Posed to Colombia's Amphibians and Threatened Species by the Government of Colombia's U.S.-Supported Program of Aerial Eradication of Illicit Crops (Aug. 2006)

Report to Congress

A Preliminary Evaluation of the Risk Posed to Colombia's Amphibians and Threatened Species by the Government of Colombia's U.S.-Supported Program of Aerial Eradication of Illicit Crops

Submitted to the Congress by the Secretary of State
Pursuant to Senate Report 109-96 accompanying the Department of State, Foreign Operations, and Related Programs Appropriations Bill, 2006
(P.L. 109-102).

August 2006

Prepared by the U.S. Department of State

This report is submitted in accordance with Senate Report 109-96 accompanying the Department of State, Foreign Operations, and Related Programs Appropriations Bill, 2006 (P.L. 109-102), which states in part:

"The Committee directs the Secretary of State, in consultation with the EPA and appropriate Colombian authorities, to submit a report not later than 180 days after enactment of the Act, with the following information: the results of a GIS analysis of the proximity of small, shallow water bodies to coca and poppy fields and of tests to determine the toxicity of the spray mixture to Colombian amphibians; and, an assessment of potential impacts of the spray program on threatened species, including in Colombia's national parks."

The Organization of American States' Inter-American Drug Abuse Control Commission (CICAD) conducted the scientific work in response to the Committee directive. The resulting report, "Interim Report on Follow-Up Studies: Environmental and Human Health Assessment of the Aerial Spray Program for Coca and Poppy Control in Colombia" is attached. The report concludes that 1) cartography of Colombia's remote regions where illicit crops are typically grown is insufficient to allow the kind of GIS mapping contemplated in the Senate Report language (though other resources are available), and 2) the spray mixture is moderately toxic to the African clawed frog, which was chosen as an indicator species because, although it does not occur in Colombia, it is known to be the most sensitive frog species to glyphosate (the herbicide used in the spray mixture). This provides baseline toxicity data for planned studies with frogs that actually live in Colombia.

This Interim Report follows a March 2005 CICAD report on the spray program which concluded that "the risks to humans and human health from the use of glyphosate and (the surfactant) Cosmo-Flux in the eradication of coca and poppy in Colombia were minimal" and that "the risks to the environment from the use of glyphosate and Cosmo-Flux . . . were small in most circumstances." Also included with the CICAD Interim Report is the CICAD-sponsored report "Hazards of Glyphosate, Other Pesticides, and Other Human Activities to Amphibians", which concludes that "the cumulative impacts of coca production, through habitat destruction and chemical application, are judged to pose greater risk to amphibian populations in coca growing regions than the spray control program."

Background:

CICAD's March 2005 report identified a potential moderate risk to aquatic organisms that live in small, shallow water bodies proximate to illicit crops which are accidentally sprayed in the course of crop eradication operations. That report concluded, however, that "when taken in the context of the environmental risks from other activities associated with the production of coca and poppy, in particular the uncontrolled and unplanned clearing of pristine lands in ecologically important areas for the purposes of planting the crop, the added risks associated with the spray program are minimal." It recommended, however, that the risk to aquatic organisms could be further quantified by a) conducting a geographic information system (GIS) analysis of coca and poppy field locations to try to understand the degree to which these fields coincide with real and potential amphibian habitat, and b) testing of the actual spray mixture for toxicity to amphibians.

Similarly, the Senate Report request consists of three components: 1) a GIS analysis of the proximity of small, shallow water bodies to coca and poppy fields, 2) an analysis of the toxicity of the spray mixture to Colombian amphibians, and 3) an assessment of potential impacts of the spray program on threatened species. The following provides context for reading, in the attached Interim Report, the results of the work performed by CICAD in support of this request.

GIS Analysis - An effective GIS analysis as contemplated in the March 2005 CICAD report and in the Senate request has not been possible because a) Colombian maps do not contain sufficient detail and resolution to undertake an analysis of small, shallow water bodies in and around areas where coca is grown (which is mostly in Colombia's remote, Texas-sized southern and eastern regions); and b) water bodies capable of sustaining amphibian habitat can be so small and fleeting as to be impossible to accurately document. A pond can exist for a month or two during the rainy season and not be seen again for many more months. Even large-scale improvements to available mapping information in Colombia would not overcome this challenge.

The CICAD team therefore proposes to use tools other than GIS mapping to attempt to quantify the proximity of amphibian habitat to spray areas. These tools include using a high-definition video camera currently mounted on a Cessna C-208 aircraft operated by the Colombia National Police, and employing local Colombian amphibian experts. As the enclosed Interim Report indicates, both of these efforts are underway but not yet completed.

Nevertheless, even without GIS analysis, CICAD's assessment draws on anecdotal evidence to analyze the issue of coincidence of illicit crops and amphibian habitat in general terms. CICAD concluded in their report (p. 7) that:

> *"Neither coca nor opium poppy grows in wet soil such as that found in wetlands, marshes, and ponds used by the aquatic stages of amphibians. The spray mixture would therefore pose very little risk to these amphibians when accurately applied. Risk only occurs to the degree that 1) amphibian habitat is located in close proximity, or among, sprayed areas; and 2) accidental overspray or spray drift causes contamination of aquatic areas used by amphibians. How often these two factors coincide is not well known, but anecdotal evidence such as the dry topography of typical crop growing regions, the environmental protocol of the spray program (which only allows spraying in low wind conditions - <8 km/h), the lack of mobility of glyphosate in the environment, and the accuracy of the spray program, all suggest that it is likely not common. Leaf-litter breeding frogs will likely be protected from the spray by the litter and organic matter covering of the eggs."*

It is worth noting here that Colombia's most significant wetlands - those it has registered on the Ramsar List of Wetlands of International Importance (the International Convention on Wetlands signed in Ramsar, Iran, in 1971) - do not coincide with illicit crop cultivation. Those wetlands are:

- Delta del Río Baudó, in Chocó department (8,888 hectares)
- Laguna de la Cocha, in Nariño department (39,000 hectares)
- Sistema Delta Estuarino del Río Magdalena, in Magdalena department (400,000 hectares)

Toxicity Analysis - To provide a quick, rough assessment of the toxicity to amphibians of the spray mixture, the CICAD scientific team conducted laboratory experiments on the most sensitive life stage (tadpole) of the frog species most sensitive to glyphosate (African clawed frog, or *Xenopus laevis*, which is not known to occur in Colombia). These tadpoles were exposed for 96 hours to a range of concentrations of the actual spray mixture used in Colombia, up to and including concentrations that would rarely, if ever, occur in the field.

Tadpole mortality was measured across the range of these concentrations. The enclosed report shows that even worst case concentrations of the spray mixture used in poppy control were unable to kill half of the tadpoles in 96 hours. However, the coca mixture (which contains more glyphosate and surfactant than the poppy mixture) reached the 50 percent mortality level at slightly less than worst case concentration levels (see Figure 1 in the Interim Report). Put another way, the poppy spray was not sufficiently toxic to kill half of the African clawed frog tadpoles in 96 hours at the worst-case concentration, but the coca spray was. Thus the authors conclude:

> *"In summary, the results of toxicity tests in tadpoles of Xenopus laevis, the most sensitive frog species to formulated glyphosate, do not suggest adverse effects on amphibians from spraying poppy with the mixture of glyphosate and Cosmo-Flux®. For the spraying of coca, there is a possibility of adverse effects in amphibians that are more sensitive than X. laevis. This uncertainty can be addressed by conducting toxicity tests with Colombian species under laboratory and field conditions."*

The EPA, in its review of these laboratory experiments, concluded that, based on the data provided by the experiments, both the poppy and coca spray mixtures are classified as moderately toxic to Xenopus laevis tadpoles, using the EPA's toxicity classification scheme (the EPA reviews of the laboratory studies are also attached).

Having thus established the spray mixtures' toxicity to the frog species most sensitive to glyphosate, the CICAD team will next investigate their toxicity to frogs that actually occur in Colombia (see Table 1 in the attached report). This examination, combined with a better understanding of the degree to which amphibian habitat and sprayed crops coincide, will help to quantify further the potential impact of the spray program on Colombian amphibians.

However, it is worth repeating that the CICAD scientists have stated in the phase one study, in the attached Interim Report, and in the attached Hazards of Glyphosate report, that the potential impact of the spray program is small, especially compared to other human activities.

Threatened Species Assessment - The term "threatened species" as used in the report language is to be understood as threatened species of amphibians, rather than all threatened species. In light of Colombia's well-known biodiversity, however, it is worth mentioning here that the first phase of the CICAD study

concluded that the spray mixture "is not directly hazardous to bees and, by extrapolation, to other beneficial insects", and concluded from available data and scientific literature that "glyphosate and (the surfactant) Cosmo-Flux®, as used in the eradication program in Colombia, will not have adverse direct effects on wild mammals or birds."

Any impact the spray program poses to the more than 100 amphibian species that occur in Colombia that are considered endangered or critically endangered (according to the Global Amphibian Assessment - www.globalamphibians.org) is not expected to differ significantly from that posed to the hundreds of species of Colombia's non-threatened amphibians. There is clearly greater risk associated with endangered amphibians by virtue of their threatened status, especially since more than half of Colombia's endangered amphibian species occur only in Colombia. However, there is no reason to believe that those endangered amphibians would be more sensitive to the glyphosate spray mixture than the African clawed frog.

Spraying of herbicide has only been allowed in one of Colombia's national parks (La Macarena) to date; any threatened amphibians living in other parks would naturally not be affected by the aerial eradication program. The amphibian populations within these parks are, however, almost certainly threatened by the human activity, such as coca cultivation and the human spread of the fungal disease chytridiomycosis, which is responsible for frog extinctions and which is present in Colombia (see section 2.2.3 of the Interim Report as well as the Hazards of Glyphosate report). Should aerial spraying continue in Colombia's national parks in the future, any impact from the spray program on amphibians within the parks would not be expected to differ from that which spray program operations may currently cause elsewhere and which the ongoing CICAD study is attempting to further quantify.

Attachments:

Tab 1 Interim Report On Follow-Up Studies: Environmental and Human Health Assessment of the Aerial Spray Program for Coca and Poppy Control in Colombia (CICAD, July 2006)

Tab 2 Hazards of Glyphosate, Other Pesticides, and Other Human Activities to Amphibians (R.A.Brain, May 2006, for CICAD)

Tab 3 Glyphosate-Cosmo-Flux® - Coca Mix: A 96-Hour Static-Renewal Acute Toxicity Test with the African Clawed-Frog Tadpole (Xenopus laevis) - Final Report (Wildlife International, Ltd)

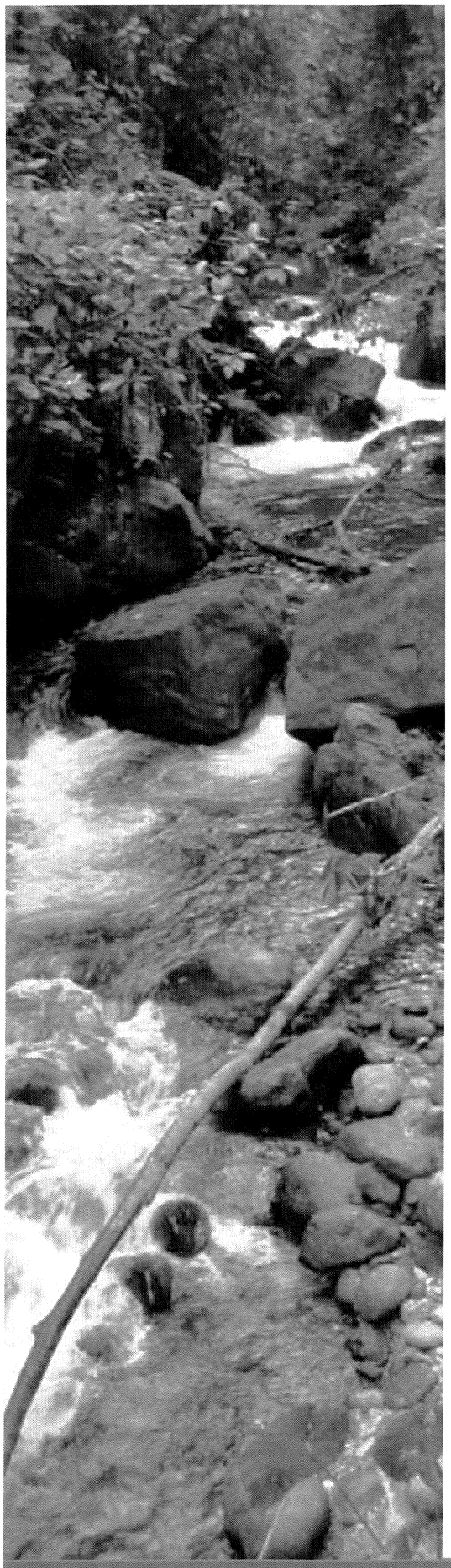
Tab 4 Glyphosate-Cosmo-Flux® - Poppy Mix: A 96-Hour Static-Renewal Acute Toxicity Test with the African Clawed-Frog Tadpole (Xenopus laevis) - Final Report (Wildlife International, Ltd)

Tab 5 Review of 96-Hour Static Renewal Acute Toxicity Tests of Glyphosate-Cosmo-Flux® Formulated End-Product Mixes used for Coca and Poppy Control in Colombia (U.S. EPA, May 2006)

MEMORIAL OF ECUADOR

ANNEX 157

Ecuadorian Scientific Commission,
The Plan Colombia Aerial Spraying System and its Impacts on the Ecosystem and Health on the Ecuadorian Border (April 2007)



ECUADORIAN SCIENTIFIC COMMISSION

THE PLAN COLOMBIA AERIAL SPRAYING SYSTEM AND ITS IMPACTS ON THE ECOSYSTEM AND HEALTH ON THE ECUADORIAN BORDER

QUITO-ECUADOR, APRIL 2007

ECUADORIAN SCIENTIFIC COMMISSION

DR. RAMIRO ÁVILA

DR. ELIZABETH BRAVO

DR. JAIME BREILH

DR. ARTURO CAMPAÑA

DR. CÉSAR PAZ-Y-MIÑO

ENGINEER LUIS PEÑAHERRERA

DR. JOSÉ VALENCIA

The Plan Colombia Aerial Spraying System
and its Impacts on the Ecosystem and Health
on the Ecuadorian Border

ISBN-978-9978-45-961-4
Quito – Ecuador
2007

Ramiro Ávila Santamaría, LLM, Dr.
Attorney specializing in International Law
on Human Rights
Professor at the Universidad Andina "Simón Bolivar"
Advisor to the Human Rights Clinic of the
Pontificia Universidad Católica del Ecuador (PUCE)

Elizabeth Bravo, Ecologist, PhD
Professor at the Universidad Politécnica Salesiana
Biodiversity expert
Researcher, Acción Ecologica

Jaime Breilh, MD. MSc. PhD
Epidemiologist and specialist in Social Medicine
Health Department Director, Universidad Andina
"Simón Bolivar"
Executive Director, Health Research and Advisory Center
(Centro de Estudios y Asesoría en Salud – CEAS)

Arturo Campaña, MD., Psychiatrist
Specialist in Mental Health
Professor at the Universidad Central del Ecuador
Scientific Director of the Health Research and Advisory
Center

César Paz-y-Miño, MD. PhD
Director of the Molecular Genetics and
Human Cytogenetics Laboratory
Pontificia Universidad Católica del Ecuador

Luis Peñaherrera Colina, Agr. Engineer MSc.
Specialist in Plant Science and Herbicides
Head of the Weed Science Department
Boliche Experimental Station, National Institute of
Agricultural Research
(Instituto Nacional de Investigaciones Agropecuarias – INIAP)

José Valencia, Esq.
M.A., Political Science
Professor of International Public Law
Universidad Católica; Universidad San Francisco
and Latin American Faculty of Social Sciences
(Facultad Latino Americana de Ciencias Sociales – FLASCO)

Photos: Cristina Herdoíza, Green Peace, Acción Ecológica and Manthra Collection • Graphic design: Manthra Editores • info@manthra.net • Quito – Ecuador

TABLE OF CONTENTS

Summary

Introduction

I. Background
Origins of aerial spraying in Colombia

II. The determinant processes of aerial spraying
Characterization model
The biological wealth threatened by spraying
Characteristics of the spraying components

III. Scientific disagreements on the notion of "evidence"
A current and trans-disciplinary scientific paradigm

IV. The false notion that Roundup is harmless
A chain of scientific errors and ethical avoidance
Toward an ethical and scientific handling of uncertainty

V. The aerial spraying system and its impact on life and health
The notion of life and health determinants as study framework
Agro-social destruction and loss of food resources
Impacts on mental health
Impacts on organic and genetic health

VI. The aerial spraying system and its impact on the environment
Impacts on the forest ecosystem
The edge effect
Impacts on the trophic networks, ecological succession, phenology
Effects on ecological interactions
The emergence of super weeds
Effects on aquatic systems and their biological communities
Impacts on other animal species

VII. The precautionary principle as scientific, ethical and legal core

VIII. General Conclusions

Bibliography

LIST OF TABLES

Table 1
Coca crop situation on the 10 km strip of border with Ecuador (Nariño and Putumayo) 2000 – 2007

Table 2
Drag or drift of a droplet launched at a height of 3 meters

Table 3
Droplet lifetime in air under different conditions

Table 4
Droplet sedimentation velocity as a function of size

Table 5
GPS Points and Distance to the border from Colombia

Table 6
Damage to crops and animals in Sucumbios (Ecuador) 2001

Table 7
Impacts of spraying on the everyday life of the people of Mataje. February 2007.

Table 8
Distribution of victims by community studied

Table 9
Comet types seen in the population exposed to aerial spraying

Table 10
Cell alterations in women exposed to aerial spraying

Table 11
Cell alterations in women from the control group

Table 12
Evolution of coca plantations in the departments bordering on Ecuador

Table 13
Pathogenic fungi isolated in plant samples in affected zones

PROLOGUE

The aerial spraying operations in Colombian territory bordering on Ecuador have left their mark on the bilateral relations between Ecuador and Colombia. As part of the definitive solution to this problem, science plays a critical role in providing knowledge, information and the necessary analysis. Scientific knowledge must lead to the formulation of terms of precaution, protection and remediation in view of the known and potential effects engendered by those operations.

It is along this line of thought and with these objectives that the Ecuadorian Scientific Commission has been working, meticulously and with the solid support provided by research and serious field work, added to the vast experience and impressive academic qualifications of each of the members of the trans-disciplinary team making up the Commission.

The fruit of the Commission's labor is this substantial document, which also constitutes an extremely valuable contribution toward clearing up the concerns raised in the international scientific community by the use of broad spectrum herbicide packages. The dangers of the aerial spraying system are not limited to the hazards of glyphosate alone and its potential drift. It transcends that boundary, with effects on all living organisms and their habitats, and that is why the study systematizes the dimensions of the problem and outlines and explains the bioethical and methodological precepts on which its view is based.

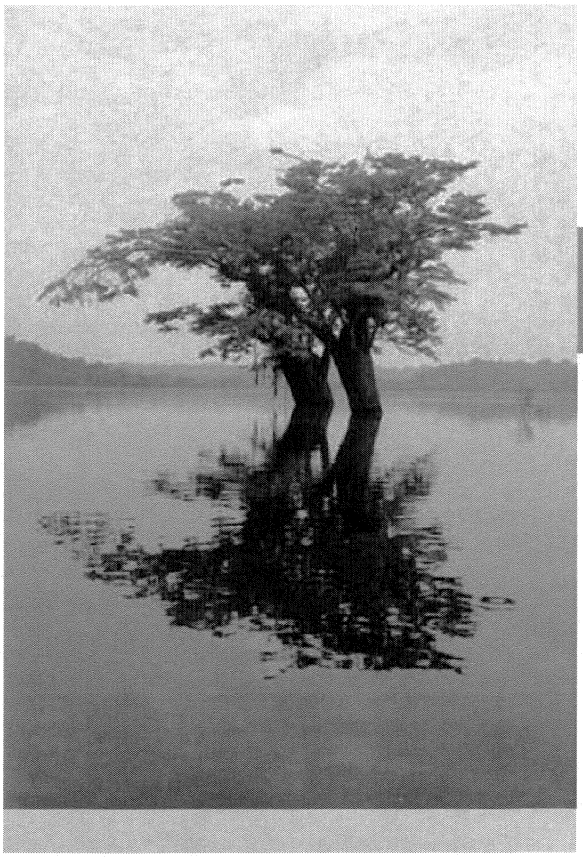
This work offers an extensive study on the main disagreements over what constitutes "valid evidence" of the damage, and on the responsibility for taking precautionary measures. This issue is crucial for reaching understandings

that strengthen good neighbor policies. However, it is important to note that, in keeping with the bi-national Ecuadorian-Colombian agreement that led to the creation of the Commission, this is a strictly scientific analysis, free of outside influences, and the sole responsibility of its authors.

The Ecuadorian Scientific Commission is deserving of praise and public acknowledgment for the work it has done.

Quito, April 2007

Maria Fernanda Espinosa,
Minister of Foreign Relations, Commerce and Integration



SUMMARY

This document tackles the problem of aerial spraying under the Plan Colombia and its effects on the Ecuadorian border. The Government of Ecuador, led by President Rafael Correa, created the Scientific Commission to assess the impact of spraying with the herbicide package containing glyphosate that Colombia has been using since 2000 to fight illegal plantations in its territory.

The scientific-technical problem surrounding this issue can be summarized in two opposing positions.

The Colombian government bases its arguments on a document prepared by the Inter-American Commission for the Control of Drug Abuse (Comisión Interamericana para el Control del Abuso de Drogas – CICAD), which has been questioned by several academic institutions and professional associations in Colombia itself because it does not involve field research, uses inappropriate methodology, reaches theoretical conclusions based solely on bibliographic compilations, leaves out the positions

and accounts of the people, uses ambiguous and doubtful terminology, and even originates from a drug-control, rather than a scientific organization. At the center of its defense, the Colombian government insists on wielding the argument that the aerial spraying – which it always reduces to the issue of glyphosate – is absolutely harmless and inoffensive, so that the complaints by the victims on both sides of the border are called exaggerated and baseless.

Faced with this problem, the Ecuadorian Scientific Commission conducted checks and verifications, gathered testimonials from the affected population and found unquestionable effects in Ecuadorian territory. It also compiled and systematized the large volume of knowledge on glyphosate produced by researchers and institutions throughout the world in recent years, much of it motivated by critical monitoring of massive aerial spraying practices. This publication gives the results of the studies on the aerial spraying system's impacts on the communities of the border area and its ecosystems in Ecuadorian territory, with all the agro-social, ecological, economic, human and animal health impacts. They scientifically support Ecuador's call for Colombia to definitively halt aerial spraying with the herbicide package in the border region within a safety zone of at least 10 km.

This scope of this document's study included the evidence for the Ecuadorian case, as well as a group of arguments issued by the international scientific community on this problem. The authors decided not to include evidence of the impacts on the Colombian people, because they believe that dealing with these impacts is up to the Colombian scientific institutions. An exception was made for the evidence found in Colombian public documents and gathered by Ecuadorian observers who have taken part in bi-national missions. The document contains data from studies on the impact of spraying in the form of damage to legal agricultural and endemic crops (measured between 2 and 10 km from the border and the spraying); damage to domestic animals (measured in percentage of death and disease, also according to distance from the border); impact on the ecology (backed by copious bibliographic material and a comparison with similar problems, and indirectly assessed with genetic tests on plants); effects on human health (verified by physicians); correlations to wind studies in the region; soil studies and studies of genetic damage in the population directly or indirectly exposed to the herbicide package used in the aerial spraying originating in Colombia.

To support its scientific position, the Commission presents a document that begins with the background of the aerial spraying affecting Ecuador. It describes the chemical components of the herbicide package and its effects at the different levels; it then presents an epidemiological argument on the current views on studying and measuring the impact of a public health problem, as well as their

ethical components. Two analysis paradigms are compared: that of the market logic, which promotes reasonable doubt, acceptable impact and non-recognition of the human or ecological role; and that of humanist logic which defends the ecology, validates human testimony, protects the environment and health, and relates the problem to social determinants and human rights.

With these arguments, the document delves deeper into the ecological effects, discusses the impacts on the ecosystems and their unsatisfactory recovery, speaks of the extinction of species and pollution of the water, soil, plants and air. It highlights studies done by Ecuadorian researchers on plant damage at the cellular level which show that glyphosate, a known component of the herbicide package, causes alterations during cell division and also in the plants' genetic material (chromosomes), compared with tests on non-exposure to the product.

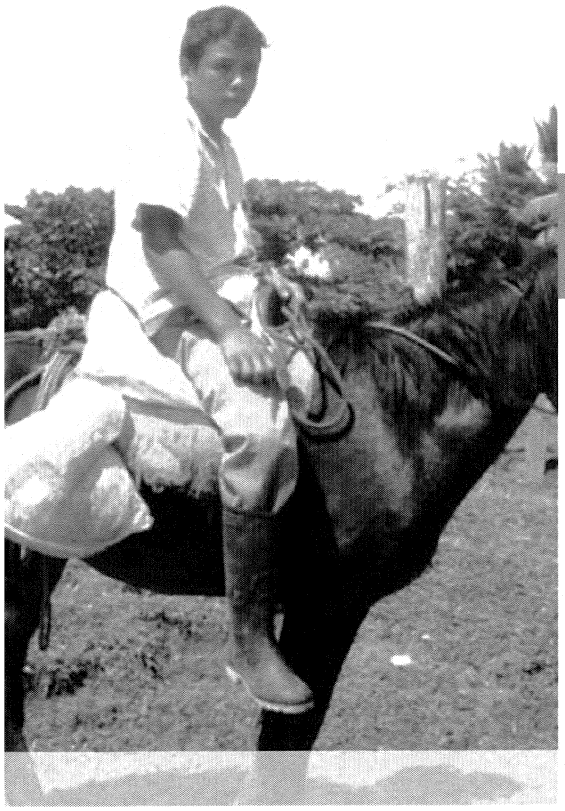
The corroboration of damage to plants and animals that have felt the impact of spraying depending on how close or far away from the border the area is located conclude that the amount of damage is very high and related to distance.

Field studies conducted at the health level show a tremendous upsurge in pathologies, distributed according to distance, which increase the shorter the distance to the sprayed sites. Regarding the mental health of the region's inhabitants, the Commission recognizes the problems created by the application logic, due to the fear of the volume and destructive capacity of the products used, the forced migration, and the presence of behavior, attention and performance disorders in school-age children and their anxiety and insecurity.

The genetic field research conducted on the population exposed to the herbicide package show that there is 26% damage at the chromosome level in the exposed individuals, compared to 4% in a population not exposed to the herbicide package or any other known genotoxic agent. The studies on genetic material fragmentation in exposed individuals, assessed with the comet assay (single cell electrophoresis), show an increase in genetic material alteration that is four times higher (26% average damage) compared to the unexposed control group.

The document contains the national and international legal arguments based on current regulatory instruments and legal agreements, supported by the United Nations, the WHO, the Convention on Biological Diversity and Conventions on Human Rights and others which stress, promote and legitimize the Precautionary Principle as a basis for the Ecuadorian Government's claim against the Colombian Government, and the request for a definitive halt to aerial spraying with hazardous herbicide packages.

The document presents scientific-technical conclusions that summarize the damage caused by the herbicide package at all levels: ecological, environmental, social, economic, and to mental and physical health. In addition, it supports the position that one of the herbicide package's components – glyphosate – is harmful alone or with its coadjuvants.



SUMMARY

The aerial spraying of glyphosate - initiated as part of the Plan Colombia - is having direct impacts on Ecuadorians and has become a major social, health and ecosystem hazard for communities living in the north of our country. The Ecuadorian Government, now represented by President Rafael Correa, has set up a transdisciplinary Scientific Commission to perform an evaluation of the impact of the wide spectrum herbicide mixture being sprayed which contains glyphosate among other harmful components. Colombia has been using this herbicide compound system since 2000, in order to eliminate illicit Coca plantations in its territory. The debate generated about this matter can be summarized in relation to the opposing positions of the Columbian and Ecuadorian government – the former assuring its safety; and the latter drawing on reliable scientific arguments and data that confirm glyphosate toxicity.

Unfortunately, the Colombian Government has ignored all scientific and ethical precautionary arguments and has appar-

ently decided to maintain its strategy of herbicide aerial spraying. It sustains its position based on a document elaborated by CICAD (Interamerican Commission for the Control and Abuse of Drugs / Comisión Interamericana para el Control del Abuso de Drogas). This same document has been questioned by several academic institutions and associations, some of which are Colombian. The argument of the Colombian government on aerial spraying at our border has generated considerable scientific criticism: it incorporates no field research; was based on documents generated by a political rather than scientific institution; it shows inappropriate methods and methodological flaws; and its conclusions are based on secondary sources and bibliographic information which not only neglect key elements of scientific observation but also omits the testimonies of affected Colombian communities. Based on inconsistent methodological and empirical evidence, the Colombian Government insists that the aerial spraying is innocuous and harmless and that all the testimonies of the affected populations on both sides of the border are overlooked and discarded for supposed lack of objectivity.

In order to face these problems, Ecuador's Scientific Commission traveled and interviewed the affected populations in the Ecuadorian side of the border, to reconfirm and verify the diverse impacts in our territory. The commission compiled information contained in previous research projects; databases on impact monitoring gathered by national researchers; and literature published by academic institutions from other parts of the world focused on health impact assessment of the aerial application of glyphosate-based herbicide compounds. Our Commission organized and analyzed this collection of scientific evidence as well as qualitative data and testimonies reflecting health and ecosystem impacts over the 5 to 7 years since spraying began.

In broad terms, our scientific analysis encompasses a multiplicity of negative outcomes provoked by pesticide spraying that is operated within unsafe distances and through inappropriate spraying practices in the vicinity of vulnerable Ecuadorian communities and ecosystems on the border. These negative outcomes include: socio economic and agricultural impacts; impact on beneficial plant and animal species and related ecosystems components and services; impact on support systems required for family and community health; and related physical, mental and genetic impacts on human populations.

The Commission has decided not to incorporate evidence related to impacts in the Colombian population, because this problem is the concern of Colombian scientific institutions. Nevertheless, some exceptions were made – including reference to information already published by Colombian researchers or that which is included in the proceedings of bi-national meetings.

Aerial spraying of glyphosate-based compounds is considered a very hazardous and potentially destructive procedure. The safety requirements outlined in the instruction manuals of glypho-

sate producers note that air spraying should be conducted at an altitude of 3 meters over plants and only when spraying can be conducted under favorable and controlled weather conditions. Unfortunately, these are not the standards that have been applied in practice by the military logic of Colombian government spraying in our northern border. Rather, the spraying has been fulfilled at heights of up to 60m and in a manner that allows for the drifting of chemical droplets in Ecuador as well as the contamination of water, soil, animals and vegetation of the bordering area. Our evidence indicates that these practices have resulted in impact on endemic vegetation and legal agricultural crops; damage to domestic animals (as measured by high morbidity and death rates); damage to fish and aquatic fauna; and multiple indicators of human health impact, with impact gradients diminishing with increasing distance to the border.

Although not all evidence and variable correlations have been fully established, the available geographic, meteorological, epidemiological and ecological information gathered has revealed concerning impacts on the determinants of health as well as specific illness and disease. It is our scientific opinion that the available evidence is sufficiently comprehensive and systematic as to recommend the immediate cessation of all aerial spraying and the application of the precautionary principle.

Our Commission's report presents a range of scientific information in support of this position. Specifically the report presents current scientific knowledge and factual evidence on the chemical residual environmental dynamics and effects of glyphosate as well as human health and ecosystem outcomes - including the psychosocial impacts of aerial military attack strategies and their association with the harmful impacts on environmental and epidemiological conditions.

The report also outlines basic ethical and juridical aspects related to the application of precautionary principle. As in all scientific debates of this kind, two opposing positions can be identified. On one side, those who produce and utilize wide spectrum herbicide systems argue in favor of its safety, not only by claiming the specificity of herbicide effect on coca crops and the innocuous nature of this compound for the human beings and the ecosystem, but also through reference to a calculation model based on minimal likelihood of chemical drift. Under those premises, the Colombian Government justifies their military strategy of aerial spraying and does not recognize any possibilities of harming human beings and the ecosystem in our territory. Furthermore, this viewpoint systematically neglects any concern for the testimonies and evidences presented by affected communities, discarding them as non scientific. On the contrary, our approach places the protection of human life and nature in the center, as non negotiable human rights; promotes a humanistic logic; and focuses on an integrated model of epidemiological and ecological research which prioritizes human and ecological protection.

Our report considers ecosystem damage in relation to impact on vulnerable species and water, soil, plant and air contamination. We also synthesize key studies conducted by Ecuadorian scientists who identify significant cellular damage (including cell cycle and genomic material alterations) in cells exposed to Glyphosate compounds, when compared to non-exposed. We also document a decline of plant and animal species which increases with proximity to the northern border - suggesting correlation with pesticide exposure.

Human impact studies are also articulated in our report. Our studies have identified that frequency of symptoms associated with glyphosate exposure increase with proximity to the border spraying zones. Psychosocial research has compared mental health symptoms before and after fumigations. Local communities have expressed increased fear, intimidation and sense of insecurity after repeated spraying, associated with forced migration from some communities, as well behavioral disorders and decreased educational performance in children. Human genetic damage was also assessed through lymphocyte DNA alterations (comet assay). This study found 26% chromosomal alterations in women exposed to glyphosate spraying. The level of chromosomal damage was approximately four-times higher than the damage found in the control or non exposed group.

In summary, our report outlines a complex profile of health and ecological aggression resulting from the aerial spraying at the Ecuadorian-Colombian border. The technical, legal and ethical arguments and findings we have compiled are congruent with international norms and prohibitions approved by UN and WHO, including the Biological Diversity and Human Rights Agreements. These international standards promote and legitimize the need for urgent application of the precautionary principle in the face of herbicide mixture sprayings and support Ecuador's demand for at least a 10 km security zone within the Colombian border.

INTRODUCTION

The institution of a high-impact military logic system to control illegal coca crops by aerial spraying with an herbicide package – the Plan Colombia – has not only triggered harmful effects, fear and unease in Ecuadorian border towns, but also drawn the criticism of the international scientific community.

Scientific evaluation of the aerial spraying system's dangers is not limited to the subject of the harmfulness of glyphosate alone and its potential drift (transportation by wind) into Ecuadorian territory; rather, it is a much more complex scientific and human problem whose different facets could only be ignored for non-scientific reasons or due to ignorance of current research and bio-ethical paradigms.

This publication systematizes the dimensions of the problem caused, explains the bio-ethical precepts

and methodologies on which the comprehensive view drawn up by the trans-disciplinary team of the Scientific Commission of Ecuador are based, and underscores several urgent recommendations for the National Government.

It gives a brief history of the problems and the contributions to its understanding made by different research centers in Ecuador, Colombia and the world, as well as the progress achieved by those who were members of previous commissions.

As a guideline for the systematization of the available evidence of damage and the Commission's scientific work itself, an interpretive and scientific analysis model is formulated and its main elements are explained to show the dimensions of the determinant impact processes in our country, their chemical components, the vulnerabilities of our people, the agro-social destruction, the mechanisms for damage to the ecology and bio-diversity, the effects on community supports and the terror mechanisms with regard to human impacts, both organic-genetic and psycho-social.

The central point of our scientific characterization of spraying is that it is obviously not limited to a simple problem of an "x → y"- type factual association: "glyphosate alone – illness." A strong scientific model for characterizing how the spraying affects health looks at several crucial dimensions in its assessment:

a. Spraying works under a high-impact military logic.

b. It is not limited to glyphosate alone, but involves a broad spectrum herbicide package consisting of at least glyphosate, POEA and Cosmo-Flux 411, and possibly other herbicide resources, including microbiological, which have already been justified in other contexts.

c. The aerial spraying operations not only trigger chemical or chemical-biological processes that directly generate human illness, phytopathology and damage to ecosystems, but also entail processes with nutritional and socio-agricultural effects, impact on biotic supports and biodiversity, and even psycho-social impact and damage to the supports for family and community life.

d. Due to the above, scientific evaluation of the impact must cover all such facts and consequences that build up to create diverse damage in our people and ecosystems.

The main disagreements on the concept of what constitutes "valid evidence" of the damage are systematized, along with the responsibility for taking precautionary measures. This not only applies to the particular case of the effects of the Colombian Government's plan in Ecuador, but is also one of the major topics of the current discussion on the ethics of similar processes, which the world scientific community has brought to the table in

response to the frequent and dilatory justifications proffered by certain sectors to make excuses for their human and ecological irresponsibility, justify their strategic ends and avoid complying with the precautionary principle.

It also summarizes some of the main evidence of the aforementioned diversity of impacts on society produced by aerial spraying, including those generated by glyphosate itself (although not that agro-toxin alone) and the proof of their effects on the mental, physical and genetic health of the Ecuadorian people.

This publication later systematizes the possible impacts on the ecosystems of the Ecuadorian territory bordering on Colombia, based on studies conducted in other countries.

The document assembles a strong set of scientific arguments aimed at supporting the authorities in making all national and international efforts to demand the appropriate compensations, press the appropriate claims and immediately restrict the use of a destructive system whose "benefits" are relative and even questioned by the data from those who promote them. In addition, they are not sustainable, because they replace the profound social, economic and cultural measures that are the best and only antidote to all forms of illegal activity that flourish, replacing the logic of shared and equitable development.

I. BACKGROUND

Origins of Aerial Spraying in Colombia

Aerial spraying in Colombia has followed the pattern described below (Puyana, 2007):

Intermittent spraying from 1978 to 1991, when the first tests with Paraquat, 2,4-D and Glyphosate were initiated in the Sierra Nevada in Santa Marta.

Systematic spraying from 1992 to 1999. The National Drug Council (*Consejo Nacional de Estupefacientes* - CNE) regulated the procedure and granted it the rank of systematic public Government policy. In that time, 187,858 hectares were sprayed, but production increased by 243%. During this period, the Office of the Colombian Human Rights Ombudsman (*Defensoría del Pueblo de Colombia*) denounced the use of Tebuthiuron, Velpar (hexazinone) and Imazapyr (Castro, 2000).

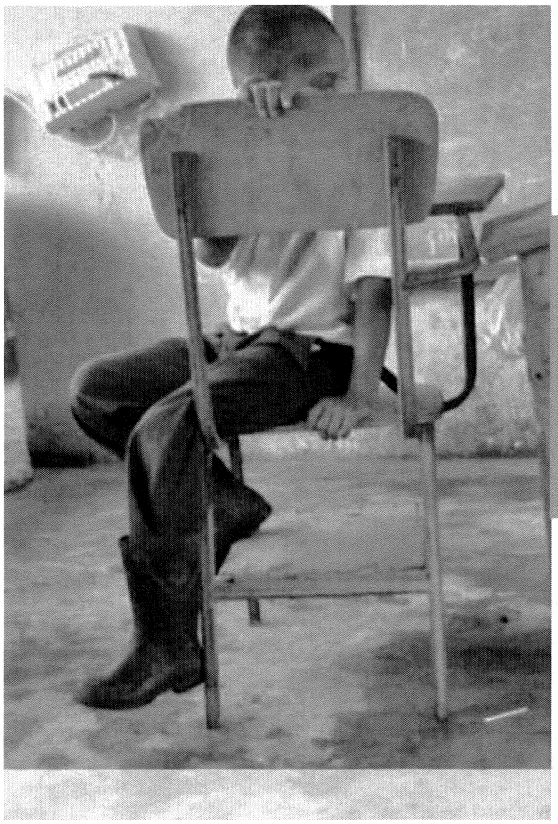
Stepped-up spraying from 2000 to 2006. Up to December 2005, 690,700 hectares had been fumigated. At the end of that year, there were 144,000 hectares of coca, which leads to

the conclusion that there was a reduction of 19,289 hectares (Puyana, 2007). This latest period has been marked by charges that tests are being conducted with *Fusarium oxysporum*, *f. sp. erythroxyi*, in the eradication programs (La Hora, 2000; New Herald, 2000; St. Clair, 2000).

This, despite the fact that in 1984, Colombia's National Institute of Health created a committee of herbicide experts to analyze the massive aerial spraying method to control coca and marijuana crops that the government was planning to implement. According to the report (cited in Vides, 2003), the experts concluded that:

1. From the point of view of human health and impact on the environment, the chemical method should be the last one considered.
2. With the available information on glyphosate, 2,4-D and Paraquat, on the implications for health and environmental impacts, the new massive use by aerial application proposed by the National Drug Council is not advisable
3. Any method that is proposed for destroying these crops should be preceded by studies of the effects on human health and the impact on the environment.

The scientific experts upheld these statements with the following arguments: "Glyphosate is not recommended for aerial use (...) because little is known about its acute toxicity in humans; there is no information in the literature on chronic toxicity, nor is there information with respect to its mutagenic and teratogenic effects ..." (Vides, 2003). Nevertheless, one month later, on May 22, 1984, the Colombian Government ordered the use of aerial spraying on coca, poppy and marijuana crops.



II. THE DETERMINANT PROCESSES OF AERIAL SPRAYING

Characterization Model

Accumulated scientific knowledge on aerial spraying with glyphosate and other agro-toxins and the available information on the system employed on the northern border lead to two main arguments: the problem that we are facing is not the application of glyphosate alone, and health is not only affected by the toxic impact, but also by the destruction or deterioration of a group of supports and determinants (agro-social, ecological and psycho-social) that create a destructive system with different components:

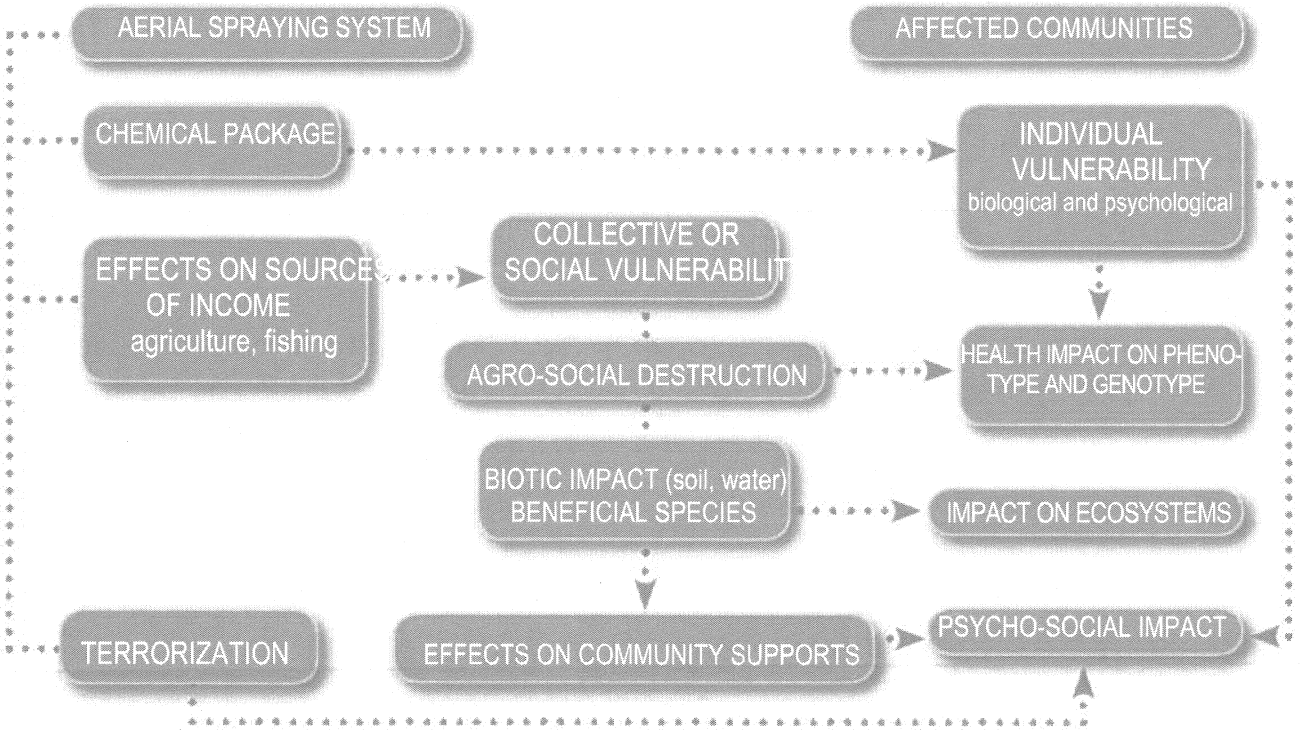
* A chemical package consisting of at least glyphosate, POEA and Cosmo Flux 411F, possibly made hazardous with a microbiological additive (*Fusarium oxysporum*). For all of them, there is evidence of non-specific phytopathogenicity and human pathogenicity, especially in populations such as those on our border, with clear vulnerability and scant resources to confront the problem. But in addition, as a "weapon" in a scenario of "war"

or conflict between armed groups, aerial spraying constitutes a high-impact mechanism that triggers other health determinants with a destructive effect on the vital community supports:

- A system of agro-social destruction which affects the agricultural and aquatic food chains, creating an impact from contamination and loss of fertility, with lower production or destruction of sources of subsistence and nutrition, destruction/deterioration of aquatic life (water and food reserve).
- A system that impacts the ecosystem, beneficial plant and animal species and biodiversity, which involves the production of unhealthy ecosystems, with the destruction of medicinal and culturally significant species.
- A system that threatens community supports because it generates forced migration and the breakdown of community and family harmony.
- A system of social and psychological aggression and terror.

In other words, aerial spraying destroys not only by the direct toxic impact of the chemical residues of glyphosate alone, but by affecting the group of determinant process for human and environmental life that we have described. The model is summarized in Diagram 1.

Model for Studying the Impact of the Aerial Spraying System



Biological wealth threatened by spraying

Ecuador is considered one of the world's 12 mega-diverse countries (those with the greatest biological diversity). Although a small country (0.17% of the planet's surface), it houses 9.2 species per square kilometer, which makes it the country with the greatest biological diversity per unit of area in the world.

In Ecuador, there are around 18,000 species of flowering plants and 1,300 species of ferns. It is estimated that 20% of the Ecuadorian flora is endemic.

With its small territorial area, it holds 4th place in Latin America in mammal diversity, and 9th place in the world. Mammal species total 369. The region with the highest diversity is the Amazon, with 191 species; i.e. 52% of the country's entire mammal diversity. Eight percent (8%) of Ecuadorian mammals are endemic (Tirira, 1999).

Some 1,616 species of birds have been identified which, for the size of our territory, means one of the highest numbers of bird species found anywhere in the world (17% of the world total). The greatest bird biodiversity is found in the tropical rain forests. Fifty percent (50%) is found in the Amazon region.

According to Coloma (1991), 414 species of amphibians had been identified up to 1990, one of the highest amphibian concentrations in the world. Most of these species are only found in limited distribution areas and many of them are in danger of disappearing. Equally high data have been recorded for reptiles (Coloma 1991; Suárez and Ulloa, 1993).

The Ecuadorian Chocó region is home to the last remains of the tropical forests on the Pacific coast. These forests are part of the Chocó biogeographical region that runs from southern Panama to northern Esmeraldas. In this zone, there are some 10,000 plant species, of which some 2,500 are endemic. This is the home of the Awá, Chachi and Tsachila people, as well as Afro-Ecuadorian communities who maintain their own lifestyles.

Additionally, the Amazon region is the center of origin of cacao, yucca, sweet potatoes, coca and Chinese yams, as well as fruits such as papaya and cherimoya, among others. In the places where a species has been domesticated, we find the so-called wild relatives of the crops, which are species very closely related to the cultivated plants and in many cases their ancestors.

Characteristics of the spraying components: broad spectrum herbicide package

According to official sources, an average of 23.66 liters (6.25 gallons) of this mixture are fumigated per hectare, which equals 10.4 liters of undiluted Roundup

(with PEO included), plus 0.24 liters of Cosmo-Flux and 0.08 liters of Cosmo-InD[1], mixed in 12.94 liters of water. However, the data provided by the National Drug Office of Colombia (*Dirección Nacional de Estupefacientes* – DNE, 2007) in response to a request for access to the information are very different. For the 10 km strip of the border with Ecuador, the crops and spraying have followed the distribution shown below:

Table 1
Coca crop situation on the 10 km strip of border with Ecuador (Nariño and Putumayo) 2000 – 2007

Year	Hectares Of Coca Detected	Eradication Operations in the 10 Km	Gallons Of Roundup Used ***	Gallons Of Cosmoflux	Roundup / Cosmoflux Ratio	Liters Of Glyphosate / Hectare
2000**	20.185	3	8.958,7	206,7	43,34/1	1,67
2001	12.359	1-Nariño 4-Putumayo	22.170,5	511,6	43,33/1	6,78
2002	5.186,7	2N 2P	44.497,5	1.026,8	43,33/1	32,43
2003	2.830	3N 2P	18.205,7	420,1	43,33/1	24,31
2004	2.691,6	1N 3P	13.316,1	307,2	43,34/1	18,70
2005	3.975	2N 1P	25.695,5	592,9	43,33	24,43
2006	5.996	2P	24.402,9	563,1	43,33/1	15,38
2007	17.000	1N 1P				
Total		28	157.246,9	3.628,4	43,33/1=2,3%	

Source: CIF, based on data from the Colombian DNE for 2007.

* Detected by the SIMCI[2] at the beginning of each year.
**In 2000, they began in the last quarter. They did not cover all the crops until the first quarter of 2001.
*** Gallons used at the end of the year.
N = Nariño and P = Putumayo

[1] We do not know if this product is currently being used; after several studies were conducted by the Ministry of Social Protection, formerly the Ministry of Health, they found such high toxicity in this anti-foaming agent that the recommendation of the Ministry and the ICA was not to use it. This was certainly one of the reasons for the worsening health problems in Putumayo in early 2001.

[2] Comprehensive Illegal Crop Monitoring System.

These data indicate that in the 10 km strip of the Colombia-Ecuador border, after it was sprayed with 594,393.2 liters (157,246.9 gallons) of Roundup plus POEA (in much higher quantities per hectare than those indicated) and nearly 13,715.3 liters (3,628.4 gallons) of CosmoFlux (at a concentration of 2.3%, double the one announced), in 6 years, only 3,185 hectares have been eradicated.

The mixture contains: 44% Roundup Ultra, while the usage label in the United States for Roundup Ultra allows concentrations of 1.6% to 7.7% for most uses, and a maximum concentration of 29%. The United States label indicates that, under most conditions, aerial application should not exceed 1 liter per acre of mixed product. In Colombia, the rate is almost 4.5 times that amount (Isacson, 2002).

If we take into account that a 300 gallon (1,137 liter) plane deposits 40 liters/hectare of the mixture, with an effective discharge of 23.4 liters/hectare of Roundup Ultra, this discharge equals 10.3 liters/hectare of glyphosate in the form of isopropyl amine(IPA) salt. In addition to this situation, Cosmo Flux 411F quadruples the biological action of glyphosate (CIF, 2003).

Glyphosate

Glyphosate is a systemic herbicide that is applied post-emergency. It is non-selective, broad spectrum, and used to eliminate weeds that can be annual and perennial grasses, broad-leaf herbs and woody species.

The INIAP[3] recommends the use of glyphosate in agricultural areas in the form of applications aimed with a shield at perennial and total crops in non-cultivated areas such as those where zero tillage is practiced, or at least with equipment coupled to a tractor, but never with aerial equipment. The recommended dose for application ranges from two to four liters of commercial product per hectare, with smaller doses for annual species and higher doses for perennial species.

According to the Farm Chemicals Handbook (1990), aerial applications are not recommended.

The United States Environmental Protection Agency (EPA) has already reclassified the pesticides that contain glyphosate as Class II, highly toxic, because they are eye irritants (EPA, 1993). The World Health Organization, however, describes more serious effects; in several studies with rabbits, it classified them as "strongly" or "extremely" irritating.

Glyphosate inhibits the synthesis of aromatic amino acids (phenylalanine, tyrosine and tryptophan) by interfering with the metabolic route of the

[3] The National Agricultural and Livestock Research Institute of Ecuador

chorismic acid. In addition, chorismic acid is used to produce other aromatic products, such as lignens, alkaloids, flavonoids, benzoic acids and phytohormones inherent to secondary metabolism, such as the allelochemicals. In fact, some 20% of the carbon that is fixed in photosynthesis is used in this metabolic route.

The metabolic route of chorismic acid is present in plants and micro-organisms. Studies done by Bode et al. (Bode, 1986) on 19 strains of Ascomicetes and Basidiomicetes yeast showed that glyphosate also inhibits the activity of the enzyme 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS), as it occurs in plants.

After the herbicide is sprayed on plants, it is absorbed through the leaves and other green parts and transported to the rest, where it acts on the enzymatic system.
Glyphosate is an acid, but is commonly used as a salt. The form most often used is the isopropyl amine salt (IPA) of N-(phosphonomethyl) glycine or glyphosate isopropyl amine salt. It is highly soluble in water and virtually insoluble in organic solvents. Because it is water soluble, it is used along with a surfactant, which fixes it to the plant and improves penetration into the tissues.

Like all pesticides, before entering the market, glyphosate goes through a commercial formulation process during which the active ingredients are mixed with other substances such as solvents, agents and others, called "inert ingredients" for which no information is provided on the labels and in many cases are biological, chemical or toxicologically active substances. These preparations confer different characteristics than those found in any of the components separately. Therefore, commercial preparations can entail a higher risk or greater damage for health and the environment.

Its most well-known trade name is Roundup, patented by Monsanto. There are several formulations that are commonly characterized by containing 480 g/l of glyphosate IPA salt and the surfactant POEA (polyoxyethyl amine). POEA belongs to the family of polyethoxilated alkylamines synthesized from fatty acids of animal origin. It has been reported that POEA has greater toxicity (Kaczewer, 2002).

According to Nivia (2001a), no one knows the exact combination used to spray the border areas. He suggests that they are using new agents which would boost the action of glyphosate, also increasing its toxicity.

Environmental fate of glyphosate

Glyphosate has been manufactured to be applied directly to the leaves of plants, but "although glyphosate is not applied directly to the soil, a significant concentration of the compound may reach the soil during an application" (Haney, Senseman, Hons and Zuberer, 1999).

Once in the soil, there are different processes that determine the final destination of glyphosate:

- The formation of complexes with water containing Ca2+ and Mg2+ ions.
- Adsorption in sediments or suspended particles in the water and the soil.
- It enters the plants' metabolism.
- It is bio-degradable by micro-organisms.
- It is carried by runoff and reaches water sources.

Some bacteria may degrade glyphosate, using it as a source of carbon, phosphorus and nitrogen. One of the main metabolites in glyphosate degradation in terrestrial environments is aminomethylphosphonic acid (AMPA), which has a structure similar to that of glyphosate. From AMPA, it turns to methylamine and from there to formaldehyde, a known carcinogen (Cox, 1991 and 1995; Dinham, 1999), When combined with nitrate (present in human saliva or fertilizers), glyphosate may create traces of N-nitrous glyphosate. Most N-nitrous compounds are carcinogens, and there is no safe level of exposure to them.

Mobility of glyphosate

Although it is claimed that glyphosate is fairly immobile in the soil, some scientific studies cast doubt on this claim.
For example, it has been found that the adsorption of glyphosate varies according to soil type. There is less adsorption in soils with low iron oxide content (Piccolo and Celano, 1994). The mineral content in clay may also play an important role. These authors found that in some types of soil, 80% of the adsorbed herbicide is released, while others release 15-35%.

There are soils that cannot retain glyphosate long enough for microbial degradation, and in those cases, the herbicide is very mobile. This released glyphosate can penetrate into the lowest soil levels.

Glyphosate can combine with hydrosoluble substances in the humus. Humic substances are the ones that are primarily responsible for the mobility of pesticides in the soil. The glyphosate transported by humic substances can also go into the deepest levels of the soil (Piccolo and Celano, 1994).

A study by Morillo, Undabeytia and Maqueda (1997) reveals that glyphosate adsorption decreases with the presence of copper due to the formation of glyphosate-copper complexes. This study concludes that in order to understand the relationship between the released glyphosate and its mobility in the soil, it is necessary to take into account the type of soil and the elements present in the soil capable of forming complexes with glyphosate.

It has also been found that the organic matter present in the soil competes with glyphosate for the adsorption sites (Gerritse, Beltrán and Hernández, 1996). A Brazilian study conducted by Prata et al. (2003) shows that glyphosate competes with phosphorus for specific adsorption sites, especially in soils with

high phosphorus levels. The soils of Ecuador behave differently than other soils in tropical countries. Glyphosate could be more mobile than in other tropical soils. An analysis of soil samples taken in the Mataje area observed high contents of Fe and N, and in certain cases, of Ca and P. Under certain circumstances, these elements can modify the behavior and final destination of glyphosate in the environment. Moreover, they are soils high in sand and lime, which also has repercussions on their behavior.

Glyphosate can enter surface waters when applied near bodies of water due to the drift effect or through runoff. There may be a percolation process toward underground waters. Depending on the suspended solids and the microbial activity, glyphosate can be transported several kilometers downstream (CCME, 1989).

Persistence of glyphosate

Another claim that is made in relation to glyphosate is that this herbicide is inactive and quickly degrades in the soil. The US Environmental Agency has reported that the half life[4] of glyphosate can be up to 60 days (EPA, 1999). The EPA adds that in field studies, the residues are often found the next year.

Following are data on the persistence of glyphosate in different environments, compiled by Cox (1995):

- 249 days in the cultivated soils of Finland
- Between 259 and 296 days in 8 forested sites in Finland
- Between 1 and 3 years in 11 forested sites in Sweden
- 353 days in one forested site in Canada
- 360 days in 3 forested sites in Canada

Two Canadian studies found that glyphosate can persist between 12 and 60 days in a body of water after direct application.

Glyphosate residues were found in the sediments of a lake one year after direct application in the United States.

Studies done in Canadian forests on the persistence of glyphosate in the soil found that in Canadian forest soils, it can persist between 45 and 60 days. A presence of from 6 to 18% of the initial levels was still found after 360 days, both in the soil and in plant residue (Bell *et al.*, 1997).

Glyphosate can adhere to soil particles and still be toxic and bioavailable to organisms that are fed by filtration, such as crustaceans and mollusks, as well as other organisms that ingest significant amounts of soil during normal feeding, including

[4] Time that it takes half the compound to disappear in the environment.

fish, birds that feed on the riverbanks, amphibians and some mammals.

It has been found that AMPA is more persistent than glyphosate. Half lives of between 199 and 958 days have been reported for this compound (WHO, 1995). Although the effect of glyphosate as a chemical *per se* has been investigated in some types of soils, the effects of the surfactants and other additives used in the spraying formulations have not been investigated in soils, much less the Cosmoflux used in the eradication of illegal crops in Colombia.

Polyacrylamide

Because water placed in the environment forms large drops due to surface tension, polyacrylamides are added in the formulation of many herbicides to decrease liquid tension and increase the contact surface between the agrochemical and plant leaves, increasing its adsorption.

Evidence seems to indicate that acrylamide is released in the form of environmental polyacrylamide.

Cooking vegetables that have been exposed to the glypyhosate used in herbicide-tolerant genetically engineered crops, or used during soil preparation in conventional crops, would result in an additional release of acrylamide.
In the United States, the polyacrylamide-type additives are considered a "trade secret," and information on the composition of herbicide formulas is not available to the public.

In a report published by England's Institute of Science in Society, Professor Joe Cummins (2002) analyzes a health alert resulting from the presence of toxic acrylamide in cooked foods. This emergency was glyphosate-related. The finding had widespread repercussions, because acrylamide is a potent neural toxin in humans and also affects the male reproductive organs and causes congenital deformities and cancer in animals.

Surfactants and Adherents Associated with Herbicides

Polyoxyethylene Amine

POEA is a surfactant used so that the glyphosate passes through the plant cuticle, because it has non-polar (lipophilic) characteristics which make adsorption of the chemical difficult. The so-called "inert elements" act as solvents and humectants capable of increasing permeability and crossing the plant cuticle barrier.

The different glyphosate-based herbicide manufacturers do not put these "inert elements" on their labels, and many of them are kept as a formulation secret. Additionally, the registration process is generally done for the active ingredient, and not the final product.

POEA (polyoxyethylene amine) has an acute toxicity much greater than that of glyphosate, causes gastrointestinal damage, alterations of the central nervous system, respiratory problems, the destruction of red blood cells, liver and kidney damage, is corrosive to the eyes, and a strong skin irritant. In addition, it is contaminated by 1-4 dioxin, which has caused cancer and liver and kidney damage in humans (Nivia, 2001a).

The acute toxicity of the surfactant POEA is 4 to 5 times greater than that of glyphosate and Roundup. The reported oral (rats) and dermal (rabbits) DL50s are >1200 and >1260 mg/kg, respectively.

Cosmoflux

Nothing is known about Cosmoflux, only that its addition makes Roundup more toxic (Category III, moderately toxic). The compound used would have a half life of between 60 days and three years (Cox 1991 and 1995).

It is chemically described as a mixture of mineral oil and special nonionic surfactants with coupling agents. The active ingredient is described as a mixture of hexitan esters: linear alcohols + ethoxylated aryl (Cosmoagro, 2004).

It also contains liquid isoparaffins: high-purity isoparraffin oil with very low phytotoxicity, very low aromatic content and low surface tension, which improves wettability, thus promoting the efficacy of the active ingredients.

It is not part of the commercial formulation, but is added to increase the level of the herbicide's action. It has been shown to increase the effect of Roundup fourfold by increasing the glyphosate's penetrating power.

It is a skin and conjunctiva irritant

A special component that is added in the applications on the border is the surfactant Cosmo-Flux 411F. Its use has been approved in Colombia without any studies on its possible effects. It is a yellowish liquid at 25°C, with a flash point over 149°C, specific gravity of 0.89, viscosity of 60 mPa at 25°C, pH in 1% solution in distilled water of between 6.3 and 6.8 and an oil concentration of 18-85% (% w/w). It is soluble in mineral oils, vegetable oils and the organic solvents used in the formulation of agrochemicals. It is dispersible in water and insoluble in ethanol. A nonionic stereospecific agent made by combining paraffinated oil plus a stereospecific tensoactive aid; it improves the adhesion and uniformity of agrochemical preparations, controlling the evaporation and hydrolysis of the active ingredient with total coverage, guaranteeing a homogenous concentration of the active ingredient per unit of area and extending the spectrum of the agrochemicals' biological activity.

Biological Herbicides

Fusarium oxysporum

Fusarium oxysporum Schlecht is an essentially necrotrophic and vascular fungus. Its different special forms parasitize a great

number of crops. It has a cosmopolitan distribution.

This fungus invades the radical cells, causing radicular rotting and plantlet death. The rate of infection speed depends on factors such as the time of the initial infection, the virulence and the weather conditions.

This fungus penetrates into the roots through the wound and continues toward the xylema, or through the water conducting tissues. The shoots and leaves wilt during the day, but gain turgency during the night. When the infection progresses, the stems turn pale. The toxins produced by the fungus discolor the host's tissue and precipitate the wilting of the leaves, which can exhibit a yellowish or reddish coloring. The xylema is obstructed, causing the plant's death.

A cross-section of the stem exhibits yellowish coloring in the vascular bundles, or brown with death, and an unraveling of the tissues, without the medulla being affected; this is a very important aspect for diagnosing the disease and distinguishing it from other vascular diseases.

The roots and stems do not exhibit significant initial damage, but are later severely affected with the formation of cavities, with dry rot occurring in the base of the plants and in the roots.
In Ecuador, one of these special forms, known as Mal de Panamá, wiped out the Gross Michel variety of banana.

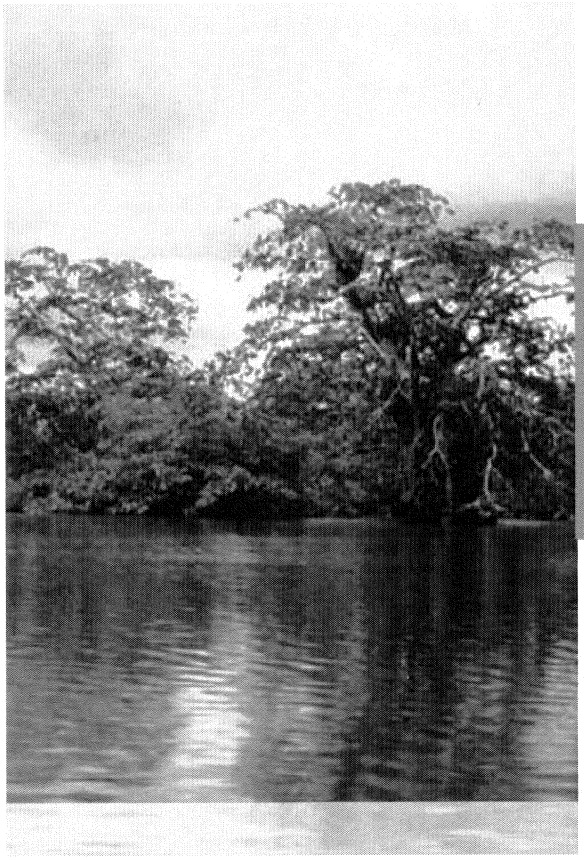
Although it is said that the special forms of *Fusarium* can be very specific to the type of crop that it is going to parasitize, this fungus, like any living thing, can mutate and become a pathogen of other crops. The loss of specificity in pathogenic species has been found in highly specific funguses, as in the case of biotrophic funguses (Griffith et al. 1993).

It is argued that *fusarium oxysporum*, *f. sp. exytroxyli*, specializes in producing the vacuslar wilt of the coca plants, but a series of factors, including the amount of innoculant that would be used in an eradication program for this crop, can turn it into a pathogen of other species, posing a potential risk for the 200 species that are wild relatives of the *erytroxylum* species. In Colombia, 4 species of *erytroxylum* are on the red lists of species in danger of extinction (Pimiento, 2001).

The high survival of its clamydospores, resistant to chemical and microbiological degradation, allow the fungus to remain in the soil for many years.

It has been reported that *fusarium oxysporum* can turn into a human pathogen, especially in immuno-compromised populations, which are prevalent in the eradication programs' zones of influence (Jave, 2001).

haracterization Model



III. SCIENTIFIC DISAGREEMENTS ON THE NOTION OF "EVIDENCE"

A Current and Trans-Disciplinary Paradigm

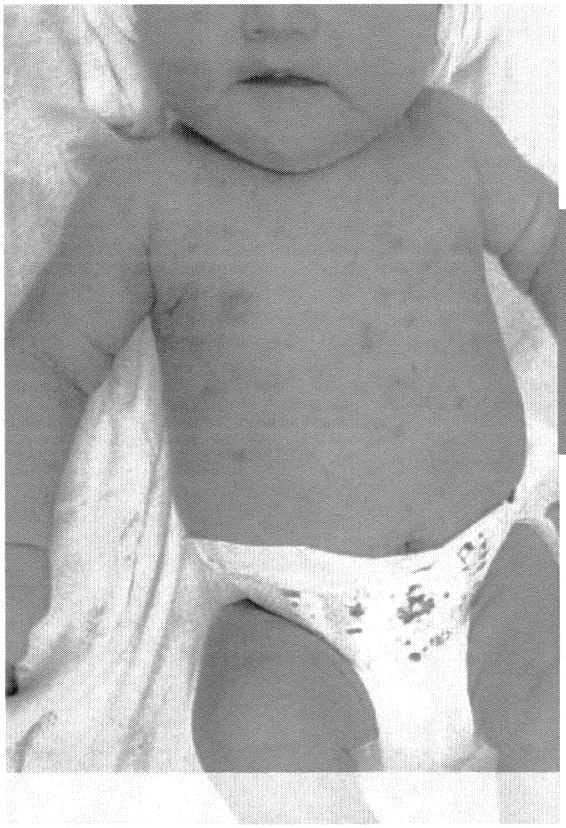
Scientific literature on the use of spraying with glyphosate and the corresponding evidence of the destruction caused to health and its determinants, both at the international level and the level of the affected area, is fundamental for questioning the pro-spraying studies. This leads us to argue urgently for immediate application of the Precautionary Principle, as a point of departure and a mandatory obligation and condition for scientific objectivity, as well as a basis for demanding immediate remediation and compensation from the parties responsible.

The detractors of that Principle are found on the side of the producers and applicators of hazardous substances or mechanisms, while the institutions whose mission is to protect life have developed powerful arguments in its favor. The principle has been discussed in international forums, and in the debates, the argument of "rigorous scientific proof" that the detractors demand from the victims before

agreeing to stop actions and enact corrective measures are a maneuver to turn "hard science" into a legal concept that goes against the Precautionary Principle, arguing in the end that it is lawful to delay any preventive measure or ban on dangerous processes until all the links of the so-called "causal chain" have been conclusively demonstrated and until a scientific consensus has been reached (Von Weizäcker, 2006).

Hence, five elements are proposed in this part of the document:

a. Adopt a comprehensive interpretive model to avoid the scientific error of the reductionist notion of glyphosate-illness causal link.
b. Uncover the scientific and ethical errors of those who advocate spraying.
c. Systematize the international scientific evidence on the dangers of the spraying in question.
d. Present the evidence of impact, gathered by the Ecuadorian organizations in the communities under attack along our northern border.



IV. THE FALSE NOTION THAT ROUNDUP IS HARMLESS

A Chain of Scientific Errors and Ethical Avoidance

Fraudulent or biased evidence of the alleged harmlessness to health of formulations with glyphosate.

The history of the health-related litigation between the public or private companies that cause pollution or other impacts and the affected communities exhibit the same pattern, extensively documented in scientific literature. That pattern seems to be repeating itself now in the litigation over spraying: the companies – in this case Monsanto – forge favorable test data to support the claim that their products are harmless. Once these products are in use, the companies resort to propaganda campaigns, and, in the event that there are harmful effects, hire or convince scientists to back them and "prove" their product's innocence. The communities, always at a disadvantage, turn to their allies to gather evidence of the destruction caused, which almost always ends up being accepted too late, when the massive destruction of

health has already taken place (i.e. a case which demonstrates the time that it takes to correct massive aggression is asbestos: mining began in England in 1879, and it was only 120 years later that the companies recognized its danger and it was banned (Von Weizäcker, 2006).

The aforementioned case brings to mind the "killing time" effect, using the argument resorted to in cases such as this one, that "up to now, the damage caused has not been demonstrated with scientifically solid proof." The so-called "scientifically solid proof" works as a dilatory tactic and turns into a political/ideological, rather than a scientific instrument (Levidow, 2004).

Against this background, let us look at the case of Roundup because it is urgent that we prevent the same cycle from being repeated, delaying bans and remediation.

Both the seller (Monsanto) and the system applicator (Plan Colombia) maintain these arguments:

a. More evidence is needed to contradict the tests for harmlessness already conducted by the manufacturer.

b. The effects are being exaggerated for non-scientific reasons.

c. If application of the questioned products is stopped, this would foster bigger threats, such as drug trafficking.

Non-scientific procedures surrounding the registration and classification of glyphosate.

While universities and research centers amass growing evidence of the dangers for humans and the environment, which has been systematized in reviews of international literature (Bigwood, 2002), the company has insisted on fabricating the image that its product is harmless.

First, we find a murky history starting with the very registration and pharmacological classification of Roundup with glyphosate. Fraudulent practices were associated with the officially required toxicological studies for its registration and approval. In 1976, an audit done by the EPA discovered serious errors and shortcomings in studies conducted by one of the largest laboratories in the United States involved in determining the toxicity of the pesticide before it was registered. The EPA publicly accused Industrial Biotest Laboratories (IBT) – the laboratory that conducted 30 studies on glyphosate and glyphosate-based commercial formulations (among these, 11 of the 19 studies done on its chronic toxicity) – of routinely falsifying data and leaving out reports of innumerable deaths in rats and guinea pigs. In 1991, the EPA accused Craven Laboratories, the company that made determinations for 262 pesticide companies, of having falsified studies, resorting to "tricks" such as forging notes in laboratory records and manually manipulating scientific equipment so that it would give false results.

Studies on Roundup residue in potatoes, grapes and beets were some of the tests questioned (Kaczewer, 2002).

Until the advent of totally glyphosate-tolerant genetically engineered crops, the maximum limit for residual glyphosate in soy established in the United States and Europe was 0.1 milligrams per kilogram. But starting in 1996, these countries raised it to 20 mg/kg, a 200% increase compared to the previous limit. An increase of this size is due to the fact that the glyphosate manufacturers are pressuring to have permits issued to them, and for the approval of higher concentrations of glyphosate in foods derived from genetically engineered crops. Monsanto, for example, already received authorization for a triple increase in genetically engineered soy in Europe and the United States (from 6 ppm to 20 ppm).

Moreover, the company has resorted to fraudulent marketing strategies. In France, where Gilles-Eric Séralini and Robert Bellé have investigated the toxic *in vitro* and carcinogenic effects of Roundup, there was a formal judgment in the Court of Lyon, after the Association of Waters and Rivers of Brittany (*Eaux et Rivières de Bretagne* – ERB) filed a complaint with the Ministry of the Environment in 2001; in addition, the Secretary of State for Consumer Affairs accused Monsanto Agriculture France and Scotts France, the distributor of Roundup in France, of lying in their advertising, and provided evidence of the deception printed on the labels of six different Monsanto products containing Roundup, whose active principle is glyphosate.

In its findings of fact, the ruling from the Court of Lyon that sentenced the companies to pay a fine explains that glyphosate is not biodegradable, not even according to the product specifications included by Monsanto in the packaging. Therefore, it does not leave the soil clean, which is even worse taking into account that its ongoing use is recommended. In addition, it indicated that Monsanto and Scotts France were aware of the product's ecotoxic characteristics, but still disseminated misleading advertising messages "containing erroneous ecological arguments for the purpose of creating a false belief that their products are completely and immediately harmless for the environment." This, despite the fact that in 2001, the European Commission classified glyphosate as "toxic for aquatic organisms" and capable of "causing long-term critical effects for the environment." Glyphosate's two main molecules are found in 55 and 35 percent of French surface waters[5]. In 1999, the New York prosecutor also charged Monsanto with misleading advertising.

[5] Le Monde (Herve Morin, March 13, 2005 published the news of the Monsanto judgment and the French studies worldwide: in an article published on February 24 in the journal Environmental Health Perspective, Gilles Eric Séralini, along with his team from the University of Caen, demonstrates several toxic effects of glyphosate and its coadjuvants to facilitate its dispersion; also, Robert Bellé of the Roscoff biological station (National Center for Social Research - CNRS), has been studying the impact of glyphosate on sea urchin cells for many years, demonstrating the early stages of cancer genesis in Roundup and an impact on the key stages of cellular division.

This refutes the alleged harmlessness of aerial spraying and the absence of drift. Well-known scientists who specialize in researching this problem have reported the dangers of aerial spraying in Colombia (Nivia, 2001b) and Brazil (Claro and Paganelle, 2000).

The very Users' Guide for Roundup (the trade name for glyphosate) prepared by Monsanto says:

> *aerial applications should be avoided if there is a danger that the chemical will come in contact with desirable species... minimum amounts of this herbicide can severely damage or destroy crops and plants for which the treatment was not intended. The risk of damage from Roundup is greater when wind speed is over 8 kilometers an hour. The instructions also indicate that "the contamination of seeds and foods intended for human or animal consumption should be avoided."*

The study conducted in Colombia for the Inter-American Commission for the Control of Drug Abuse (*Comisión Interamericana para el Control de Abuso de Drogas* - CICAD) (Solomon et al., 2005), is not only the product of institutions with related interests – the CICAD itself - but also, lacking an independent opinion, contains design biases that have been denounced by the Institute of Environmental Studies of the National University of Colombia itself (Sicard et al., 2005). In fact, according to that institution, the study suffers from:

- General methodological errors: it does not have a scientific structure with a connecting thread between questions, hypotheses and demonstration; it surprisingly excludes the social and economic elements; it depends on secondary studies to study the herbicide's impacts on human health and, moreover, does so by ignoring the studies that recognize its dangers.

- The study expressly ignores the cases of over 8,000 complaints formally filed with the Office of the Human Rights Ombudsman by affected communities in Colombia, which include damage to vegetation (87%), human health (6.9%) and the rest to animal species and water.

- The crux of the methodology consists of lines of inquiry intended to make the most acute and extensive negative impacts invisible: it chooses human fertility, whose latency exceeds the period covered for weighing the effect on health; it does not focus on the impact on legal crop species; it stays away from the impact on destruction of the soil; it hides the fact that the illegal crop zones are areas with high biodiversity; it does not provide data on the glyphosate concentration in the surface waters of the affected area. In short, the questioned study sets its sights on unquantifiable ecosystem effects instead of concentrating on direct, easily studied effects such as: destruction of biodiversity, elimination of beneficial species and soil erosion.

- Specific technical errors: to assess the impact on surface waters, it does not explain the criteria for selecting the zones where the herbicide is applied; it does not specify the agrological and ecological parameters that make it possible to evaluate the herbicide's dynamic, or the times between spraying and sample taking.

A recent official communiqué (2/26/2007) from the Government of Afghanistan explains the scientific reasons of human, social and ecological impact that led it to totally ban the system of aerial spraying with glyphosate to control illegal poppy crops (Papaver somniferum) (Ashraf, 2007).

The problem of drift

The Brazilian Agricultural and Livestock Research Institute (*Empresa Brasileira de Pesquisa Agropecuaria* – EMBRAPA) has demonstrated that there is normally a "technical drift" and that, under ideal calibration, temperature and wind conditions, current spraying equipment distributes its sprays as follows: nearly 32% is retained by the target plants; 49% goes into the soil; 19% travels by air to other neighboring areas. Thus, spraying affects nearby crops and inhabited areas, violating the rules for contact in areas with sources of water, rivers and residences, as prohibited by the Forestry Code and the Agro-Toxins Law of Brazil (Chaim, 2004). Moreover, they have measured the drift in that country and established that it is 800 meters for low-altitude flights (4 meters over the plant cover) (Claro and Paganella, 2000). Bear in mind that, in Colombia, they fumigate at height of between 60 and 100 meters, as acknowledged by the U.S. Embassy itself (Williams, 2003).

In his work for the Bayer company, Leiva (2007) recalls that, in 1974, Himel said that "only 25% of the volume (of herbicides) applied reaches the plants," and that this low percentage is due to the problems of endo- and exo-drift. The former is the drift that falls to the soil within the target crop, without reaching the plant, and the latter is the drift that travels outside the target area.

The elements that support the Ecuadorian argument on drift are:

Droplet size

Although smaller diameter droplets are more effective on plants, they remain in the air longer and the wind can act on them, carrying them long distances, while they simultaneously undergo evaporation. Although large droplets fall harder and faster, decreasing the drift, they can bounce off the leaves and fail in the purpose of acting on them, falling by runoff. In this regard, the so-called Volumetric Mean Diameter (VMD) has been defined as the droplet size that divides spraying into two equal volumes; i.e. 50% of what is sprayed has this diameter, while the remaining 50% has very different sizes. In each spraying, it is impossible for all the droplets formed to be the same size. The volume that has been proven most appropriate for spraying legal crops (done at just three meters high) suggests

the use of droplets with a diameter of between 200 and 250µ, because after 350, "there is no adhesion and the droplet runs off" as Leiva mentions in his work for Bayer (2007). However, in Colombia, Solomon (2005) notes that the PECIG[6] spraying program uses droplets with a VMD of between 300 and 1,500µ, a range that is too broad; moreover, at the actual spraying height and under the prevailing weather conditions, a high percentage of droplets will unquestionably be smaller diameter, and therefore have greater drift than the theoretical calculated average that has been reported.

Droplet depositing efficiency

This will depend on droplet size and the surface area of the vegetation's foliar lamina. Therefore, aerial spraying is avoided during the rainy season. It has already been noted why the mesological conditions alter depositing efficiency on the target vegetation, which is coca, at the expense of other vegetation.

Atmospheric stability

In this section, we must not only take into account the wind velocity where, depending on the company, spraying is prohibited at between 2.8 and 4.2 m/s (10 and 15 km/h) (Bayer-Leiva), or between 1.7 and 2.2 m/s as Pérez reports in his work for Syngenta: *No matter how large the VMD, if wind velocity is over 1.7 m/s (6 km/h), the drag is very strong and in this case, it is better to stop the application.* Unfortunately, according to reports from the National Institute of Meteorology and Hydrology of Ecuador (Naranjo, 2006), it has been found that at representative points in the border area, there are winds higher than those recommended by the Syngenta model. Thus, in Nuevo Rocafuerte, the winds are from 1.8 to 2.4 m/s; in Lago Agrio, from 1.5 to 2 m/s; and in Tulcán, from 3.5 to 4.5 m/s, predominately from the northern direction in all three cases. In other words, spraying is being done under conditions that create drift. According to average data, between December and February, a continental high-pressure ridge from the South Atlantic and the Caribbean is located in the northern zone of the inter-Andean and eastern region which favors the presence of northern winds at the 850 hPA (1500 m) level, with an average intensity of 12 m/s.

We must also assess the temperature and relative humidity that act directly on spraying with an aqueous substrate, such as the PECIG spraying, which undergoes more evaporation that increases in drier environments. The PECIG spraying is usually preferably done in the dry seasons, between December and February, when the humidity is lower. An example of this is the fact that, at the same ambient temperature (30°C) and relative humidity (50%), a 200 µ droplet takes 42 seconds to shrink to half its size, while a 100 µ droplet takes only 14 seconds to evaporate (Leiva, 2007). Therefore, as a safety measure, it has been established that aerial spraying should be done at a temperature under 25°C or a relative humidity over 60%. However, these conditions are not always met in the PECIG.

[6] Program for the Eradication of Illegal Crops with Glyphosate implemented by the Colombian Government.

The *campesinos* say that spraying is even done at noon, when the sun is the strongest. A final point to take into account is that the so-called heat inversion phenomena can sometimes occur. The temperature in the atmosphere drops approximately one degree every 100 m in height. This means that when the cold air descends, it helps the spray settle. In heat inversions, when the layers of hot air stay up, the sprays can remain suspended in the air for prolonged periods of time, and then drift for long stretches in the presence of light breezes. However, Solomon (2005) proposes that the wind velocity measured from helicopters using the smoke generated by the crop spraying aircraft is a good enough indicator to measure drifts.

Evaporation

In mixtures with water, evaporation depends on high temperatures, low relative humidity and droplet size. Syngenta acknowledges that "*another consequence of evaporation is decreased droplet size, which allows greater drag and can cause: human environmental pollution and damage to susceptible crops*." We must bear in mind that the decrease in droplet weight over unit of time is related to the decrease in droplet size due to evaporation.

The flight altitude of the plane

Aerial spraying is normally done at between 1.5 and 4 meters above the plant cover to be sprayed, a height that should be the lowest possible, since at higher altitudes, the possibilities for drift increase. The DNE itself recommends a flight altitude of less than 25 meters for coca. However, due to the orography and the fear that the planes will be shot down, this parameter is never met and, according to the DNE, spraying is done from over 30 meters high. However, films and photographs show that spraying is done at no less than 60 meters, and even between 60 and 100 meters high according to the U.S. Embassy in Bogotá (Williams, 2003).

The reason that they are using such high concentrations of chemicals (23.65 liters/hectare) in the PECIG program is due precisely to what Bayer (Leiva, 2007) recognizes as the maximum volume, applicable when, for reasons of uncontrolled drift, the required coverage must be ensured. But the problem is that in the PECIG, this maximum volume is the one systematically used. A coverage of 20 droplets/cm2 can be achieved with a volume of 5.3 liters/hectare, spraying 150µ droplets, or with 42.4 liters/hectare, using 300µ droplets (Leiva, 2007). Thus, while Bayer, citing Leiva (2007) recommends that spraying be stopped at over 25°C and under 70% humidity due to high product losses from evaporation, Syngenta (Pérez, sf), however, advises that application volumes under 9 gallons/hectare not be used in order to ensure the coverage of spraying at temperatures between 28° and 32°C, with relative humidity under 70%.

In short, based on flight parameters, weather elements, intentionally high volumes and concentrations, and

the characteristics of the package that is being sprayed, we have established the fallacy of the calculations indicating harmlessness and slight drift that have been argued on the basis of mistaken analyses.

Contradicting proven scientific arguments, in a letter written by Colonel Plazas Vega (2004) as director of the National Drug Office of Colombia to the Scientific Commission of Ecuador at the time, he mentions that the mathematical model used by Syngenta (Pérez) was adopted to measure drift (D), where it is proportional to height (H) and horizontal wind velocity (U), and inversely proportional to terminal droplet velocity, per the following formula:

$$D = \frac{H \times U}{Vt}$$

The formula does not account for ambient temperature or humidity, or measure the evaporation process at an altitude of between 60 and 100 meters, or the heat inversions, or the velocity of the plane in flight, which influence the droplet's initial velocity. In addition, it takes droplet size to be uniform, without taking into account that only half the volume (VDM) matches the one indicated. Presented as unquestionable truth, it ends up asserting that, for an average droplet of 650 µ, the maximum drift is 12 meters for a height of 25 m x 1.3 m/sec (equal to a wind of 4.8 km/hr) divided by a terminal velocity of 2.7 m/sec.

However, in the document consulted by Colonel Plaza, Syngenta itself (Pérez) recognizes that 5µ droplets can remain in the air for 66 minutes and travel 4,827 meters when they are launched at a height of 3 meters:

Table 2
Drag or drift of a droplet launched at a height of 3 meters

Droplet size (µ)	Time needed to fall 3 meters	Drag with a velocity of 4.8 km/hr
5	66 minutes	4,827 m
20	11.58 sec.	338.2 m
50	72.8 sec	54.29 m
100	11 sec	14.64 m
400	4 sec	2.59 m
1000	0.75 sec	1.48 m

Source: Pérez, Horacio. Syngenta

droplet can decrease in size. In the following table, Syngenta maintains that temperature and humidity have a significant influence.

Table 3
Droplet lifetime in air under different conditions

Droplet size in µ	Temp. 20°C – 22°C and Relative Humidity 80%	Temp. 30°C and Relative Humidity 50%
50	15 sec	3.5 sec
100	50 sec	14 sec
200	200 sec	56 sec

Source: Pérez, Horacio. Syngenta

The formula mentioned by Colonel Plaza was accompanied in his document by Stokes law for the terminal velocity (Vt) of the droplet, expressed with the following formula:

$$Vt = \frac{G \times D2 \times W}{18A}$$

This law establishes that the droplets reach a constant falling velocity based on gravity acceleration (G) in m/sec, droplet diameter (D) in µ, and droplet density in kg/m3, being inversely proportional to air viscosity (A) in newton-s/m2.

Syngenta (Pérez) establishes a guideline chart on this velocity:

Table 4
Droplet sedimentation velocity as a function of size

Droplet size in microns (µ)	Terminal velocity (cm/sec)
1,000 = 1mm	400
500	220
200	72
150	48
100	26
90	21
50	7
20	1.2
10	0.3

Source: Pérez, Horacio. Syngenta

However, the company notes that these are the characteristics for a droplet launched in calm air with no evaporation; what it is attempting to demonstrate is that droplets under 100 μ reach the equilibrium between the force of gravity and friction with the air in less than 25 cm of fall, maintaining a constant velocity, while in droplets over 500 μ, the terminal velocity is reached at 70 centimeters. But the drop from the height that is being used in Colombia should call for corrections given that the size of the droplet is different from the time that it is sprayed until it falls to the ground, a measurement that the formula does not include. It also fails to include the influence of the droplet's initial speed, or the atmospheric conditions, when they have been shown to be decisive.

The statements of the DNE Director to the Ecuadorian Commission are surprising, given that they were made after the test conducted in 2000 before the press and U.S. Congressmen Paul Wellstone, who received a "glyphosate bath" when he was invited to witness the demonstration of the "technical precision" of the aerial fumigation operations. A slight wind carried the herbicide to the site where all the invited guests were found, some 200 meters away, demonstrating that the precision of the fumigations is unreliable (Hotakainen, R. 2000).

These statements are also surprising because five years earlier, Nivia (1999) described how in terrestrial applications, between 14% and 78% of the glyphosate applied leaves the site, describing dead plants over 40 meters away, and finding residues 400 meters away from a terrestrial application. In applications with helicopters, he describes how the losses of glyphosate traveling beyond the site range between 41% and 82%, finding it in measurements taken over 800 meters away from the application point. This situation worsens with planes, because a California study found residues at 800 meters, which was the greatest distance studied.

Recent studies in Costa Rica and California have found pesticide residues in rainforest areas more than 20 km away from where the agricultural farms are located (Minard, 2007). The studies have not only found pesticide levels that are 10 times higher in frog ponds, but also in the frogs' bodies, which means that it can cause the death of over 90% of those populations. This is explained by the vaporization of these products which, when they are employed and reach the coldest layers of the atmosphere, return to the liquid phase, and when it rains, concentrate in places where these amphibians live.

A recent bulletin from the Pesticide Action Network in Latin America (Bellé, 2007) published an interview with one of the major scientific authorities on research into the impacts of glyphosate, Dr. Roberte Bellé of the National Center of Scientific Research of the Pierre and Marie Curie University of France, who stated the following verbatim:

- *The problem is that when atomized in planes or even with a manual atomizer, the mixture is one hundred times more concentrated than the mixture that can deregulate cell functions. Each micro-droplet can touch thousands of cells simply when we breathe them in, and if those micro-droplets are atomized in a plane, they can travel hundreds of kilometers. When a garden is fumigated, the droplets can travel between 2 and 3 km if there is wind. Monsanto recommends not fumigating when there is wind, but that is impossible because there is always wind. It also recommends the use of masks, rubber gear, boots and gloves. The one fumigating is protected, but those 500 m away are not.*

  Aerial fumigation is another thing. It is a catastrophe. It has been shown that there is sand from the Sahara in the North Pole, and a grain of sand is bigger and heavier than a micro-droplet. The atomized micro-droplets are almost like water vapor, and travel simply with the movement of the earth, like the clouds. It is madness to atomize with a plane.

Toward an ethical and scientific handling of uncertainty

Approximately three decades ago, a concern over the gap between science and health and environmental problems arose around the world. The occurrence of unfortunate episodes of impacts caused by urban or agro-industrial processes using products such as certain agro-toxins, which had been proclaimed as safe, plus the growing uncertainty over new processes and products made by humans but whose effects on life were little known, added a point to the debate which could be summarized as follows: science rarely provides conclusive evidence, and the decisions to protect life on the planet and health must be made before there are definitive conclusions based on tests universally recognized as conclusive.

Since then, knowledge on this problem has multiplied, in more responsible social and environmental contexts, and a voluminous bibliographical base has grown that has begun to be systematized. There is also the need for a critical examination of not only the scientific paradigms and governance logics, but the institutional contexts that have, up to now, defended an out-of-sync and insensitive science. The debate over policies, constituent rules, and setting standards and regulations for the protection of life in the European Union is an extremely useful experience, because more than a decade of discussion and heightened polemics have made it possible to distill the key points of the criticism against a blind scientific view of society's needs, which clings to a paradigm that uses

uncertainty as a tool to justify permissiveness, placing the interest of companies before the common good and the protection of life (Guimares *et al.*, 2006).

In Latin America, it is not only the pro-health and environmentalist social organizations that have fed the discussion of the problems of the link between science, society and policy-making. A large group of scientific and academic centers has also created a significant current of critical thought in this regard, and one of its expressions has been the Latin American Association of Social Medicine (*Asociación Latinoamericana de Medicina Social* – ALAMES). Several of the region's most prestigious research centers take part in this academic and socio-medical think tank network.

At the center of this worldwide scientific and social network is the criticism of a reductionist and linear scientific paradigm that fragments and decontextualizes health and environmental problems; impoverishes scientific observation, reducing it to quantitative, supposedly precise evidence; and reduces the notion of scientific proof to the demonstration of factual associations (Breilh, 2004).

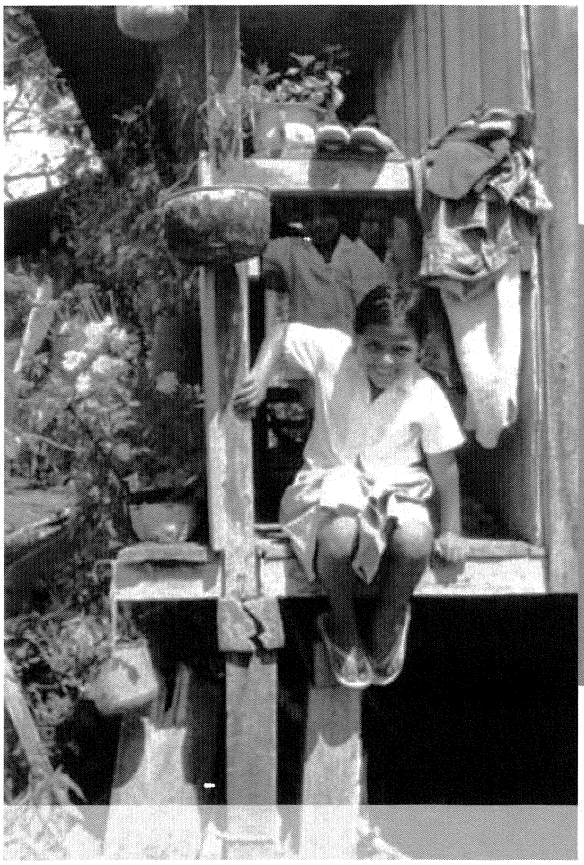
This scientific paradigm has facilitated the domination of a narrow model of "science-based decision-making" that uses uncertainty as a way to expiate guilt, as an instrument for maneuvers linked to strategic interests, and as an obstacle to applying the precautionary principle (Craye, 2006).

The questioned model works as follows: policy-making is based only on "conclusive" and "positive" evidence. Other evidence is non-conclusive and results from a lack of knowledge and a momentary shortage of base data. The solution for the lack of conclusive evidence is more research. This route involves recording precise quantitative probabilistic data and is only workable when that type of "certainty" is available (Craye, 2006).

Throughout the years, environmental and health controversies have resulted in a scientific questioning of this model for the relationship between science and decision-making, precisely in problems such as the one that Ecuador now faces – proximity to spraying with a herbicide package that includes glyphosate - and in cases caused by similar aggressors, where there are points of uncertainty (i.e., chemicals, endocrine disruptors, dioxins, genetically modified organisms, radiation, etc). It has become evident that the controversies basically do not arise due to the lack of conclusive factual information, and are not resolved with a little more research. Rather, they are the result of the problem's complexity, [and] of the existence of opposing scientific and social perspectives or views; and very importantly, they arise in institutional contexts intersected by opposing interests (those of the companies causing the problems and those of the affected population) (Craye, 2006).

The European experience over the last two decades allows us to understand that if we want to develop a scientifically objective and ethically just model, we must overcome the framework that we have explained. A central point is overcoming the *false notion of uncertainty*, which supposes the lack of more research, and recognizing that the complexity of our problems goes hand-in-hand with more profound forms of uncertainty that are not reduced to what is expressed in probabilistic terms. Thus, several scientists have demonstrated that there is also *ignorance* (not only *not* having the basis for estimating probabilities of damage, but being ignorant of impacts that may arise in a specific context) (Funtowicz and Ravetz, 1990); *indetermination* (due to the unanticipated action of unpredictable systems) (Wynne, 1992); and *ambiguity* (there is no agreement on the precise meanings of the subject, or the meanings are confusing) (Wynne, 2001).

Therefore, it is clear that scientific evaluation of the impacts of aerial spraying must distance itself from this scientifically deficient and ethically irresponsible model.



V. THE AERIAL SPRAYING SYSTEM AND ITS IMPACT ON LIFE AND HEALTH

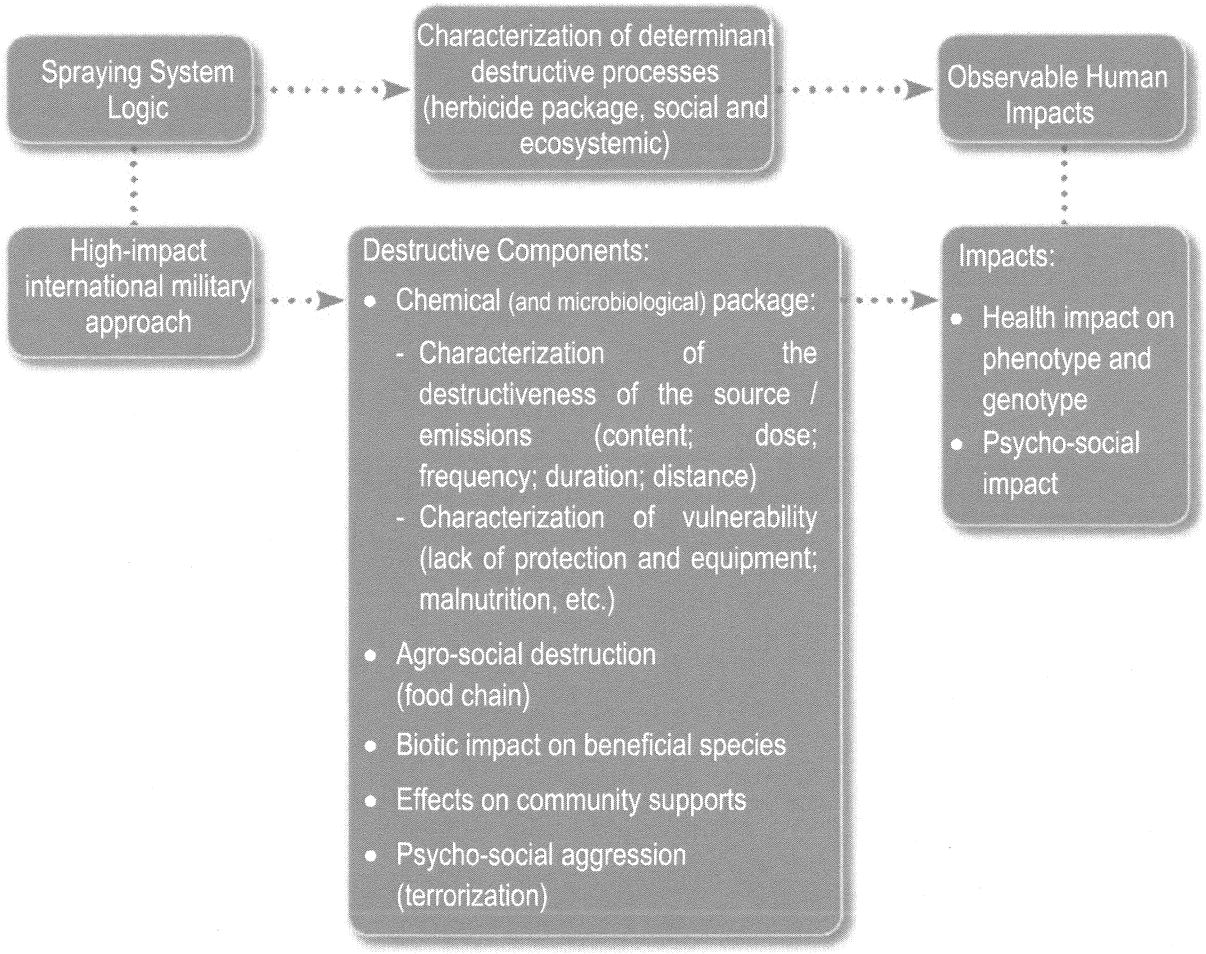
The Notion of Life and Health Determinants as Study Framework

The epidemiological investigation of a destructive process involves the study of a system of relationships – with empirical evidence – that explain the connection found between the elements that create collective harm, the determinant processes for health, and the different impacts caused.

The World Health Organization establishes a model for the determination of health (Commission on Social Determinants of Health, 2005) which should be applied to the investigation of collective health problems, such as those suffered by the population on Ecuador's northern border due to the start of the aerial spraying system.

Therefore, this study assumes the notion of *health determinants* (Marmot, 2005; Breilh, 2005) as a logical framework for studying the system of relationships that allows us to understand the damage wreaked on Ecuador's border population and the ways to determine that damage. (See the following diagram.)

Model for Studying the Impact of the Aerial Spraying System



An epidemiological analysis of the spraying system confirms its high-impact, highly dangerous design:

* System logic: not accidentally, but intentionally high-impact
* System destructivity

Content of the source/emissions package: Glyphosate, N-(phosphonomethyl) glycine, a broad-spectrum, non-selective herbicide applied in a package with other hazardous components (POEA, Cosmo Flux 411 F as a minimum), and under a system of high-altitude aerial spraying, with multiple and terrorizing effects (already described).

"Dose"/magnitude of the applications: high concentrations that are corroborated by the short latency of the effect. Interviews with key informants from the town of

Mataje[7] established the following on the latest aerial incursion:

- Fleet of six planes and five helicopters.
- Number of flights observed: most saw 3, and others 5.
- Each pass lasted between 4 and 5 minutes, covering the entire horizon.
- Distance: The informants in the town of Mataja were between 700 and 1000 meters away during the latest spraying.

In the case of spraying in 2002 (Maldonado, 2002), to check the distance of the fumigation done on the border, the verification mission went into Colombian territory and used GPS equipment to identify the zones that were fumigated in Colombia and their distance from the San Miguel River, with the following results:

Table 5
GPS Points and Distance to the border from Colombia

Location	Point	Elevation	18° North	UTM	Distance to Ecuador
La Pedregosa (Col)	7	248 m	0317989	0029601	6 m
Nueva Granada (Col)	8	266 m	0318341	0031095	1,412 m
Nueva Granada (Col)	9	275 m	0318295	0031318	1,635 m
La Pedregosa (Col)	10	270 m	0318088	0030359	706 m
Los Cristales (Col)	14	270 m	0333976	0037515	8,285 m
Aguas Blancas (Col)	15	276 m	0332612	0035459	6,981 m
Aguas Blancas (Col)	16	292 m	0332616	0035463	6,986 m

- Estimated altitude: around 100 m; 30 m over the forest canopy.
- Emissions: most saw that they were abundant and white; one thought that they were very abundant and dark green.

[7] Interviews in the town of Mataje (Esmerladas) on Wednesday, February 21; i.e. 16 days after the latest aerial spraying by the Colombian air force.

In that study, done for the Putumayo area, the following was also established: aerial fumigation under the Plan Colombia officially began in the Putumayo department on December 22, 2000. Up to January 28, 2001, around 29,000 hectares were fumigated; during 2001, 94,000 hectares were fumigated according to the United States Embassy in Colombia. The United States government planned to expand the fumigation area to 150,000 hectares in 2002, and to 200,000 in 2003, which would exacerbate the social-environmental and human health impacts on the border populations.

The research made it possible to provide accounts and establish a precise record of the spraying operations as early as 2002, as the study in question underscores.

ACCOUNTS OF SPRAYING IN 2002

In La Peregosa (point 7), six meters from the San Miguel river, signs of crops destroyed by the fumigation were found, possibly as a result of aerial drift.

At point 10, severe impacts were observed, given that the fumigation was done directly over the area and 706 meters away from the border.

In the Nueva Granada community (points 8 and 9), 1,600 meters away from the border, the people's accounts report that between August 30 and September 6 the planes fumigated directly over the houses. As evidence of this, large chlorosis circles were observed on the soccer field, located in the center of the town. The school teacher stated that her 35 students fell ill with headaches, watery eyes and fever.

In Aguas Blancas (points 15 and 16), 7 to 8 km away from the border, the destruction of all types of crops was confirmed.

In Los Cristales (point 14), accounts were gathered that the planes passed over the houses and sprayed on August 1 and 18, 2002, without regard for the fact that they were affecting the homes, food crops and sources of water.

In La Playera Oriental and Chone 2 (between 1 and 1.257 m away from the San Miguel river basin), evident damage was observed from the fumigation done on September 6, 2002 on the Colombian side, on the banks of the San Miguel river.

At all points, soil and vegetation samples were taken, and health data on the population and accounts of the social impacts were gathered.

Exposure Pattern

In the case of Mataje, all those interviewed were in the town (1 in the yard of the daycare center, 2 in the river washing clothes, another outside, in front of the river bank); several felt the effects on the skin almost immediately: "a tingling sensation" followed by "itching" and irritation of the eyes; others felt the onset after being in the river for awhile that day; others drank water from the river or other sources in the area; all had skin contact with the water that same day and the following days. In addition, they reported having cases of diarrhea and dizziness in the family and neighboring families, and a few days later, several children developed purulent conjunctivitis. In the families that were interviewed, there were 2 cases of acute respiratory problems. The town's nurse was able to treat these cases.

In the case of previous spraying, the study by Maldonado (2002) established the same pattern of evidence as in Mataje. The "Santa Marianita" Campesinos Association (Ordóñez, 2002) of the General Farfán Parish, with 27 members, reported that after recent fumigations in Colombia, they suffer from "diseases of the skin and eyes, respiratory infections, fevers similar to those of malaria, but always with negative test results. The female animals miscarry and we have low corn, cacao, rice and plantain production, to the point that we can't recover the investment." The Chone 2, Puerto Nuevo and La Playera communities on the road to Tetetes, Pacayucu Parish report damage to their crops and animals. There is also talk of serious damage and health problems in the border community of Cohembi.

Protection and vulnerability of the population

In the case of the most recent spraying in Mataje, all those interviewed also said that they were surprised; that their arms and legs were uncovered. Some went into their unprotected homes for a short time, but had to leave and still go to the river that same day and the following days. Signs of chronic malnutrition are found in the area's affected children.

On the Ecuador-Colombia border, there is a higher level of malnutrition among the school-age population than in the same population over 20 km away from the border. Chronic, acute and widespread malnutrition is higher in the population under 10 km away from the border that has felt the impact of the Plan Colombia fumigations on repeated occasions. The violence that is seen along the border is increased in this area due to an additional component: fear. Fear, stress and malnutrition are a burden that is too heavy to bear for a population with no aid, 56% of which has fled over the last 5 years (Maldonado, 2006).

In January 2001, the Ecuadorian press reported the impacts from the December fumigations in the Province of Sucumbios (*El Comercio*, Quito, 1/12/01).

Months later, c*ampesinos* from different communities filed a complaint with the Office of the Human Rights Ombudsman of Lago Agrio, which was forwarded to the Quito Human Rights Office but went no further. The complaint contained the claims of the *campesinos* from the General Farfán, Nueva Loja, Pacayucu, Dureno and Tarapoa Parishes, and included the following losses:

Table 6
Damage to crops and animals in Sucumbios (Ecuador) 2001

Crops	Number of hectares damaged	Percentage	Animals	Number of dead animals	Percentage
Coffee	1,215	47.4%	Fish	6,355	53.7%
Pasture	785	30.6%	Hens	4,681	39.6%
Plantain	182	7.1%	Pigs	315	2.7%
Rice	103	4.0%	Cows	188	1.6%
Corn	87	3.4%	Guinea Pigs	117	1.0%
Cacao	79	3.1%	Ducks	73	0.6%
Fruit trees	53	2.0%	Dogs	49	0.4%
Yucca	51	2.0%	Horses	43	0.4%
Total	2,560		Total	11,828	

As we will next see, similar impacts have been reported by social and indigenous organizations in Colombia.

A verification commission (ADUC, 2003) in the department of Arauca (northern Colombia on the border with Venezuela) in 2003 reported significant economic losses and effects on the population's nutrition:

- *"Aerial fumigation is done indiscriminately, directly affecting sectors that do not have illegal crops; to the contrary, the most affected fields are those intended for*

the subsistence of the region's inhabitants, as well as the natural habitats near the fumigated sectors (...) There is no direct eradication of the illegal crops; the food crops have been fumigated, affecting nutrition and subsistence in the region."

Three years earlier, the fumigation put an end to an annatto project for manufacturing dyes to export to European countries (Puyana, 2007).

In Nariño, the Municipal Human Rights Office of Buesaco prepared a report (Cabrera, 2003) in which university professionals, members of the Nariño Department of Agriculture and the Environment, the coordinator of the municipal Department of Technical Assistance for Agriculture and Animal Husbandry (UMATA) and professionals from that municipality describe the fumigation as follows:

- *It was found that there are no illegal crops in the sectors in question, and the fumigated crops are legal food crops (...) the government planes sprayed the food crops and destroyed their only means of subsistence."*

Representatives from the Kankuamo People (Rodríguez, 2003) living in the Sierra Nevada of the Santa Marta department (northern Atlantic coast of Colombia) have reported how:

"Fruit trees such as avocado, orange, lemon, etc. are already scarce products in this zone, due to the many fumigations that have been done; we have diseases in medicinal plants, (....) diseases in the animals; we are suffering the same consequences as southern Colombia, the death of horses, donkeys, cows, goats, pigs... and the wild animals that we live from."

In August 2000, palmito growers who had joined together in "Agroamazonia," part of the official PLANTE project financed by USAID in Putumayo, reported the loss of 100 hectares of crops intended for the Puerto Asís processing plant and the Carrefur ***[sic]*** supermarket chain, worth 300 million pesos (Puyana, 2007).

The National Indigenous Organization of Colombia (*Organización Nacional Indígena de Colombia* – ONIC, 2007) has stated that despite the fact that judgment SU 383 of 2004 obligates the Government to consult on fumigations in indigenous territories, it continues to fumigate, and in the sites affected by aerial fumigation, the families are left helpless and without a way to make a living, because the fumigation of one hectare of coca leaves 10 damaged hectares around it.

The Embrera town council (2001) filed charges with the Office of the Human Rights Ombudsman that the communities of San Antonio, La Danta and San Juan are starving, with no harvests, no seeds and without knowing what to eat, because they even fumigated the river and the fish died.

All these impacts, as we have said, are similar to those suffered by the Ecuadorians on the border. The communities of Chone 2,

Playera Oriental, Yanamarum, Puerto Nuevo, Chanagué, Santa Marianita, Puerto Mestanza, 5 de Agosto, Monterrey, La Frontera, Corazón Orense, El Trampolín, San Francisco 1, San Francisco 2, San Pedro del Cóndor, 10 de Agosto, Nuevo Mundo, Salinas... are names on a long list of communities that have been impacted by the fumigations inside Ecuador.

In the Mataje area, the complaints are the same. Five families who lived on fishing were forced to abandon it or have seen it drastically reduced because, as they stated in the interviews in 2007, neither freshwater shrimp nor prawns can be found now, and fishing for them was an important part of their diet and survival (Ecuadorian Scientific Commission, 2007).

The Ecuadorian Scientific Commission found other impacts on the everyday lives of the residents of Mataje. The following table systematizes the accounts that were gathered regarding the changes that spraying has meant in their everyday lives, especially in the use of time and space.

Table 7
Impact of glyphosate spraying on the Colombia-Ecuador border

ACTIVITY	PROBLEM CREATED BY SPRAYING	CHANGE IN THE USE OF TIME	CHANGE IN THE USE OF SPACE	DAMAGE TO THE POPULATION
Agriculture	The spraying has damaged many crops, especially plantain and yucca. When the planes fly overhead, the crops burn. Several weeks later, when they want to plant again, the crops do not flourish. The soil loses its fertility. In other cases, it is reported that the crops shrivel from the root upward.	Many people have abandoned agriculture due to the impact of spraying on the crops.	UDENOR has delivered cacao to several *campesinos*, but they are not certain that it is going to result in a profitable crop, or if they are going to have a market. Cacao is planted on land dedicated to food crops such as plantain (a basic food), yucca and sugar cane.	Due to the crop destruction, the townspeople who formerly sold plantain in San Lorenzo now have to buy it. The same thing is happening with other crops.

Fishing	In last year's spraying, the river filled up with dead shrimp and fish. The natural freshwater shrimp populations have not recovered.	The individuals who collected freshwater shrimp have had to engage in other activities.	The river is no longer used to collect freshwater shrimp. The freshwater fish populations have also been reduced.	The loss of natural shrimp populations has had an economic effect on the people who engaged in this activity. They worked 3 days a week and made US$ 80. The inhabitants can no longer include shrimp in their regular diet.
Hunting	The spraying has scared off the hunted animals.	The men can no longer go out to hunt.		Decrease in sources of protein.
Domestic activities.	Pollution of the river. The women wash clothes in the river. The Northern Development Unit (UDENOR) has provided them with tap water, but at a cost, so they prefer to wash in the river.	Many women stop washing clothes during the spraying period so that their health isn't affected. This means a work overload when the level of pollution decreases.	Other women have stopped washing in the river and use running water	Women have to wash clothes with tap water, stop washing during the spraying period, or face health problems due to the pollution present in the river.
Socialization	The river is a place for socialization. The women go there to get water for multiple activities.			With the pollution of the river, the places for socialization decrease.
Recreation	The town's children play in the river. When they are in the river during spraying, they come into direct contact with the chemicals.	The children have to stop playing during the spraying period.	The river is no longer a place of childhood recreation.	This generates psychological impacts on the children.

Health	The spraying has affected all the people who were exposed to the chemicals and those who consumed contaminated products.	The people have had to take time to go to the medical center (where there is only one nurse and occasionally a doctor), and in more serious cases, they have gone to San Lorenzo.		The impacts on health have entailed financial losses for the townspeople.
Paid work	Loss of crop productivity	Because agriculture does not produce as it used to, many men have had to go to work on the palm plantations. This work is very low paid. They are paid an average of US$6 a day (75 cents an hour, if they work 8 hours a day.)		In economic terms, they now have lower income than they made when they engaged in other activities.

Genetic effects on an agricultural crop____

In order to analyze the impacts of glyphosate on agricultural crops, Dr. Mariana Moýon, a biologist from the Central University of Ecuador, conducted studies on genotoxicity in onions. The studies assessed the damage that glyphosate alone, on one hand, and glyphosate prepared with its agents, on the other, produces in the plants' genetic material. The onions were subjected to concentrations of glyphosate alone and glyphosate prepared in the percentage recommended by the manufacturer (3.3 %) for variable periods: 4, 24 and 48 hours. Rootlets obtained by generation in glyphosate-water mixtures were studied (Astudillo et al., 2006).

The study found that there is also damage to the plants' genetic material, manifested in cells with two or three nuclei, chromosome fragmentation, cells with giant and abnormal nuclei and other damage to the DNA structure.

Some of the alterations present in the onion assays[:] Telophasic bridges A (Photograph 1); anaphasic points B (Photograph 2), and cells with micro-nuclei C (Photograph 3).

There is currently a list of studies validated in the scientific media which attest to the damage that that glyphosate causes to different species and mitigate any doubts in this regard.

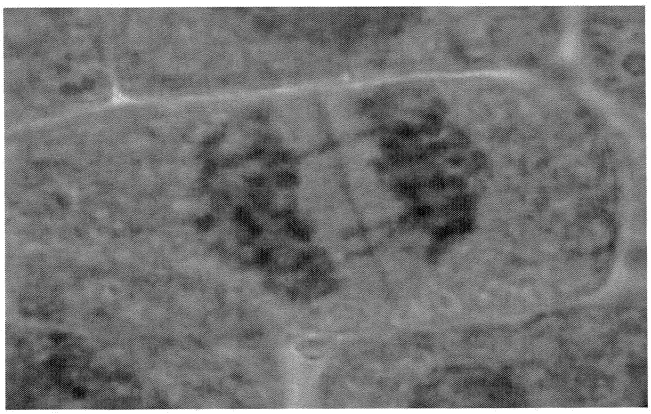
Presence of glyphosate in water

There are several reports that found the presence of glyphosate and AMPA in bodies of water. The presence of glyphosate has been reported in surface and underground waters in Canada, Denmark, Holland and the United Kingdom.

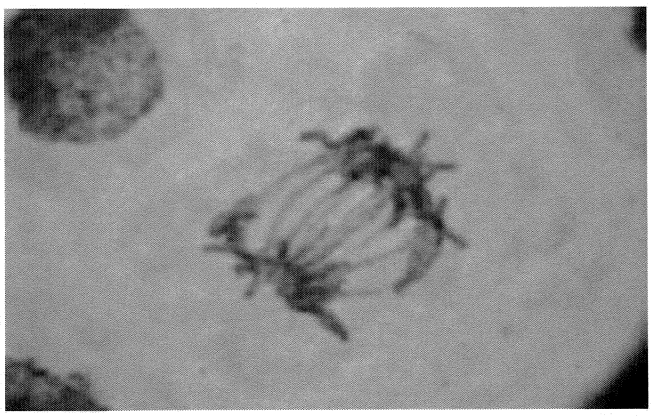
A World Health Organization report on glyphosate and AMPA in drinking water reports that sources of water have been found in the United States containing between 90 and 1700 µg of glyphosate per liter and from 2 to 35 µg/liter of AMPA. In running water, contents of between 35 and 1237 µg/liter of glyphosate and up to 10 µg/liter of AMPA have been reported (WHO, 2005).

In Canada, glyphosate residues of up to 5153 µg /liter were found after an aerial application on lakes. Its degradation depended on the vegetation present (WHO, 2005).

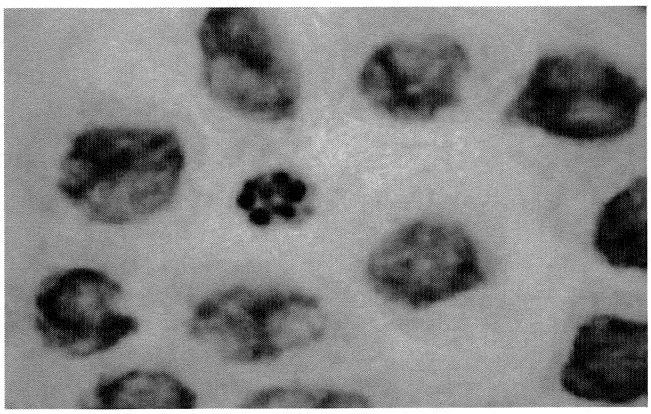
In 2003, the Ministry of the Environment of Denmark prohibited the use of glyphosate in places where there could be runoff, in order to prevent the pollution of underground water (the source of drinking water in that country) with unacceptable levels of glyphosate and AMPA (Legarth and Schmidt, 2003; Kjaer et al., 2003).



A Photograph 1



B Photograph 2



C Photograph 3

Presence of glyphosate in food

As we already indicated, with the advent of glyphosate-tolerant genetically engineered crops, starting in 1996, the limit for residual glyphosate in soy was surprisingly raised by over 200% in the United States and Europe. The increase is due to the requests and influence of the glyphosate manufacturers.

The vestiges of glyphosate and its metabolite in genetically engineered soy are also present in the foods prepared from soy. The analyses for glyphosate residues are complex and costly, which is why they are not routinely done by the United States government. But there is research which shows that glyphosate can be absorbed by the plants and become concentrated in the parts that are used as food. For example, after its application, glyphosate has been found in strawberries, blueberries, raspberries, lettuce, carrots and barley. According to the World Health Organization, its use before the wheat harvest for drying the grain results in "significant residues" in the grain; the bran contains residues in concentrations 2 to 4 times higher than the grain.

Impacts on Mental Health

Our assessments of the impacts on mental health are based on:

- The notions that guide scientific thought regarding collective Latin American health;
- The evidence, opinions and reactions that were gathered directly during two bi-national missions to visit the border (Campaña, 2004; Campaña, 2005), and the national scientific mission to visit Mataje, where first-hand information was collected (2007)[8];
- A review of the available studies on this subject.

In the three missions in question, we have spoken with and interviewed not only the townspeople and nationalities directly affected by the aerial spraying, but also members of the broadest variety of institutions concerned with the problem, such as church organizations, human rights organizations, international organizations, municipalities, governments, the army, police, and health and education services.

[8] Ecuadorian Scientific Commission. Evaluation of the impact of the aerial spraying in February 2007 on the health of the inhabitants of Mataje.

The commitment to the defense of the health and lives of our compatriots, based on the principles of scientific ethics and unwavering adherence to the precautionary principle, also obligates us to pay attention to the situation created by the aerial spraying for our Colombian brothers and sisters along the border. As the representative of a United States human rights organization stated, herbicide concentrations and adhesion agents have been used that drastically exceed the admissible quantities for common agricultural and gardening practices (Isacson, 2002). From the scientific point of view, it is, moreover, completely valid to make reference to the experiences of the Colombian people and the accumulated impacts on their mental and physical health after being subjected for years to this program for the "eradication of illegal crops."

Thus, let us generally characterize the effects on mental health when, against the background of prevailing violence, the impact of aerial spraying is more vertical or direct; in other words, when it depends less on drift with the wind, transport by water, and being too close to "unplanned" locations/targets.

Suffering due to hunger and illness

The first thing that should be noted is that, according to the Office of the Human Rights Ombudsman of Colombia, in most of the complaints about fumigation (already approaching ten thousand), the issue of serious damage to health and the availability of food, i.e. the suffering from associated illnesses and hunger, is always present.

Suffering due to displacement and the search for refuge

Another medical/social and public health problem that is seen over the course of conversations with agents from the regional office of UNHCR in the city of Pasto is the number of displaced persons and refugees due to the internal violence and the spraying; in Nariño, over 25,000 displaced persons have already been counted. The implications on mental health are truly serious: the loss of collective ties, frequent breakdown of the family unit, psychological wear – sometimes reaching the level of abuse – all accompany the process of applying for refugee status. In 2004, it was calculated that 350 Colombians had crossed the border between Chiles and Truciño seeking refuge on the Ecuadorian side; also, that some 47 families had crossed over from Mataje to San Lorenzo. The social, economic, cultural and psychological impacts that precede physical displacement are prolonged and extremely wearing, and the responses to the refugees' specific health needs, especially mental health, suffer from major limitations, or simply do not exist.

Suffering from sudden exposure

The predictable attitude stated by those who execute the spraying plan and claim that they announce

the applications in advance to alert the population and remove it from the target locations, is flatly contradicted by the victims. The common expression that they use is "we were fumigated." The first fumigation "caught us at 11 o'clock in the morning one day in October; after the helicopters, the planes came and made around four passes; the white peace flags that we naively flew were useless; the community mother managed to lock the children in the house so that they wouldn't be affected," say the inhabitants of the Martín Pérez settlement in El Rosario. In January 2004, they were subject to two massive fumigations eight days apart. As a result, 70% of the crops died, the stream water was contaminated, and most of the exposed people exhibited allergies, skin inflammation and infections, irritation of the eyes, nose and throat and trouble breathing, nausea, vomiting, stomach aches and diarrhea. It was even reported that an adolescent died because he was unable to recover from these symptoms.

Suffering due to crop loss and economic uncertainty

The *campesinos* explain that since the coca crops are not concentrated on the same piece of land, but rather scattered over many small plots, the fumigations fall indiscriminately on all other crops and, when they damage those crops, the *campesinos* are deprived of all possibility of sustenance. The stress created by the war environment that surrounds them, as well as by the feeling of being part of an illegal activity, and also by the economic uncertainty, the absence of actual development plans and the lack of hope for the future, play a part in creating signs and symptoms of psychological problems, and even psycho-neurotic and mental illnesses that probably go unnoticed due to the absence of health services and professionals trained to detect them. However, if medical attention and the proper records were to exist, such illnesses would be shown to occur at a rate much higher than the rate considered reasonable for a "normal" population.

Mental suffering in indigenous and Afro-descendent communities

Fear, terror, insecurity, sadness and depression, formerly little known by the natives, have now become an everyday occurrence. Native doctors indicate that fumigation has affected the medicinal plants; there are places where they have simply disappeared, and if they reappear, "they no longer have the same spirit as before." As these resources are lost, illnesses have proliferated. They also indicate that the impact of fumigation on the crops – yucca, sugar cane, plantain, etc. – ends up altering their diet and that water pollution adds to the hunger, disease and death. The natives tell of the death of two children (one ten and the other thirteen) who, after a massive spraying, returned to take their usual bath in the shallow part of the river. That night, they began to experience headaches, vomiting and more vomiting, and died on the way to the hospital. They also say that four more

children have been hospitalized in Tumaco as a result of the symptoms caused by the fumigation.

From the start of the first armed uprisings in Awá territory in 2005, and with the aerial spraying since 2000, the epidemiological profile of the indigenous peoples has undergone a critical transformation: the morbidity and mortality associated with the reign of violence has reached extraordinary levels; infectious diseases have also increased, especially those associated with malnutrition and weakened immunity or defenses. Moreover, armed outsiders have introduced diseases to which the natives are sensitive (for example, sexually transmitted diseases); and a group of illnesses associated with stress and the alteration of cultural development and personal relations patterns have been added that are manifesting themselves in obvious behavioral problems, such as neurotic behaviors, pathological character disorders, and in some cases even outright psychopathies.

An entire group of human health problems directly and indirectly related to a structure of prevailing social, economic and political relations in Colombia can be found over the length of the border with Ecuador. We certainly share the point of view of the governor of Nariño who said in 2004 that instead of the costly fumigations, alternative crops, cooperatives and a business culture should be promoted, a good price should be paid for the products, and product marketing should be facilitated.

With the background described above, and given that it has never been and will never be possible to disrupt the dynamics and socio-economic exchanges inherent to the close proximity of the two neighboring countries (who even share an everyday flux of people from the Ecuadorian side as day workers for illegal, but better paid agricultural jobs) we have been following the path of these harmful effects on Ecuadorian territory.

The actual impacts on the mental health of the Ecuadorian population living along the Colombian border due to the aerial spraying scheduled and conducted by Colombia to control illegal crops from 2000 to date basically fall into three categories:

Impact due to the direct effect of high doses of chemical substances – glyphosate, surfactants and probably others used but not declared – on the human body.

The direct daily spraying on the very edge of the border, the drift caused by the combination of wind and the spraying height and the flows of polluted water, have been systematically reported by the affected Ecuadorian population as the causes of immediate symptoms and signs, generally very traumatic from the psychological point of view, because they are characterized as massive – irritation of the eyes, nose and throat, a sudden general sick feeling,

bumps over the entire body, marked difficulty breathing, vomiting and diarrhea, headache, dizziness and confusion.

In traditionally very healthy populations such as the Awá nationality in the San Lorenzo canton, psychological assessment of such symptoms is more difficult because they experience them as a true harbinger of death.

Much the same happens with the Afro-Ecuadorian population that uses the Mataje river, previously considered pure water for bathing and preparing food, which now carries chemical pollution coming from the tributaries and the Mira river, from Colombia, and produces acute irritation of the skin and a general sick feeling. We should make special note of the cases of white blotches (like vitiligo or skin depigmentation) that appear some time after the water comes into contact with the skin of the children and youth. Since they are a black people, it is more obvious and impacts self-esteem as a painful stigma.

The number of neuro-psychological symptoms reported by those who have been affected by the spraying drifting from Colombia allows us to suspect that among the substances combined to attack the illegal crops, one - or more - of an outright neurotoxic nature are being used. We must keep in mind that the surfactant POEA which Roundup carries is more toxic than glyphosate itself and causes damage to the central nervous system. The neurotoxic action of glyphosate, an N-phosphonomethyl glycine salt, is well-known and results from activation of the N-methyl-D-aspartatic acid (NMDA) receptors by glycine, promoting the incorporation of calcium into the neurons which, in high concentrations, causes hyperexcitability and cell death (Newell et al., 1997).

A case of Parkinson's disease due to accidental exposure to glyphosate has been reported by Brazilian specialists (Costa, M.D.L. et al., 2003). The man is a security guard, previously healthy, who at the age of fifty-one, when applying glyphosate to the garden at his workplace with no protection, accidentally spilled the herbicide on his body and did not clean it off until thirty minutes later. Six hours later, he felt sick and the conjunctivae and exposed skin turned red. A week later, he developed the general symptoms of Parkinson's disease and from the onset of the symptoms, exhibited memory loss for recent events. He received treatment with levodopa with good response. Two years later, he began receiving outpatient treatment at the Movement Disorders Department of the Neurological Clinic at the São Paulo University Hospital. For the Mini Mental State Examination, he received a score of 23 out of 30 possible points, with evident problems in the areas of attention, memory and judgment. The MRI -T2 revealed damage characteristic of Parkinson's disease in the striopallidum, substantia nigra, nigrostratial pathway and in the periaqueductal gray matter.

On the subject of this case, it is worth bringing up the results of research conducted by

a scientific team led by Dr. Anthony Seaton of the University of Aberdeen, Scotland and published in the electronic edition of the journal New Scientist, which assessed more than three thousand people, including 767 who carried Parkinson's disease, in five European countries: Scotland, Italy, Sweden, Romania and Malta. Those studied were over sixty years old and had very similar life and health histories, although they were exposed to pesticides at different frequencies. The study demonstrated that "*the use of pesticides has a significant influence in terms of occupational risk for developing Parkinson's disease.*" In short, those who gardened and were therefore exposed to high pesticide levels were up to *43% more likely to develop Parkinson's disease compared to the non-exposed*. In individuals exposed with less frequency, the rate is 9%. Although the research was not intended to identify the type of substances that entail greater health risks, we must recall that among them are the herbicides – including glyphosate – with controlled, focal and ground-level application in the routine tasks of European gardening.

The case of the intoxication or poisoning and health alert due to acrylamide in food (Cummins, 2002) has already been mentioned in another part of this document. This neurotoxic substance is often added to glyphosate to increase its contact surface.

Therefore, there is nothing to stop us from thinking that the repeated and massive aerial spraying which has been taking place from 2000 to date, due both to its immediate direct impact on people and the pollution that accumulates in the atmosphere and the food chain, has created a scenario which facilitates alterations of human and animal neurophysiology. Repeated or chronic attacks on the nervous system can seriously interfere with the neuroevolutionary growth of children – neuroevolutionary toxicity - and cause deterioration of the neurological and psychological reaction capacity in youth and adults – neuropsychotoxicity.

Impact due to the massive effect on the sources of subsistence, because the chemicals also act directly on the flora and fauna and the domestic crops and animals.

This situation, always reported by our brothers and sisters on the border – the overwhelming majority of whom are engaged in agriculture and cattle farming and in one way or another related insofar as a great dependence on the ecosystem is concerned – is unquestionably the most devastating in terms of mental health. Bear in mind that most are members of poor families, many of whom arrived in the area as tenant farmers, but filled from the start with hope and the desire to live, resolved to make great sacrifices and accept the challenges imposed by the process of adapting to natural, still untouched areas.

The loss of the fruits of agricultural labor (harvests) and even the weakening or death of the plants (plantain, yucca, malanga, papaya, etc.) caused by the aerial spraying of chemicals lead to serious consequences

for the psychological balance of any human being: the loss of his or her immediate source of sustenance, the feeling of helplessness and uselessness and, even worse, uncertainty about tomorrow and the loss of hope for the future. This is the reality that no less than three thousand Ecuadorians of working age have been living with since 2000, when the spraying began to affect them.

We must pay particular attention to the impact that this situation has had on the children and adolescents. First, because under normal conditions, the desire to live and an optimistic spirit are a virtually innate characteristic at these ages; and second, because in the context of the zone's socio-labor relationships, they play an appreciable role as apprentices and collaborators in agricultural activities. Therefore, the devastating results of the chemical spraying on the socio-economic activity of their families, sometimes strike a doubly traumatic blow: vast material resources and spiritual resources critical for harmonious personality development are lost, and the positive stimuli for acquiring the knowledge and skills associated with the profession or vocation closest to their reality are weakened. As the members of the Martín Baró research/community action group well indicate:

- *Boys and girls in the rural areas have a very deep affective link with the natural environment; unlike the adults, the boys and girls relate to this environment with their imagination, but we note that this environment is also being destroyed by the armed confrontations or the fumigations, and we can see how this impacts the children and causes them deep pain that destroys this natural relationship: dead, bleeding, emaciated animals are also the reflection of the state of their relationship with them* (Supliguicha et al., 2006).

In other words, the misery and uncertainty, the anxiety and anguish, the fears created in the parents by the economic crisis, which many times force them to temporarily leave the farms in search of a momentary solution, end up producing an inauspicious family atmosphere for the spiritual development of their sons and daughters. The total or partial abandonment of the home by one of the parents, or the search for refuge in destructive solutions – alcohol, for example – further aggravates the problem.

Impact due to direct perceptions of a danger comparable to outright terrorism and war.

For anyone with even a basic knowledge of the potential of the projective tests used in psychology to gain knowledge of an individual's internal world, it will not be difficult to look at the drawings done by school-age children in the affected zone and find conclusive evidence of the concern, fear and even terror that these children have internalized because

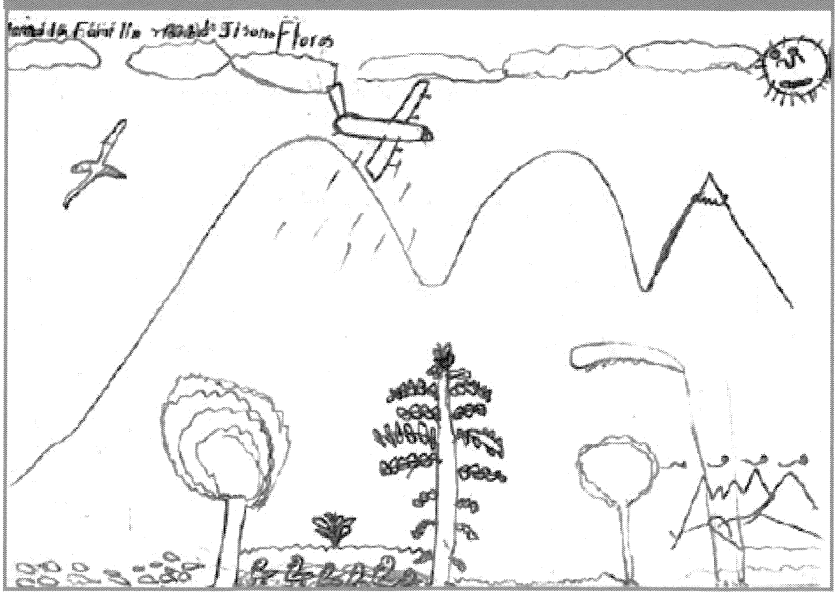
they witnessed these operations and their immediate and mediate consequences first-hand.

Drawing 1

Without exception, all of the first drawings done after the first fumigations in 2000 and 2001 on the Putumayo border depict scenes of pain, disease and death; all show the presence of planes spewing liquid, polluted rivers, dead birds, dogs and cattle, stunted crops, sick and even dead people. At that time, despite this experience, the children had not yet lost their spirit, and put great detail into their pictures, with the generous use of color.

The same test, conducted in 2006 under similar conditions, reveals the presence of the same fears, pains and anxieties in the children, but the pictures are now curiously drawn in muted tones and with additional elements that reveal personal collapse, family breakdown, absence and helplessness.

Drawing 2

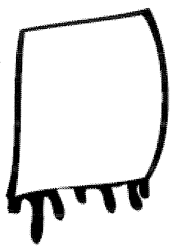


Moreover, it is of great concern that this child, who was asked to draw a family, ended up drawing a picture of the spraying, with all its drama and impact on nature, in which even the sun shows its grief! Is there any denying that the drawing is projecting the loss of his family as a result of the atrocities of spraying? The psychologists of the Martín Barón group are right when, faced with evidence such as this, they state:

- *One of the most extreme cases that we can observe in the drawings is that of elimination per se, the elimination of the child him/herself; many times the elimination is not complete, but rather it can appear subtly in the midst of the drawing or the conversation, sublimated or projected, because it is complicated for a child to renounce his or her existence; but unfortunately, in this diagnosis we find that, in fact, there are several boys/girls who eliminate themselves completely – and eliminate their entire families, we might add – which reflects very serious depression that manifests itself in this absence (Supliguicha et al., 2006).*

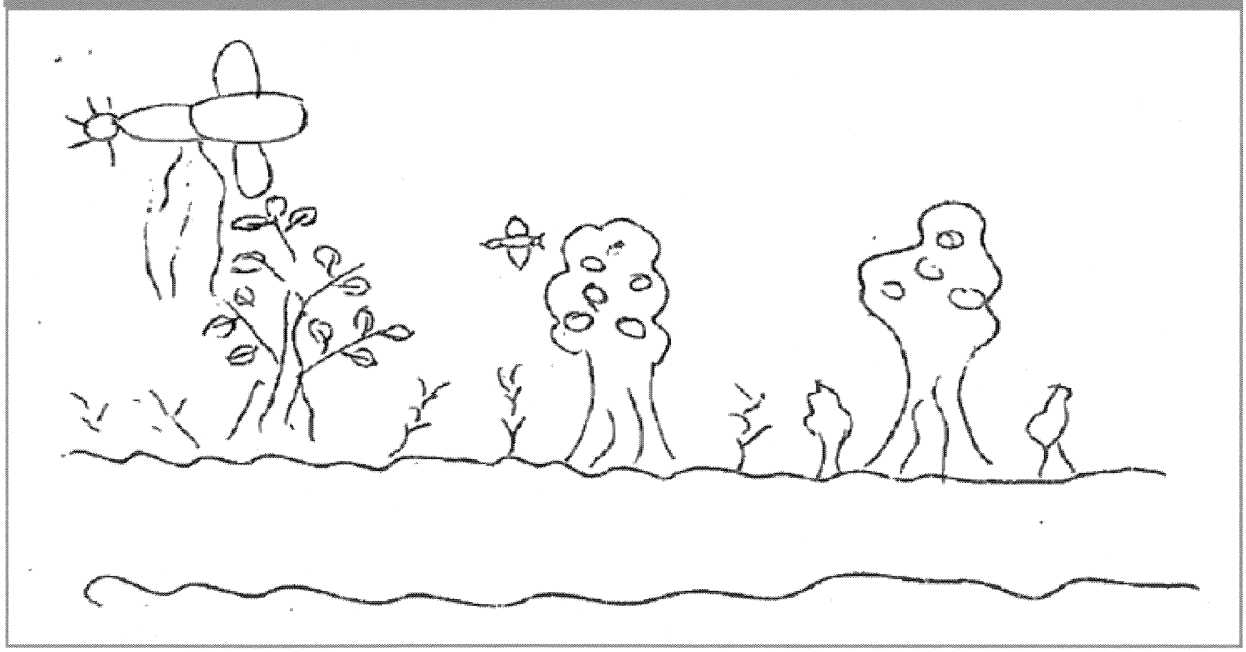
In our visit to Mataje on February 21, 2007, two weeks after continuous aerial spraying that was directly visible from the Ecuadorian side, as the films that were provided to us by the Ecuadorian Armed Forces show, when we asked Gabriel, a seven-year-old child, to draw what he had seen, he asked us if we were talking about "the poison." We once again asked him to draw what he had seen, and he drew the following image:

Drawing 3



The expression "THE POISON" is certainly the one that comes to mind as the most immediate mental association when the inhabitants of Mataje are asked to talk about what they experienced days ago in connection with the aerial spraying. Landy, a 23-year-old wife and mother of two children, made the following drawing:

Drawing 4



The image, in which nature and her personal tie to it are simply but beautifully reflected, obviously shows the proximity of the fumigating plane, as she experienced it, because she was washing in the river while her two children swam nearby.

- *THE POISON falls on the trees and in the river, on the animals, which die; it is so strong that it wipes out everything; and when it rains, everything is washed off and the POISON flows down the creeks and comes into the river. The moment that the fumigation arrived, my eyes hurt and turned red; the same thing happened to my two little children. When you wash clothes in the river, your skin starts to itch and bumps appear; I was rubbing a cream on myself; it was an itching that wouldn't stop; it must be that – the poison – because I was washing in the river just then, and my children were playing in the river … they just love to play there; their eyes were red and started to ooze a kind of yellow matter; since there was a strong rain and the river swelled, all the bad stuff came out of the creeks. This happened two or three weeks ago.*

This young wife and mother describes the following as among the best memories of her life:

- *The most beautiful thing that has happened to me was to fall in love, have two beautiful children and always be with them, never leave their sides…."*

The situation so distresses her that when asked what she most wants or desires in life, she writes:

- *"What I want is no more fumigations, because they really affect us, the poor who live in the Mataje Parrish …"*

The example is a succinct illustration of how and in what ways the lives and psychological condition of the people in the region are directly impacted, and allows us to foresee future deterioration of the mental health and the family and social fabric of the people of Mataje in the event that these violent actions persist and continue to become worse.

A Mandatory Reflection

We understand mental health-illness processes not as something that results exclusively from individual conditions, but rather as something historically determined and shaped by the social relationships in which individuals have an active or passive role. For that reason, in our analysis, we give key value to concepts such as personality, understood as a combination of attitudes, behaviors, values and capacities acquired in the midst of social relations, through family and community life, through human activities such as creativity, work, and revitalization; loving and being loved; self-realization and feeling part of specific places and times.

The father of psychoanalysis, Sigmund Freud, maintained that in order to be mentally healthy, two capacities must be completely fulfilled: to work and to love. These are rights of the border populations: to work and love in peace and in freedom. We know that the aerial spraying directly affects these two pillars of healthy mental life, and interferes with the desires of the current Ecuadorian government to promote the material and spiritual progress of the area's population.

Impacts on Organic and Genetic Health

We have already mentioned the worrisome discoveries of a French team on the impact of pesticides containing glyphosate on the verification systems for cellular division and the initial phases of a genetic damage process that leads to carcinogenicity (Belle et al. 2004). And we have indicated that when it degrades in the body and the environment, it produces damaging substances such as N-nitrous glyphosate and formaldehyde – known carcinogens – and aminomethyl phosphonic acid which can damage erythrocytes. It has also been stressed that glyphosate affects enzymatic systems in animals and humans; for example, in rats, it has been found that after an intra-abdominal injection, the activity of certain detoxifying enzymes decreases: Cytochrome P450, a monooxygenase, and the aryl hydrocarbon hydroxylase (Cox 1991 and 1995).

Some of the signs and symptoms associated with glyphosate and its components in the commercial formula are highlighted below:

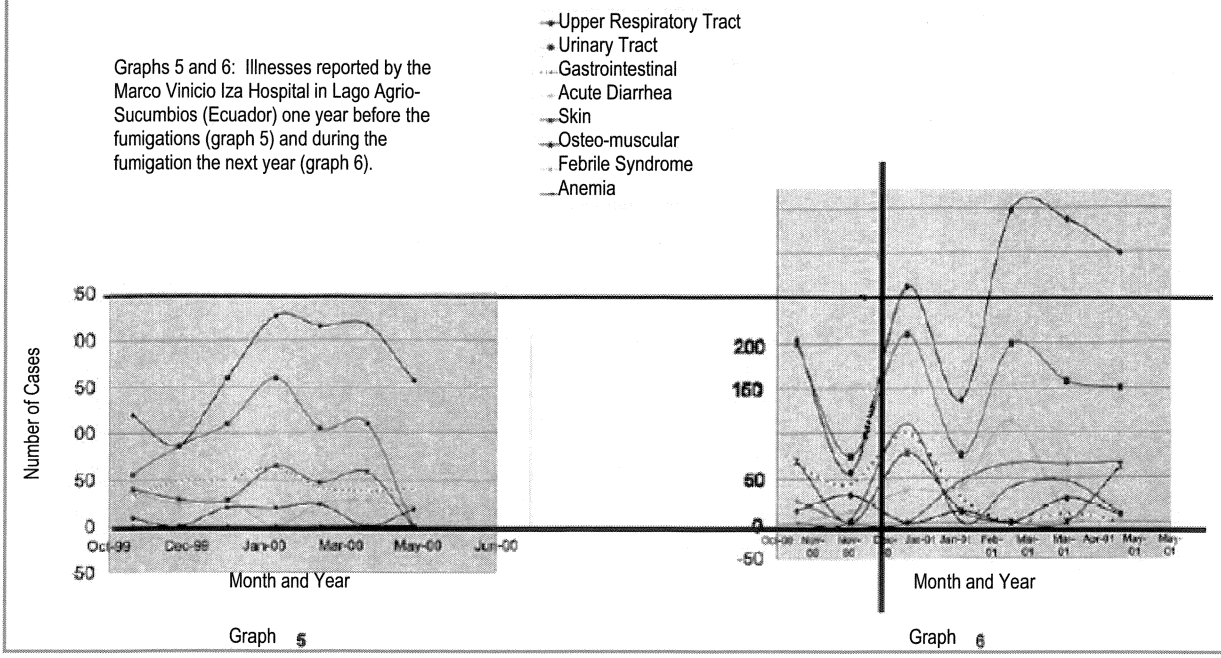
- **Ammonium sulfate:** Eye irritation, nausea, diarrhea, allergic and respiratory reactions. Irreversible eye damage from prolonged exposure.
- **Benzysothiazolone:** Eczema, skin irritation, allergic photoreaction in sensitive individuals.
- **3-iodo-2-propynyl butyl carbamate:** Severe eye irritation, greater miscarriage frequency, skin allergy.
- **Isobutanol:** nausea, depression of the nervous system, dyspnoea.
- **Methyl pyrrolidinone:** Severe eye irritation. Miscarriage and low birth weight in laboratory animals.
- **Pelargonic acid:** Severe eye and skin irritation, respiratory tract irritation.
- **Polyoxyethylene-amine (POEA):** Eye ulceration, skin lesions (erythema, exudation, ulceration), nausea, diarrhea.
- **Potassium hydroxide:** Irreversible eye lesions, deep skin ulcerations, severe digestive tract ulcerations, severe respiratory tract irritation.

- **Sodium sulfite:** Severe eye and skin irritation along with vomiting and diarrhea, skin allergy, severe allergic reactions.
- **Sorbic acid:** Skin irritation, nausea, vomiting, chemical pneumonitis, angina, allergic reactions.
- **Isopropylamine:** Substance extremely caustic to the mucous membranes and upper respiratory tract tissues. Tearing, runny nose, laryngitis, headache, nausea.

For now, research can only reveal part of the morbidity and deaths caused, which are those due to short-range disorders, since processes that incubate over several years are as yet undetected. The compilation of health data in the sprayed area showed a change in the behavior of the health of the population on the Ecuador-Colombia border; the diseases were different before and after the start of spraying with glyphosate. The health checks made in the area and after the visits to several health centers conclude that 90% of the people in the area exhibited significant changes in the state of their health: treatment-resistant dermatoses, eye irritation, upper respiratory tract system problems, weakness, muscle pain (Inter-Ministerial Commission, 2001; Maldonado, A. 2002; CIF, 2003). The following graphs show how the pathologies change after the fumigations in the area.

After the spraying, in 2001, a clinical toxicological study was conducted on 142 individuals from the sprayed area,

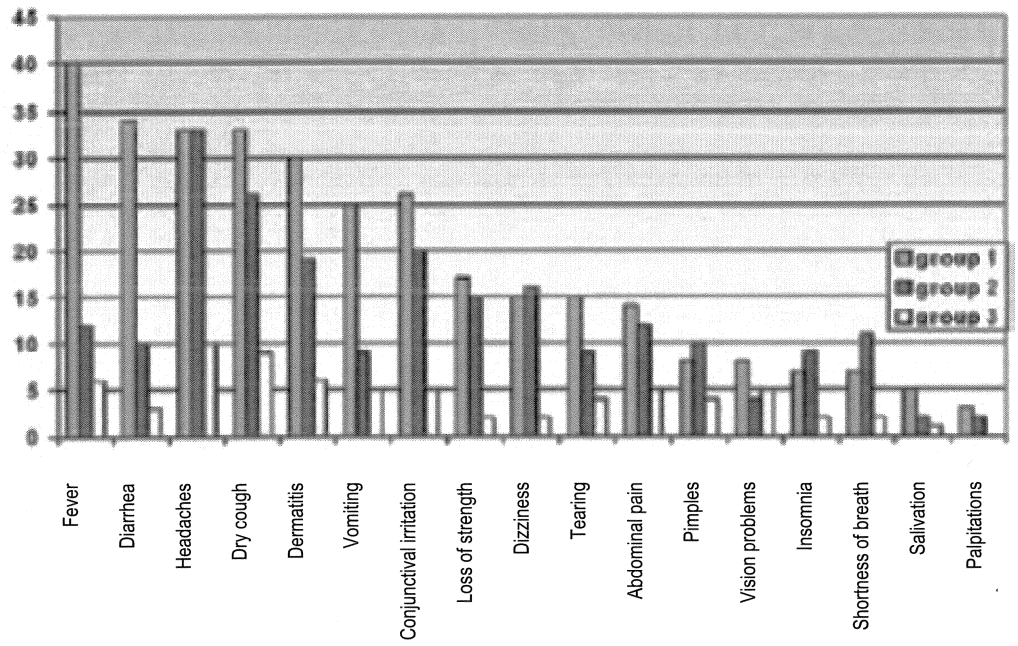
Graphs 5 and 6: Illnesses reported by the Marco Vinicio Iza Hospital in Lago Agrio-Sucumbios (Ecuador) one year before the fumigations (graph 5) and during the fumigation the next year (graph 6).



which study assessed 54 symptoms reported as new in the affected population. The study showed that 89% to 100% of the people who lived 5 km from the border exhibited the series of symptoms described (Inter-Ministerial Commission, 2001; CIF, 2003). It was observed that the symptoms decreased as the analyses were done 2, 6 and 10 km away from the border.

Impacts up to 10 km from the border inside Ecuador were reported, and cases including human deaths, animal deaths and losses of 70% - 90% of the harvests were found. The events coincided with the times that the fumigations took place. (See following graphs). The area's inhabitants suffered a dramatic increase in respiratory, gastrointestinal, allergic, dermatological, neurological and psychological problems, which are precisely the signs and symptoms that have been reported in other studies (CIF, 2003). The accounts (reasons for seeking medical help) from the area's inhabitants and records of the damage done by glyphosate are copious, and have even been reported by Human Rights Organizations, the Office of the Human Rights Ombudsman, NGO's and others (Ecumenical Human Rights Commission [CEDHU], 2007; Ecuadorian Organizations, 2007; Inter-American Platform for Human Rights, Democracy and Development, 2007).

Most frequent pathologies found on the border during fumigations according to distance to the fumigated area in Colombia Sucumbios – Ecuador – June 2001



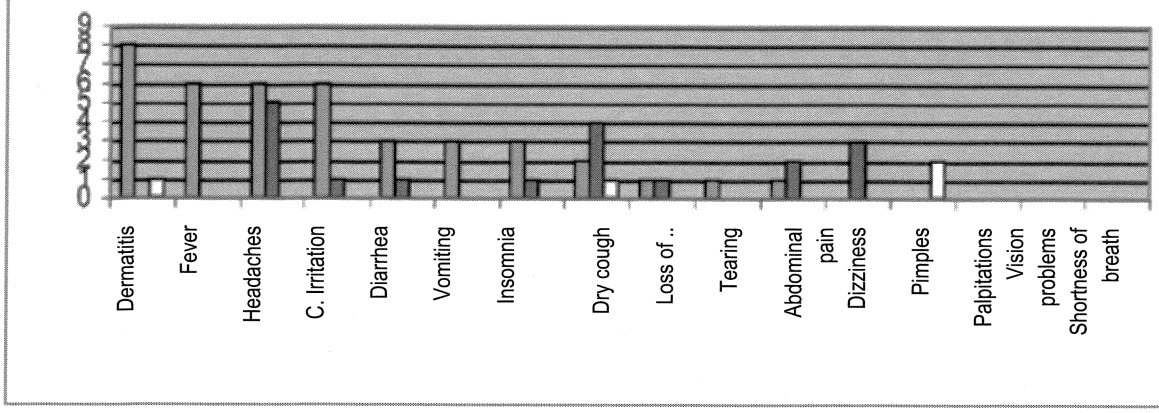
Group 1: less than 2 km; Group 2: between 2 and 5 kms; Group 3: from 5 to 10 km
Source: Acción Ecológica

All the symptoms were more frequent in the population near the border and decreased with the distance from it. Three months later, the illnesses in the area had decreased 500% compared to the time of the fumigations.

The study provided several basic systematizations for the Sucumbios border, based on the impacts of the 2001 spraying. (Ecological Action, 2001). They showed that:

- 100% of the population in the border area has been impacted by the spraying with Roundup Ultra in a 5 km strip, and 89% when the strip is extended to 10 km.
- Three months after the fumigations, the population up to 5 km away still has symptoms of chronic intoxication, with signs of neurological problems, skin problems and conjunctivitis.
- There is a direct time relationship between the fumigations and the appearance of the illnesses.
- There is a direct relationship between the distance at which fumigation took place and the symptoms. When the distance from the fumigation focal point increases, the symptoms in the population decrease.
- The possibility of further fumigations on a population that already has symptoms of chronic intoxication can cause an impact of incalculable consequences for their lives.
- The population, which has suffered the impacts of the fumigation, is in anguish. Without economic support, without compensation and without proper attention, their health is deteriorating due to a fumigation program that makes them invisible.
- The negative impacts on the health of the population and their nutritional state may increase if the appropriate measures are not taken to replace their failed harvests and the dead cattle and animals.

Pathologies found according to distance to the fumigation source, 3 months after fumigations
Sucumbios – Ecuador – June 2001



The persistence of Roundup in the soil (which is estimated at 45 days to 3 years) subjects the *campesino* population in these areas to uncertainty over the future of their crops.

Due to the presence of winds in that season, communities such as San Francisco 1 and 2, Nuevo Mundo, San Miguel, 10 de Agosto, Proyecto San Miguel and Perla del Pacifíco, among others, were seriously affected.

In the border area, the INHAMI's studies on winds show that the currents come from the northeast and travel to the southwest, i.e. from Colombian territory toward Ecuadorian territory. At the Nueva Loja weather station, it has been found that, at the annual level, there is a clear predominance of winds from the West, with 28.1%, and the South, with 26.4%. This station covers the area of influence of the Ecuadorian northern Amazon region, near the foothills of the Cordillera Oriental. The wind data from this station covers the 1981-2004 period.

However, in some months, the maximum frequency is found in the South direction. In April, the winds from the South account for 42%, followed by those from the West, with 33%. In May, the maximum frequency is found in the South direction, which account for 38%. In June and July, the winds from the South account for 54% (the highest level during the year), and in August, 38%. This means that the aerial spraying is carried toward Ecuadorian territory and therefore contaminates the water, land, plants, animals and people (INAMHI, 2006).

In a second study, conducted after the 2002 spraying, surveys were conducted on 17 families from a universe of 102 (16.7% of the total), distributed in four communities, with an approximate total population of 657 people. On the average, the number of victims is 85.5%, as can be seen in the following chart:

Table 8

Distribution of victims by community studied

Town surveyed	Families surveyed	Total families	Percentage	No. of people in the families	Percent victims
Chone – 2	6	30	20%	39	79%
Playera Oriental	5	18	27.7%	38	63%
Palma Seca	1	18	5.5%	10	100%
Puerto Nuevo	5	35	14.3%	23	100%

Source (Maldonado, A. 2001)

From the clinical histories analyzed, we can deduce the following:

- After the fumigations, the overwhelming majority of the population exhibits problems such as headaches, eye irritation and tearing. In the Colombian communities that feel the fumigations with greater intensity, digestive tract symptoms are very common, with dizziness, abdominal pains, vomiting and nausea, diarrhea, fatigue and loss of strength. The presence of fever in Colombia increases significantly compared to Ecuador.

- Another set of symptoms appears due to skin problems. Terrible itching accompanies different symptoms that range from dermatitis (inflammation) to the appearance of pimples for different reasons. The irritating nature of the chemical is made evident with these symptoms, which accompany those of the eyes, and have a higher incidence on the Ecuadorian side than the digestive symptoms.

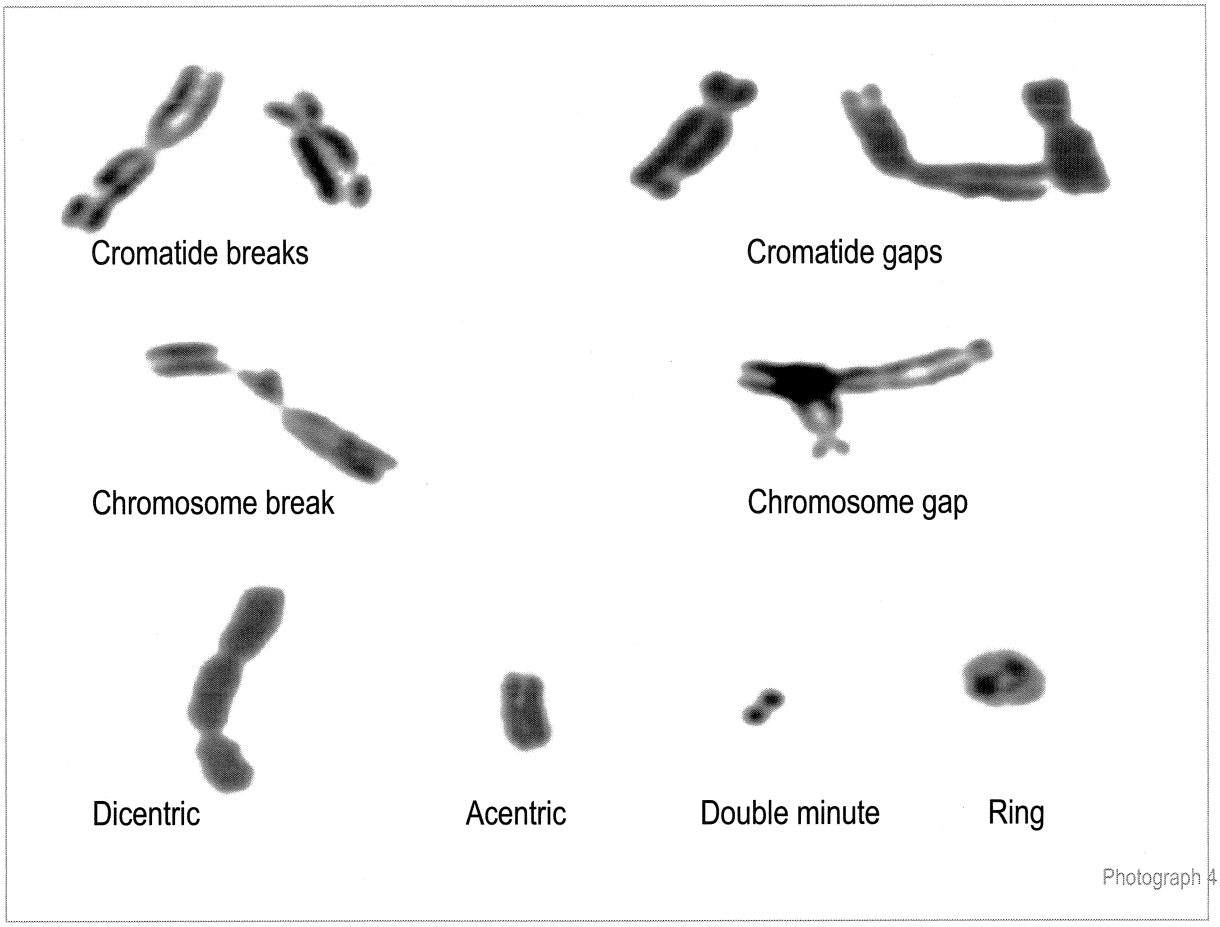
- Some *campesinos* say that there are two types of fumigations: one a white or transparent liquid, and another a dark liquid, after which a terrible itching begins.

- The psychological effect that the fumigations have on the *campesinos* in Ecuador is different than the effect in Colombia. While the Ecuadorians experience stress that causes insomnia, the Colombians are depressed as a result of the complex reality faced by the Colombian population in this region, a depression aggravated by the impacts of the fumigations.

A preliminary chromosomal study on the inhabitants in the sprayed zone.

Following are several findings on the impacts attributable to aerial spraying with glyphosate on the genetic health of the inhabitants of the sprayed border region.

In September 2002, a verification commission consisting of 11 organizations traveled to the Colombia-Ecuador border to assess the damage that the fumigations against coca crops done at the time had caused to the Ecuadorian population, its crops and animals (Maldonado, 2002). On that occasion, random blood samples were collected from 4 individuals affected by the fumigations. Lymphocyte B cultures were prepared in the standard appropriate medium (RPMI 1640), stimulated with phytohemaglutin; after 72 hours of culturing, they were harvested using the standard technique: colchicine, hypotonic shock, extension and staining with Giemsa colorant (Paz-y-Miño et al., 2002b). When the chromosomes were assessed with an optical microscope at 1000x, it was found that the number of chromosomal aberrations was 17 times higher than in the control population (2%, which consisted of healthy individuals not exposed to other known genotoxins and of the same ages and sexes as those exposed to spraying. A study similar to the 2002 study was conducted on a sampling in February 2007, with similar results:



Photograph 4

34% chromosome damage in the exposed individuals from the Mataje area, Esmeraldas province, compared to the results for the control population, with 3% aberrations.

Some of the chromosomal alterations that were observed in individuals exposed to genotoxins: both breaks and gaps are the alterations most frequently observed in the individuals exposed to aerial spraying, as well as a small number of cells that exhibited acentric and double minute fragments.

In view of this situation, the decision was made to conduct a new study in 2002 that would make it possible to determine whether the origin of these lesions is aerial spraying, or whether they have some other cause.

The starting hypothesis is that spraying with a product of these characteristics (with that mixture) and at this concentration, because of the synergistic components of the product's effect, i.e. some enhance others, will also enhance the secondary effect on people.

Study of the genetic material in individuals exposed to aerial spraying.

The purpose of the study was to determine, in a selected sample of the border inhabitants, whether or not they exhibited genetic alterations as a result of aerial spraying with an herbicide package.

Health surveys were conducted on women who reported symptoms after aerial spraying. They mentioned having felt the impact of the fumigations on their homes between one and two weeks later, and having protected themselves there during the time of greatest intensity. A similar population was also selected as a control group. The decision to study only women was made because the agrochemicals in agriculture are less often used by women than by men, and the women are therefore less exposed to genotoxins. As far as could be determined, the individuals selected for the analysis were not exposed to other known genotoxins (tobacco, alcohol, medications or drugs).

Forty-seven women were analyzed and interviewed, distributed into two study groups of similar ages (around 37 on the average) and length of time living in the area (around 16 years on the average): 1) The exposed group, consisting of 22 women who had felt the impact of aerial fumigation on at least one occasion and exhibited signs or symptoms of problems. 2) The control group, including 25 women located 80 km from the border where the fumigations were done, and as far as could be determined, who were not exposed to any type of known genotoxin.

The study on the affected group focused on the Sucumbios Province (Ecuador) in Ecuadorian communities along the border with Colombia impacted by the fumigations, with no signs of having been affected by oil industry activities, located less than 3 km from the border, with individuals from Puerto Nuevo, Palma Seca, Playera Oriental, Santa Marianita and Corazón Orense. The individuals from the control group came from Abdón Calderón, Huamayucu, Morán Valverde, 23 de Julio and Unión Manabita.

None of the women from the exposed group works with pesticides. The control group was not exposed to any type of genotoxin. The exposed individuals are not smokers and do not regularly drink any kind of alcoholic beverage. As far as family congenital malformations or problems are concerned, there are 10.5% among the exposed group and 12% in the control group. However, the histories of cancer reach 52.63% in the exposed group compared to 35% in the control group (the fumigation period is not separated).

Genotoxicity results: comet assay

Genotoxicity is a substance's capacity to produce changes in the DNA, which may or may not be reversible. Genotoxins are classified into genotoxins *per se*, mutagenic, carcinogenic and teratogenic.

Pesticides are considered agro-toxins, i.e. they have the capacity to be genotoxins and, because of this property, can act as any of those described (Paz-y-Miño et al., 2002a). Genotoxicity can be evaluated by the percent fragmentation of the DNA, observable in chromosomes or pieces of DNA which, under special assay conditions, migrate out of the nucleus prepared for observing this effect. The effect looks like a comet, hence its name. The comet has a nucleus that should be uniform if things are normal, compared to nuclei with fragmentation located on the periphery, like the tail of a comet.

The longer the tail of the comet, which is produced by electrophoresis in the laboratory assay, the greater the damage. The damage to the DNA is assessed by calculating the percentage of nuclei with tails (Paz-y-Miño et al., 2002c, 2007).

The comet assay is very sensitive to changes or alterations in one or both cellular DNA chains on which genotoxic agents have acted. Its advantage is that results are obtained quickly. It is currently used in biochemistry for human monitoring in exposure to genotoxins (Paz-y-Miño et al., 2002a, 2002b, 2002c). The assay consists of subjecting the cells to an electric flow. If there is no cellular damage, the genetic material does not change and the cell nuclei remain circular (normal). As the damage to the genetic material increases, the cell nuclei undergo deformation and take the form of a comet (hence the assay's name) which, depending on the damage, will be more or less dispersed (see photograph 5 and attached chart – table 9 – for types of comets A-F).

An increase in the frequency of chromosomal aberrations (CA) is related to exposure to genotoxins, and there is a known association between the frequency of CA and the risk of developing cancer. There are reports that the incidence of cancer is double in individuals with a high frequency of Chromosomal Aberrations; therefore, CA analysis can be used to estimate genotoxic risk (Paz-y-Miño et al., 2000, 2002a, 2002b,

Table 9
Type of comet per measurement and its percent presentation

Type of comet	Measured in nanometers	% presentation
A	22.5 – 25	70 – 90 normal
B	27.5 – 35	10 – 30 low damage
C	37.5 – 75	2 average damage
D	75 – 110	1 high damage
E	112.5 – 120	1 very high damage
F	120 - +	0 maximum damage

2004, 2005, 2007). If the population exposed to fumigations exhibits significant chromosomal alteration or DNA fragmentation assessed with the comet assay, this would mean that it as a population with a high mutagenic, carcinogenic and teratogenic risk (Paz-y-Miño et al., 2002a, 2002b, 2002c).

In Table 10, we can see that 100% of the women studied on the border who were in contact with the fumigations exhibited a high incidence of genetic damage in their cells, in the category C comet.

The number of cells with genetic damage (C+D+E) in the exposed group (see table 10) reaches an average of 36%, i.e. 9 times higher than the figure considered normal by the laboratory (4%). In this group of exposed women, the high and low values for the samples were 18.7% and 85.3% damaged cells, i.e. between 4 and 21 times greater than expected, compared to the control population.

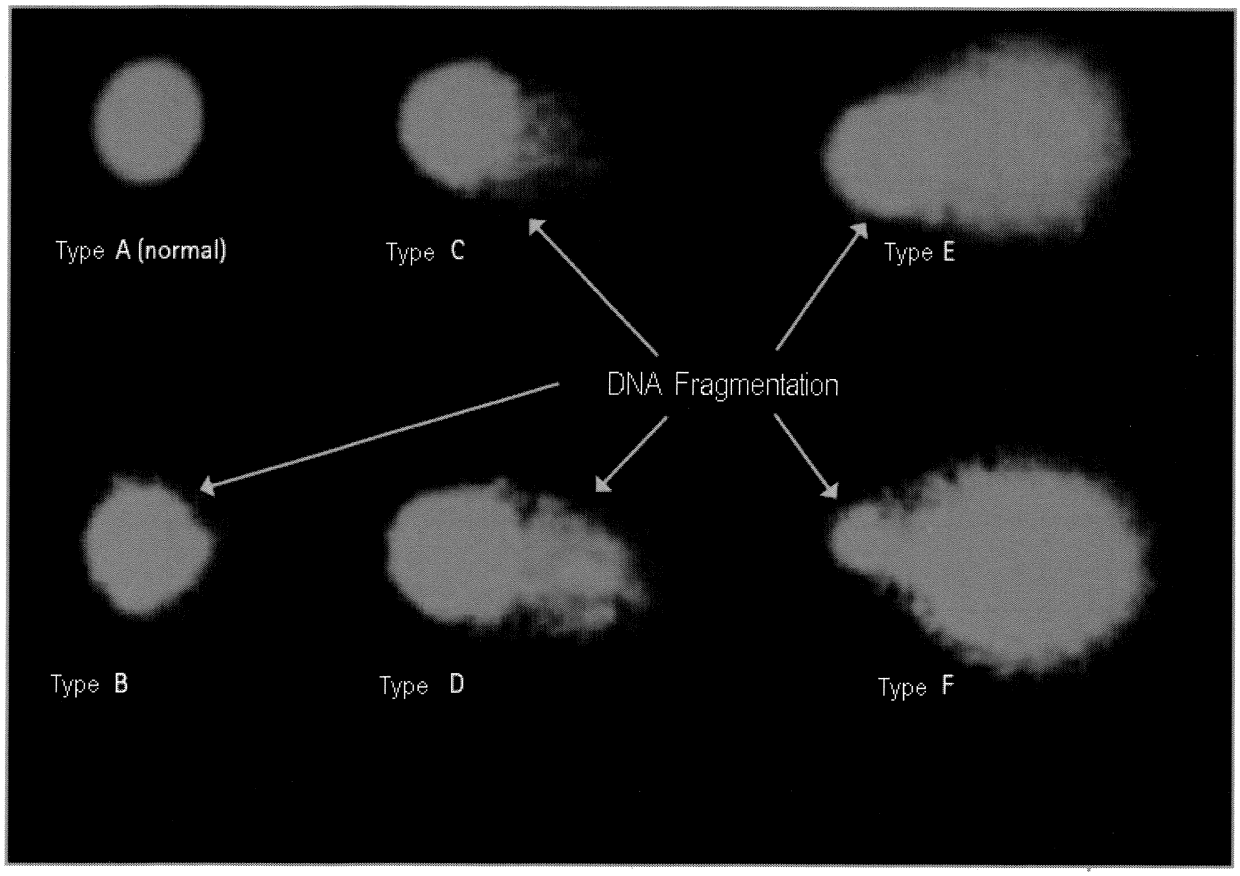


Image showing the comet assay and different types of comets. A: no DNA damage, no migration during electrophoresis. B – E : Progressive damage, with an increase in tail size until total nucleus destruction in F.

Photograph 5

Table 10
Cell alterations in women exposed to aerial spraying

Women	A	B	C	D	E	Age
1	0.9	53.7	38	5.55	1.89	53
2	0.9	29.7	28.7	36.1	4.65	40
3	6.93	45.5	40.6	6.93		37
4	7.2	62.2	28.8	1.8		44
5	26	57	15	2		50
6	10.3	65.4	22.4	1.87		38
7	10.3	54.2	33.6	1.87		46
8	10	54	36	0		55
9	12.4	47.6	40	0		50
10	13.2	58.5	28.3	0		22
11	4.8	62.5	29.8	2.88		59
12	18.7	61.7	18.7	0.93		28
13	4.9	47.1	48	0		59
14	17.3	52.9	29.8	0		55
15	29.1	49.5	21.4	0		17
16	3.37	64	32.6	0		34
17	4.67	70.1	23.4	1.87		45
18	5.55	74.1	20.4	0		28
19	0	75.5	23.5	0.98		21
20	0.94	66	33	0		34
21	0	14.7	85.3	0		23
22	0	43.1	55.9	0		34
Total Average Exposed	8.52	55	33.3	2.85	0.3	

The values found show: 40% of the women had between 16% and 32% damaged cells, i.e. 4 to 8 times more than expected; 50% had over 32% and up to 56% damaged cells (8 to 14 times the expected damage); and one woman (10% of the sample) had 69.5% damage, i.e. 17 times that expected. In all women in the study (100%), the percentages of type C cells, i.e. cells with medium damage, are increased. The percent cellular damage of all women in the exposed group is 36.45% on the average.

Samples 1, 2 and 3 are from women exposed in October 2002, when the fumigation intensity was greater. It is noteworthy that their cellular damage comprises types D and E, with very serious damage, possibly due to greater and ongoing exposure.

The data on the control group in the Amazon region are found in the next table: 25 women located 80 km away from the sprayed zone. The differences compared to the affected group are marked:

The number of cells with genetic damage (type C) in the control group from the Amazon region averages 6.9%, i.e. less than double the figure considered normal (4%). In this group, the high and low values for the samples vary between complete absence and 29% damaged cells; i.e. between normal and a ceiling of 7 times greater than expected, according to the control data.

Table 11
Cell alterations in women from the control group

Ages	A	B	C	D	E	Age
20	46.1	50	3.92			42
21	43.5	47.8	8.69			40
22	56.6	32.1	11.3			29
23	27.1	57.9	15			32
24	73.5	22.6	3.92			21
25	69.8	23.6	6.6			43
26	80	15	5			53
27	78.9	11.5	9.61			35
28	82.9	17.1				57
29	80.8	12.5	6.73			38
30	89.3	6.79	3.88			22
31	94.1	3.96	1.98			71
32	91.6	5.6	2.8			39
33	87.3	8.82	3.92			25
34	80.2	16.8	2.97			21
35	86.5	9.61	3.84			21
36	92.2	6.79	0.97			50
37	46.6	48.5	4.85			40
38	50	42	8			21
39	63.6	26.2	10.3			38
40	66.3	30.8	2.88			38
41	51.5	35	13.6			43
42	38.3	32.7	29			28
43	55.7	37.7	6.6			50
44	66	27.3	7			41
Average	67.9	25.1	6.93	0	0	

The values were distributed as follows: 44% of the women had less than 4% damaged cells, i.e. were normal; 32% of the women had between 4 and 8% cell damage, i.e. up to double that expected; 20% of the women had up to 4 times the expected damage, and only 4% of the women had 29% damaged cells, equal to 7 times the expected damage.

The assessment of the effect of aerial spraying with glyphosate on the exposed individuals along the border with the comet assay is reinforced with in vivo studies conducted on rats using the same technique. After intravenous injections of 0.4% glyphosate with varying amounts of the chemical (100, 200 and 400 mg/kg), the clastogenicity (DNA fragmentation) produced by this herbicide was assessed. The same study evaluated micronuclei production (chromatin fragmentation). The results show that there is progressive DNA damage, with the most alteration produced at 400 mg/kg in both the comet assay and the micronucleus assay. The work demonstrates the genotoxic effect of glyphosate (Mañas-Torres, F. et al., 2006).

Conclusions of the genetic studies

All the women studied (100%), inhabitants of the sprayed zones who reported symptoms associated with this event, exhibited genetic lesions in 36% of their cells.

The genetic damage in these women is 800% higher than that of the control group established by the laboratory, and 500% higher than the damage found in populations with similar characteristics in the Amazon Region 80 km away from the study area. The studied population that was subject to the spraying was exposed at least once over the last 9 months; therefore, it could not be determined whether the lesions were an effect of the impact from the latest fumigations or a consequence of the accumulation of previous fumigations.

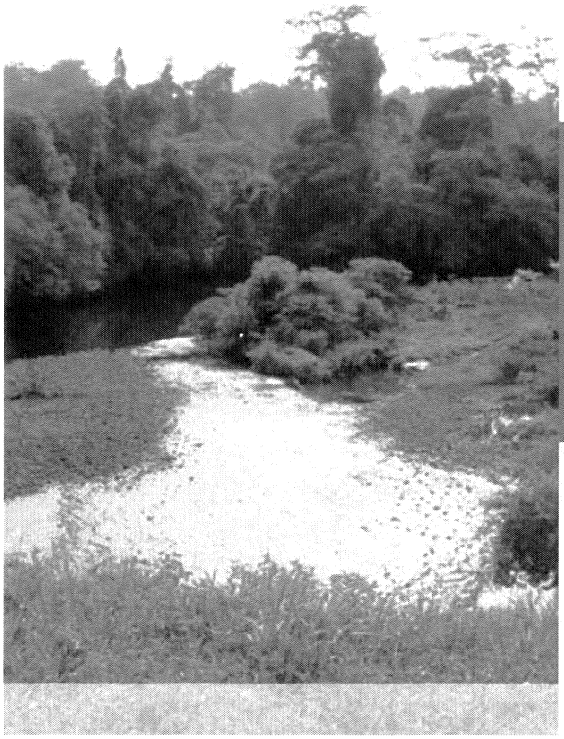
However, it can be affirmed that subjecting the population to more fumigations will increase the risk of cell damage.

Fragmentation of genetic material is related to gene alterations in the sites where the DNA is broken; the genes can deactivate, get lost or travel to other sites, causing mutations that are directly related to a 30% greater risk of developing cancer, 20% greater risk of miscarriages, and 10% greater risk of pregnancies with congenital deformations.
This is a high increase because continuous contact with the sprayed genotoxins is involved.

Both miscarriages and children with deformations are already being reported by the exposed population; other problems, such as cancer, must be evaluated periodically until their origin is identified.

Cases of genetic alterations have been reported in studies by Colombian universities (Groot, 2005; Lacera-Rua, 2000; Monroy, 2005).

In a recent study, we cultured lymphocytes in the presence of glyphosate, applying different concentrations of this herbicide directly to peripheral blood cultures (1, 2, 5 and 10%). Plates were prepared to observe alterations and fragility in metaphysical chromosomes, and cultures were prepared at 5% with sterilized and non-sterilized glyphosate. The culture medium degrades, and its properties change (dark red color, compared to the bright red of the control). After the culture is harvested, the cell button also varies, already exhibiting destruction at 5% glyphosate. The same occurs with the number of cells, because the controls have a higher number. Under the microscope, at 5% concentration of the chemical, normal and deformed nuclei were indeed observed, and the number of deformed nuclei was higher. At a 0.98% concentration, the culture is also altered; normal and deformed, non-metaphasic nuclei are observed. We conclude that glyphosate is cytotoxic and genotoxic in the evaluated concentrations. The results agree with the observations on cell toxicity reported in the literature (Paz-y-Miño et al., 2007).



VI. THE AERIAL SPRAYING SYSTEM AND ITS IMPACT ON THE ENVIRONMENT

The focus of this review of the ecological impacts that the program for the eradication of illegal crops is having in Ecuador is based on the best available scientific information on the problem.

However, the use of pesticides in tropical environments may not produce impacts immediately, but will have accumulative and synergetic effects, probably when the impacts are already severe and irreversible.

Moreover, there is a series of potential impacts that have not yet been identified by science, because the tropical rainforests are more complex and little studied ecosystems.

Generally, the risk assessments do not take all these variables into account, especially when more complex problems are involved, such as the case of spraying under

Plan Colombia (multiple exposures, sensitive populations and other possible dangers). Only the conventional risks are assessed.

In the case of contaminant chemicals, the analysis is usually done chemical-by-chemical and organism-by-organism, but the overall problem is not analyzed. The analysis does not take into account the problems that already exist in the studied locations, or the differing reactions of different types of ecosystems, the biological communities within those ecosystems, the organisms that coexist within those communities, and the interactions between different ecosystems. It also fails to assess the pesticide's effect on the subjected environment's trophic networks, or the effects of the interaction between the terrestrial and aquatic ecosystems.

Many assessments use hierarchical schemes. They start with simple experiments on a few species and progress through a scaled sequence of experiments which increase in complexity, sophistication, cost and duration. Depending on the results in the tests at the lowest levels, experiments are initiated at the second level only if the results from the first indicate potential adverse effects.

In many cases, the analysis uses species that are not present in the ecosystem in which the impacts of the pesticide are to be assessed, or assesses species outside their natural context.

This is the case of the study by Solomon et al. (2005) commissioned by the CICAD. This research team did a risk assessment on the impacts of the formulations prepared in the Plan Colombia eradication programs using the following organisms: a freshwater green algae (*Selenastrum capricornutim*), a water flea (*Daphnia sp.*), a rainbow trout (*Onchorynchus mykiss*) and a fathead minnow (*Pimephales promelas*). We ask ourselves whether any of these organisms represent the complexity of the Colombian Amazon region's biodiversity well enough for the researches to conclude that glyphosate + Cosmoflux do not produce impacts on this environment.

These researches believe that it is not important to do studies based on the organisms present in the ecosystem to be assessed. They maintain that:

- *A common question when doing risk assessments in tropical and other non-temperate regions is the scarcity of toxicity data on "tropical species." It is true that most of the species used in the laboratory tests for toxicity, especially on pesticides, are "temperate zone species," mostly due to the location of the research laboratories with the capacity to conduct toxicity tests using good laboratory practices. With the exception of a few substances with defined action mechanisms, there is no reason to believe that organisms in tropical regions are inherently more or less sensitive than the organisms in temperate zones."*

In the review that we present below, we will attempt to refute this claim, showing how glyphosate has a differing effect, even on organisms present in the same community.

In this section, we will review the probable impacts of the programs for the eradication of illegal crops on the environment, based on existing scientific literature. Here we include information generated by scientists from different parts of the world, who report studies that they have done on different ecosystems and organisms.

With this information, we will analyze the dangers of aerial spraying, not only from the perspective of the impact on isolated organisms, but the way that these programs impact ecological interactions, trophic networks and the ecological balance in general.

Impacts on the Forest Ecosystem

The programs for the eradication of illegal crops in the Colombia-Ecuador border area take place in the Amazon and El Chocó tropical rainforests, both considered regions with extremely high biodiversity rates and high vulnerability.

The Amazon jungle, with its enormous surface area and complex ecosystem, is one of the most important biological reserves in existence in the world. Its natural base is made up of numerous ecosystems that interact, and present a great diversity of flora and fauna and a high level of endemism. Another, no less important dimension is the Amazon jungle's water supply, which plays a significant role as regulator of world climate.

The biogeographical Chocó constitutes a mosaic of terrestrial and marine species; its territory crosses the Colombian Pacific and Ecuadorian northeast coasts. Scientists give much importance to Chocó, because in addition to having extraordinary biodiversity, it also maintains the only continuous tropical rainforest in the South American Pacific. El Chocó has a great number of life forms thanks to its multiple ecosystems. It is important to note that in this region, there is a significant number of endemic species in danger of extinction (Boada, 2006).

Ecuador and Colombia are considered mega-diverse: they have 10% of the world's biodiversity with less than 1% of the earth's surface. This considerable biodiversity is the result of geological and geo-morphological processes, climate conditions and the intervention of the indigenous cultures which have inhabited the region for thousands of years.

The aerial spraying with a chemical package that includes glyphosate puts this biodiversity at risk.

A study based on Landsat Enhanced Thematic Mapper Plus (ETM+) images conducted by a University of Michigan team on Colombia's Putumayo region, where spraying as been done with defoliant agents to eradicate the coca plantations (Messina and Delamater, 2006), found that this program has not only impacted the illegal crops, but also farms planted with food crops and native forests. Spraying had affected 106,178 hectares, despite the fact that the United Nations Drug Control Program reported that just 71,891 hectares had been eradicated. This means a difference of 34,287 hectares which, according to the authors, consist of legal crops, pastures, fruit orchards, short-cycle crops and natural forests, with a defoliation ratio of 2 hectares of illegal crops to one of legal crops or forests.

It is also important to point out that, despite the eradication programs since 2000, the total surface area planted with coca has increased by 18% in Nariño, and 5% in Putumayo, the two Departments that border on Ecuador, as summarized in the following table:

Table 12
Evolution of coca plantations in Departments bordering Ecuador

Year	Nariño	Putumayo
2000	9,343	66,022
2001	7,494	47,120
2002	15,131	13,725
2003	17,154	7,559
2004	14,154	4,386
Total % 2004	18%	5%

Source: UNODC; Government of Colombia, 2005

The Edge Effect

The impacts of the herbicide package with glyphosate on the forest ecosystem are not limited to the area directly affected, but are much greater due to the edge effect.

The edge effect refers to the change in the composition of plant communities near the edge caused by the herbicides. There, the typical species of a climax community are replaced by pioneer species. The edge effect also affects the plants' eco-physiology, for example their tolerance to variations in temperature and humidity, as well as their hydric potential (Kapos, Wandelli, Camargo and Ganade, 1997).

Given that the edge effect also produces changes in the micro-climate, which is strongly determined by the plant communities present, this phenomenon also affects the microbiological communities (Stephen, Turton and Freiburge, 1991). The microclimatic effects due to the edge effect have been found up to 30 meters inside the forest, starting from the deforested zone.

The edge effect also alters the phylosphere microorganisms, which are more exposed to the variations in heat and fluctuations in humidity, and the hydric power along the edge than they would be in the shade.

In studies on soil invertebrates, it has been found that the beetle populations are affected by the edge effect in areas ranging between 100 and 200 meters in forests that have been disturbed (Didham, 2007).

Impacts on the Trophic Networks, Ecological Succession, Phenology

The impact of glyphosate on the trophic networks was demonstrated in a study done in Australia, where it was found that specimens of five native species of chaffinches died after being exposed to seeds treated with glyphosate (Evans and Batty, 1986).

Other studies have shown that birds can be affected by alterations in their feeding and nesting sites, by changes in the natural succession of the ecosystems, or by a decrease in their food sources. This decreases bird population density, leading to the selection of certain species that are more tolerant to altered ecosystems, and puts species with more restricted ecological requirements at a disadvantage (MacKinnon and Freedman, 1993).

Similar results have been found in small mammal populations. These populations have been negatively impacted after the use of glyphosate to clear the forest. These species lost their food sources, especially plants and arthropods (Santillo *et al.*, 1999; D Anieri *et al.*, 1987; Richie *et al.*, 1987).

In their study in the state of Maine, Santillo et al. (1989) found that after the application of glyposate, plant composition is less diverse.

The impact of glyphosate on a forest's ecological succession was studied by Bell et al. (1997), who did a study in northwestern Ontario, Canada on temperate deciduous forests. They found that the use of this herbicide decreases the plant cover of deciduous trees, bushes and ferns. In the case of conifer forests, they found that glyphosate reduced the woody and herbaceous vegetation. In other words, it has an impact on the composition and structure of these forests.

Changes in plant phenology due to the effect of glyphosate have also been found. A research group in the United Kingdom studied the impacts of glyphosate and other herbicides on the vegetation of marginal forests, hedgerows and marginal fields that had been exposed to these pesticides once a year over the last three years (Marrs, Williams, Frost and Plant, 1989). They analyzed the effect of sub-lethal doses on species productivity, flowering patterns, seed production, seed variability and the invasion of new species in these spaces. They found that all the species studied had been negatively impacted by the drift that resulted during applications with herbicides. But the behavior of each species was different, depending on the structure of the plant community in which they were found. This study shows us that it is extremely difficult to extrapolate toxicological results between one plant community and another.

However, it must be stressed that the changes in phenology in plant communities in tropical forests are a critical factor for ecological balance. Several studies have been done on co-evolution between plants and animals, and the relationship between the flowering or fruiting of certain plant species and the reproductive ecology of certain pollinator species responsible for dispersion of the fruits, etc. (Bawa and Hadley, 1990).

Changes in the phenology of plant communities caused by the effects of glyphosate can interfere with these processes.

The plants need to defend themselves form biological attacks and environmental stress, but their lack of mobility and the lack of an immune system such as the one that animals have has caused them to develop defense mechanisms in which each cell has an induced and preformed defense capacity. However, these mechanisms can be influenced by the use of herbicides. Some of them increase the severity of

certain diseases by inducing or inhibiting the formation of phytoalexins. Since the diphenylether herbicides favor the production of active forms of oxygen, applications of sub-doses of glyphosate have the opposite effect, decreasing the formation of these elements and increasing disease severity, as indicated by Rizzardi *et al.*, (2003).

Effects on Ecological Interactions

The ecological effects of the program for the eradication of illegal crops on forest ecosystems cannot be assessed by analyzing only the deforested zones. The changes that they cause in the forest's structure and functions affect the interaction between biological communities, ecological succession and the trophic networks as well as the availability of ecological niches, altering the ecological balance.

The alteration of certain populations has a negative effect on other populations in the same biological community, creating a phenomenon called the "cascade effect."

For example, when certain plant populations particularly vulnerable to glyphosate and its agents are food for certain species of insects, the insects will be affected and, in turn, affect the birds or amphibians who feed on them. If there are other animals that depend on the birds for food, they will also be affected, creating impacts throughout the entire trophic network.

Since these same plants have symbiotic relationships with other species such as epiphytes, saprophytes, parasites, nitrogen-fixing microorganisms or mycorrhizas, those species will be impacted, which means the disappearance of ecological niches and imbalance in the existing biological interrelationships.

There will also be negative effects at the soil level, because it is possible that the original plants will allow a certain type of microbiological community to develop in the soil and disappear, and the decomposition process and the nutrient cycle will be altered.

Moreover, given that there are species which are more susceptible to the herbicide than others, there will be a selection of the more contamination-resistant species, altering the ecosystem's ecological structure. We will see this in greater detail when we discuss the emergence of superweeds.

Impacts on the nutrient cycle

Several studies show the impact that glyphosate has on micro-organism communities which play important roles in the nutrient cycle.

It is well known that in tropical forests, the nutrient cycle is accelerated, with most of the nutrients being stored in the live part of the system. Therefore, most of the net primary production is used to produce leaves and fruits. This fact is related to the low availability of mineral nutrients in the soil.

Due to the low availability of nutrients, associations between the tree roots and certain fungi develop in tropical forests, creating fungal mycorrhizas. The mycorrhizas transfer nutrients from the decomposition of organic matter in the soil to the roots. The process allows runoff to produce small mineral losses, and leads to rapid mineral circulation.

There are also bacterial and cyanobacterial populations in the soil which play an important role in maintaining a high biomass because they are nitrogen fixers. In addition, certain cyanobacteria are lichens, which are equally involved in the nitrogen cycle.

Given the low fertility of tropical soils, a proper equilibrium in the nutrient cycle and the microorganisms involved in each of them is critical.

Nitrifying bacteria

There are several studies which show that glyphosate interferes with the nitrogen-fixing processes, both in free-living bacteria and bacteria that establish symbiotic relationships with plants.

In studies done with glyphosate-resistant genetically engineered soy, Zablotowicz and Reddy (2004) found that the nitrifying bacteria *Bradyrhizobium japonicum*, which fixes nitrogen in the soy's roots, has an enzyme that is sensitive to glyphosate which, when exposed to this herbicide, accumulates chorismic acid and hydroxybenzene acids. This inhibits the growth and even causes the death of the bacteria in high numbers. It was also found that glyphosate accumulates in the soy root nodules. This has repercussions on the growth of all leguminous plants (which establish symbiotic relationships with nitrifying bacteria) and the health of the soil in general. Thus, this herbicide affects the nitrogen cycle in agricultural ecosystems. This phenomenon is also reported by Hutchison (1995) and Forlani *et al.* (1995).

A study done in India with degraded soils from tea plantations treated with glyphosate showed that it reduced nitrogen-fixing bacteria colonies (Bazbaruah *et al*., 1995). Inhibited nodulation in clover roots in soils with glyphosate levels of between 2 and 2000 mg/kg has also been reported. The effect persisted 120 days after treatment (Eberbach *et al*., 1983).

Studies have also been done with free-living nitrifying bacteria. Santos and Flores (1995)

studied the effects of glyphosate on nitrogen fixing in free-living heterotrophic bacteria. These authors found that doses of glyphosate higher than 4 kg/hectare inhibited nitrogen fixing. This herbicide also affected respiration and caused a reduction in cell size.

Given the low fertility of tropical soils, the biological fixing of nitrogen is critical for maintaining the nutrient balance in the soil.

Glyphosate is one of the few herbicides with a positive electrical charge, something that gives it the particular feature that when it comes into contact with the negatively charged soil it is quickly immobilized and unavailable for radicular absorption. However, there are mineral elements that complete with other elements and with glyphosate itself, such as Ca, Fe and P, and salts with metals such as Al and Fe can be formed. In fact, according to different studies, high phosphorus levels promote the precipitation of Fe and Al in the soil, decreasing the adsorption of glyphosate, which increases absorption by the plants, with the resulting risk of damage (Souza, 1982).

Mycorrhizal fungi

The interaction between microorganisms, substrates and soil components can alter herbicide biodegradation, which can be greater or lesser depending on the soil's adsorption capacity. Adsorption can reduce the amount of herbicide in the soil solution. The presence glyphosate in forest soils may favor the microbiota able to degrade the molecule, and on the other hand, suppress other microorganisms, including the beneficial ones, with the resulting alteration of the balance of the microfauna in these environments.

The relationship between micorrhizal fungi and the roots of certain plants and trees is essential for the adsorption of phosphorous.

Junior and Zambolin (1994) reported that glyphosate reduces the colonization of eucalyptus roots by mycorrhizas. According to Dodd and Jeffries (1989), cited by Tuffi Santos et al. (2005), it is quite possible that the frequent use of herbicides in a given area causes a selective decrease of mycorrhizal fungi in the field.

A study done on the effects of glyphosate in soy crops in Brazil revealed that glyphosate inhibits the growth of the germinative tube of the vesicular arbuscular mycorrhizas that are symbionts of soy (Dos Santos Malty *et al.*).

A study done by a Canadian team headed by the scientist Wan et al. (1991) identified the harmful effect of glyphosate on the vesicular arbuscular mycorrhiza fungus *Glomus intraradices* in carrot roots. Given that many plants cannot grow without this mycorrhizal relationship, this is a possible effect of the fumigations with glyphosate to take into consideration. Wan *et al.* (1998) subsequently conducted another study to assess the sub-lethal toxicity of

glyphosate on the relationships between mycorrhizal fungi, nutrients and plants.

The fact that glyphosate interferes with the relationships between mycorrhizal fungi, nutrients and plants was published by Wan et al. (1998). The relationship between mycorrhizal fungi and the roots of certain plants and trees is essential for phosphorus absorption.

In sub-tropical soils, several commercially important species are associated with vesicular arbuscular mycorrhizas that play a fundamental role in phosphorus adsorption, a nutrient that is very scarce in this type of soil. It is also been reported that the vesicular arbuscular mycorrhizas influence nodulation in legumes for nitrogen fixing (Panus, 1980).

Decomposition processes in organic matter

The soil's micro-organisms are responsible for the decomposition of organic matter into nutrients. Given that the metabolic cycle of chorismic acid is also present in micro-organisms, glyphosate has an adverse effect on them, and for the same reason, interferes in the decomposition processes of organic matter.

An Egyptian research team studied the impacts of Roundup on soil fungi and on the decomposition of organic matter. They found that the herbicide increased the presence of certain species of fungi and decreased others. A decrease in the respiration rate and decomposition rate of organic matter was also found (Abdel-Mallek *et al.*, 1994).

In Argentina, the use of large quantities of glyphosate associated with the growing of genetically engineered soy is already affecting the natural equilibrium and microbial life of the soil, creating problems in the decomposition of organic matter and threatening the biodiversity and productive future of vast tracts of land (Joensen and Semino, 2004).

In Canada, it has been confirmed that growing herbicide-resistant colza affects the biodiversity and microbial activity in the soils (Dunfield and Germida, 2001).

Glyphosate has negative effects on nematodes and other worms and invertebrates (Dewar, Haylock, May, Beane, Perry, 2000). A study in New Zealand showed that glyphosate had significant effects on the growth and survival of common earthworms. Low-dose applications every 15 days (1/20 the normal dose) reduced growth and increased maturity time and mortality (Springett, Gray 1992; Cox, 1995).

Increase in pathogenic organisms

According to many studies published in scientific literature, glyphosate increases the growth of pathogenic fungi. As a result, these fungi predominate in an area by releasing their own toxins (microtoxins), which are harmful to many other nearby life forms, including mammals.

One of the genera that tends to increase in the presence of glyphosate is the genus *Fusarium*. In the United States, it has been found that the increasing use of glyphosate on genetically engineered crops increases the problems of root colonization by *Fusarium spp*, a fungus that causes major crop damage and whose presence in food can have harmful effects on human life, becoming fatal at high concentrations (Kremer and Donald, 2003; Sanogo, Yang, Scherm, 2000; Wan et al., 1989; Delcalzo, Punja, Levesque and Rahe, 1996; Johal and Rahe, 1984; Levesque, Rahe and Eaves, 1992; Levesque, Rahe and Eaves, 1993; Levesque, Beckenbach and Rahe, 1993; Rahe, Levesque and Johal, 1997; Wan, Rahe and Watts, 1998).

Scientific literature associates other pathogenic agents with the use of glyphosate. A study done by the United Kingdom's Forestry Commission found that 19% of the ash tree hedgerows showed symptoms of dieback, an ash tree disease that can be caused by a series of agents, but which the Forestry Commission attributed to the use of glyphosate, among other causes (Forestry Commission, 1991).

It has also been reported that the use of glyphosate increases the pathogenicity and survival of *Gaemannomyces gramminis*, the causal agent of wheat take-all. It was also found that, due to the herbicide's effect, there was a decrease in the soil fungi that are the pathogen's antagonists and are able to significantly reduce the incidence of this disease. Moreover, glyphosate is known to increase bean sensitivity to anthracnosis (the causal agent of which is the fungus *Colletotrichum lindemunthianum*) and the incidence of *Rhizoctonia* in the root rot of barley (Johal and Rahe, 1984; Smiley, 1992; Mekwatanakarn and Silvassithamparam, 1987).

A verification mission to the zone affected by the spraying under the program for the eradication of illegal crops on the Ecuador-Colombia border in Sucumbios Province found the presence of *Fusarium sp.* in all the samples assessed (Maldonado et al., 2002). Other isolated pathogenic fungi were *Rhizoctonia, Cylindrocarpon and Helminthosporium*. The sampling was done on grass, corn, peanuts, rice and soils. The results are summarized below (Table 13).

The proliferation of *Fusarium* is of special importance in the context of the Plan Colombia because up to September 2002, *Fusarium oxysporum f. sp. erythroxyli* was going to be used as a microherbicide to eradicate coca in Colombia on the recommendation of the United States Government, a proposal that was rejected by the Andean Committee of Environmental Authorities (Comité Andino de Autoridades Ambientales – CAAM), although there is once again pressure to use it.

Species of the genus *Fusarium* have been responsible throughout the world for serious damage to many crops, poisoned soils, birth defects in human beings, and in one documented case, the deaths of thousands of people caused by its microtoxins when they ate contaminated cereals during

Table 13
Pathogenic fungi isolated in plant samples in the affected zones

Crop samples and fungi present					
Location	Crop	Sample	Results		
Playera Oriental	Corn	Roots	Fusarium sp.	Rhizoctomia sp.	Cylindrocarpon
Playera Oriental	Corn	Leaves	Helminthosporium	Rhizopus sp.	Mucor sp.
Pedregosa	Hay/ fodder	Roots	Fusarium sp.	Rhizoctomia sp.	
Pedregosa	Hay/ fodder	Leaves	Fusarium sp.	Rhizoctomia sp.	
Chone-2	Peanuts	Roots	Fusarium sp.	Rhizoctomia sp.	
Chone-2	Peanuts	Leaves	Fusarium sp.	Alternaria sp.	
		Soil	Fusarium sp.	Rhizoctomia sp.	Cylindrocarpon
Chone-2	Rice	Roots	Fusarium sp.	Rhizoctomia sp.	Rhizopus sp.
Chone-2	Rice	Leaves	Fusarium sp.	Rhizoctomia sp.	Rhizopus sp.
Playera Oriental	Hay/ fodder	Roots	Fusarium sp.	Rhizoctomia sp.	

Source: Maldonado et al. (2002)

the final years of the Second World War (Marassas, Nelson and Tousson, 1984).

The CIF team also found that the protein levels were very low in the plants. The analyses of the plants' nutrients done by the Soil, Water and Plant Laboratory in the city of Coca (Labsu) found that:

- *"The plant does not absorb this nutrient due to a possible external influence, which was clearly seen during the extraction of the study material. The aerial parts of the plant were dry, with rotting at the roots and stems. The Dallis grass exhibits high levels of total phosphorus, almost double what is reported as normal in the bibliography (760 mg/kg). We believe that this is an abnormal figure, which indicates that the plant has not absorbed the excess from the soil, because the soil from which that material was extracted has proper and not excessive amounts of this element. The excess possibly comes from an external influence that was applied directly to the plant's leaves" (Pazmiño, 2003).*

The widespread use of glyphosate in areas of genetically engineered crops resistant to this herbicide has allowed the development of weed biotypes that are also resistant, and therefore more difficult and costly to combat, because even stronger herbicides are needed to control them.

Although the herbicide glyphosate is considered non-selective, several species of weeds of the genera *Commelina, Ipomoea* and *Richardia* exhibit a certain level of tolerance to the recommended doses, especially in areas where this product is extensively used. An assessment of the dynamics of the seeds of these and other susceptible genera found that the populations of the species of the genera said to be tolerant increased significantly, mainly when lower doses were applied; therefore, it is believed that intensive use of this herbicide can cause a change in the area, increasing the frequency of the presence of these species over the years (Monquiero and Christoffoleti, 2003).

Effects on the Aquatic Systems and their Biological Communities

Glyphosate can contaminate bodies of surface water, whether by direct spraying, due to the drift effect, or because the pesticide is leached into the aquifers.

Studies conducted by the Ecuadorian Atomic Energy Commission on soils and water in the Sucumbios region, using the EPA 547 analysis methodology based on liquid chromatography, have shown that there are traces of glyphosate under 100 µg/kg in the soil in samples from Estero Tapi and La Balastrera, and traces in water under 10 µg/l in samples from Azul Chiquito and Río San Miguel. The analyses were done at a distance of between 200 to 500 meters from the Ecuador-Colombia border (CEEA, 2005).

The persistence of glyphosate in water is shorter than in soil. Due to its capacity for adsorption into particles in suspension, organic matter and minerals, its persistence in sediments is more prolonged.

Due to the high precipitation levels that exist in the areas where the coca eradication programs take place, glyphosate is quickly carried by runoff from the soils into underground waters.

The possibility of glyphosate and its agents polluting the surface and underground bodies of water in Ecuador's tropical border regions, where the

coca eradication programs take place, constitutes a serious threat for the ecological balance of the affected regions, where there are a great may bodies of water on which all the biological communities depend, not only the aquatic ecosystems, but also the adjacent terrestrial ecosystems, because there is an interaction between both (Victoria *et al.*, 2004; Sedell *et al.*, 1989).

The Amazon region is considered one of the planet's major sources of fresh water, and its river basins are home to the greatest biodiversity of fish in the world. The Tiputini basin in the Ecuadorian Amazon has the highest number of fresh water fish anywhere in the world (Barriga, 2001).

Toxicity in aquatic organisms

Glyphosate alters the aquatic systems' trophic chain starting with the first link. For example, a study done on the impact of 23 pesticides on aquatic plants found that the diatoms and a species of cyanobacteria were vulnerable to glyphosate. One of the study's conclusions is that the level of vulnerability to glyphosate varies greatly from one species to another, and that there is an uncertainty factor when these products are assessed in aquatic ecosystems (Peterson et al., 1994).

Another study found that glyphosate can stimulate eutrophization in aquatic ecosystems, because several primary producers, such as the diatoms, use this herbicide as a source of phosphorus. One of the concerns raised by the results of this research is that the presence of glypohsate under detectable levels induces eutrophization in canals, ponds and other small bodies of surface water, which affects the habitat of fish species (Austin *et al.*, 1991).

Although it is claimed that glyphosate does not bioaccumulate in the trophic networks, the fact is that altering the ecology of the primary producers means altering the ecological balance of the entire community. This is a serious problem for the tropical ecosystems (where the coca eradication programs take place), because there are a great many bodies of water in these regions.

One of the most serious problems of the glyphosate formulations used to eradicate coca is that some of the ingredients are more toxic for aquatic life than glyphosate itself. Moreover, in the combination that is used, the sum of these ingredients has an additive toxic effect (Bidwell and Gorrie, 1995; Cox, 1995; Abdelghani, 1997).

The impacts on Amazon fish biodiversity has significant economic and cultural repercussions, because may communities depend on fishing for their survival. Such is the case of a major agro-industrial business concern on the border (Mestanza, 2002), whose owner charged that after the three sprayings in 2001 and 2002, he lost more than 170,000 fish in the 18 pools built for their commercial production,

in addition to the loss of over 400 ducks, 150 chickens, 20 pigs, 3 mares, 30 hectares of banana, 8 hectares of sugar cane, 10 of coffee, 6 of cacao and all the production of orange, croton lechleri, laurel and guarea kunthiana. These losses were confirmed by the governor of Sucumbios at the time (Velasco, 2002), and in 2006, the businessman said that that the effects on his production were still being felt.

There is a comparative study on the impact of herbicides and surfactants on aquatic species done by Abdelghani (1997). He established the acute toxicity of three herbicides alone or as mixtures (2,4-D, Garlon-3A and Roundup) and a chemical additive (the surfactant Syndets) on three fresh water species: catfish, bluegill (Lepomis macrochirus) and a freshwater crab. Of the three herbicides, Roundup was more toxic for the catfish and the bluegill than Garlon-3A and 2,4-D. The results for the freshwater crab were exactly opposite those found for the fish.

The surfactant Syndets was much more toxic than the three herbicides for the three organisms.

A group of researchers found that glyphosate is harmful in sub-lethal concentrations for the carp *Cyprius carpio* (Neskovic et al., 1996). The effects they reported include changes in enzymatic activity in the plasma, liver and kidneys. They also found morphological alterations in the gills, liver and kidneys.

Studies done in France on cell reproduction in sea urchins show that pesticides containing glyphosate alter the G2/M phase of the universal cell division cycle by dephosphorylating the cycle regulator known as "CDK1-cycline," altering the cell "checkpoints" that determine the normal functioning of cell DNA (Marc, Bellé et al., 2004). According to Dr. Bellé, although his studies have not demonstrated the complete cancer genesis process, which takes many years, they have managed to show the first stages of the process of damage and genetic instability that turn into cancer with time (Bellé, 2007).

Other studies reveal that glyphosate is also harmful for other aquatic organisms. For example, changes have been reported in the development and reproduction of the sea snail *Psuedosuccinea columella* when it was exposed to sub-lethal concentrations (Tate et al., 1997). The researchers also found that when the snail was exposed to different concentrations of glyphosate, its growth and development was stimulated; there was an increase in the number of eggs with more than one embryo. This means that the population of snails of that species could increase. Moreover, this species of snail is one of the hosts of a liver parasite of sheep. The study concludes that the presence of low levels of glyphosate can promote the increase of this parasite.

Different species of fish have differing levels of vulnerability to glyphosate (Wan, 1989).

Other factors that determine the herbicide's toxicity include the quantity of minerals dissolved in the water (Hartman and Martin, 1984) and the water temperature (Folmar *et al.*, 1979).

Impact of glyphosate on amphibians

Water pollution by this herbicide is extremely lethal for amphibians, according to a research study that revealed a 70% decrease in amphibian diversity and an 86% reduction in the total number of tadpoles in ponds contaminated by Roundup (Relyea, 2005).

In studies conducted in Australia, the Roundup formulation has been shown to be toxic in amphibians in several ways. A study commissioned in 1995 by the Western Australian Department of Environmental Protection (DEP), headed by Dr. Joseph Bidwell of the Curtin Exotoxicology Program, concluded that Roundup 360 (another Roundup formulation containing glyphosate and surfactants) can be acutely toxic for adult frogs and tadpoles at the recommended application rates (1.8 to 5.4 kg/hectare) (Mann and Bidwell, 2004).

The herbicide Roundup 360 was more toxic to frogs and tadpoles than the technical grade of Roundup alone. It was assumed that the surfactant used in the Roundup formulation, and not the glyphosate itself, was responsible for the increased toxicity (Bidwell et al., 1995). It should be noted that this is precisely the same surfactant (POEA) found in the Roundup used in Colombia.

Similar results have been found in Canada, where glyphosate caused paralysis and even death in native amphibian species (Bruce, 1996).

Given the reported impacts of glyphosate on amphibians, the United States Congress asked the Department of State (DoS) to assess the risk for amphibians caused by the aerial spraying program that the United States is financing in Colombia. In response to the Congress's request, the DoS hired the CICAD to do the scientific work (AIDA, 2006).

Amphibians are an important component of the biodiversity in this Amazon region, where the highest rates of amphibian biodiversity per unit area in the world have been reported. A high extinction rate of several species of amphibians has also been reported in Ecuador (Coloma, 2005), and it is believed that this problem could worsen due to the effect of spraying with glyphosate.

Effects on non-target organisms.

One of the main problems with the use of pesticides in general is that they affect organisms other than those that they are intended to combat.

Insofar as glyphosate is concerned, it is claimed that since glyphosate interferes with the metabolic route of chorismic acid, which is absent in animals, it does not affect them. However, there is an abundant bibliography

which proves otherwise. The impacts can result from a direct effect on the individuals exposed to the pesticide, or from the destruction of the species' basis for survival. Changes at the hormonal level have been reported.

Impacts on other animal species

Effects on insects.

To assess the impact of glyphosate on live organisms, work was done with the fruit fly as a genetic model for studying mutagenesis. Culture media were prepared, and flies placed in them for fecundation and reproduction. The glyphosate concentration in the medium ranged between 3, 6, 12, 24 and 40%. In three runs with the 3% and 12% crosses, third-stage larvae were not obtained; therefore, neither polytenic nor metaphasic chromosomes were observed. Only one 3% cross produced a pupa at 17 days (normal pupation is at 6 days), which turned brown and died. We see that glyphosate alters the number of eggs laid by the flies, with the number decreasing as the concentration increases, i.e. it retards the life cycle of *Drosophila*. In the control group of flies (medium without glyphosate), the cycle was completed at 13-16 days. In the 6%, 24% and 40% concentrations, the cycle was not completed because the adults died. We conclude that glyphosate impedes the normal development of the fly and larvae (Paz-y-Miño, *et al.*, 2007).

The use of glyphosate in agricultural environments has triggered the outbreak of several agricultural plagues, and this has been related to the decrease in the populations of those plagues' predatory species, which act as natural biological control agents. Such is the case of the violent outbreak of cereal aphid that took place in the United States in the early 1970's (Potts and Vickerman, 1994).

An assessment done by the International Biological Control Organization on the impacts of pesticides on beneficial species reported that 80% of a population of plant pest predator beetles died when exposed to glyphosate. Moreover, 50% of the population of parasitoid wasps, ladybugs, lacewings and predator mites also died after exposure to glyphosate (Hassan *et al.*, 1988).

Products such as glyphosate, simazine+ametrine, 2,4-D, acetylchlorine and oxyfluorofen significantly reduce the plant growth and sporulation of the isolate of *Beauveris bassiana* (UEL 114), an entomopathogen which controls

the coffee root mealybug (Dysmicoccus texensis Tinsley) (Andaló *et al.*, 2004).

Glyphosate formulations can also affect the behavior of other plague-controlling organisms, such as the hymenopter *Trychogramma pretiosum* (Giolo *et al.*, 2005), especially their parasitizing capacity.

A study done in North Carolina, United States, found a drop in the population of Carabus beetles treated with glyphosate. After 28 days, the population had still not recovered (Brust, 1990). Similar results were found in a study done in the United Kingdom on marginal grasses treated with Roundup, where a reduction in the Carabus beetle populations was found (Asteraki *et al.*, 1992).

There is a scientific bibliography which attests to the effects on beneficial insect populations due to changes in their habitat. Such is the case of a study done in the United States for three consecutive years in a forested area that had been cleared with Roundup 4-5 years before and then planted with Christmas tree seedlings. The researchers found that the populations of herbivore insects and soil invertebrates had decreased significantly, and did not recover during the study period. The authors conclude that the drop in population was basically due to the change in these organisms' habitat (Santillo *et al.*, 1989).

Asteraki *et al.* (1992) report a decrease in the number of spiders in marginal grasses treated with Roundup, possibly because the plants where they made their webs were destroyed.

Alterations in the reproductive patterns in several beneficial arthropod populations have also been reported. Chiverton *et al.* (1991) conducted a comparative study between arthropod populations sprayed and not sprayed with herbicides in spring wheat fields in the United Kingdom. They found that the female Carabus beetles that had not been treated with glyphosate laid more eggs than those that had been exposed to glyphosate. It is possible that a reduction in the species that served as prey to the carabus beetle resulted in the specie's low fertility, which meant a reduction in the depredation capacity for agricultural plagues.

Many substances are used to combat plagues, diseases and weeds, but most of them are toxic for humans and animals, and can also reduce the level of control by predators, parasitoids and entomopathogens. Some agrochemicals can have a negative impact and reduce these organisms' biological control effect.

Glyphosate formulations can also affect the behavior of other plague-controlling organisms such as *Trichogramma pretiosum* (Himenoptera: Trichogrammatidae), especially its parasitism capacity. The formulations made with isopropylamine salt are moderately harmful (Giolo *et al.*, 2005).

Another group of beneficial insects affected by glyphosate includes the pollinator species.

Professor Joe Cummins of the University of Western Ontario did a review of the alarming decrease in bee populations around the world. He attributes the decrease, among other effects, to the growing use of pesticides. He indicates that the bees are particularly susceptible to herbicides, because herbicides affect their development and longevity, cause changes in behavior (navigation, feeding habits and learning), in the immune system and in oviposition. The sub-lethal toxicity can cause fatal changes in the hives (Cummins, 2007).

One of the complaints about the program for fumigating with Roundup (plus surfactants) that the United States implemented to eliminate poppy crops in Guatemala was that it had destroyed beekeeping in the areas closest to the spraying.

- *"Although the fumigation program had minimal effect on the poppy crops, according to the local campesinos, it destroyed the traditional production base in the region, particularly tomatoes and bees."* (Freed, 1989).

According to studies done by Nemoto et al. (2002), the presence of glyphosate strongly reduced the micelial growth of *Bipolaris euphorbiae*, also affecting the germination of the conidias.

As a result of environmentalist pressures, this Fumigation Program was halted, and poppy growing in Guatemala is now controlled with manual eradication.

Effect of Glyphosate on Mammals

In field studies, populations of small mammals have been found to be affected by glyphosate due to the death of the vegetation that they or their prey use for food or protection.

In the case of herbivores, ingesting vegetation contaminated with glyphosate can also have negative effects. Additionally, the animals can come into contact with this herbicide in an ecosystem that has been fumigated through skin or eye contact or by inhalation.

The application of glyphosate in forest ecosystems can alter the reproductive rates of some species, favoring those that adapt to disturbed habitats, such as pastures, and displacing species that live in less disturbed forests. Santillo et al. (1989) found a lesser presence of small mammals in the north central area of Maine, on land "treated" with glyphosate.

Richard et al. (2005) concluded that glyphosate disrupts the activity of Cytochrome P450 aromatase in mammals at concentrations 100 times lower than those recommended for its agricultural use. The

cytochrome plays an important role in the metabolism of substances foreign to the organism, such as pharmaceutical substances, pesticides, etc., many of which can have carcinogenic effects.

They also found that in concentrations lower than those recommended for agricultural use, Roundup can cause reproductive problems.

Studies done on rabbit spermatozoids (Yousef et al., 1995) found that treatment with the herbicide glyphosate reduced body weight, libido, ejaculation volume and sperm concentration and volume; a high percentage of abnormal and dead spermatozoids was also found. The harmful effects continued in the recovery period.

Effect of glyphosate on reptiles

Although few studies have been done on the impacts of pesticides on reptiles, Sparling et al. (2006) found adverse effects in embryos of the turtle *Trachemys scripta elegans* when they were exposed to glyphosate and its surfactants at different concentrations.

In the Ecuadorian Amazon region, giant river turtles are an important source of protein for the indigenous communities, including those that live near the Colombian border. It would be important to know if spraying with glyphosate and its additives is having any impact on these animals.

Effect of glyphosate on birds

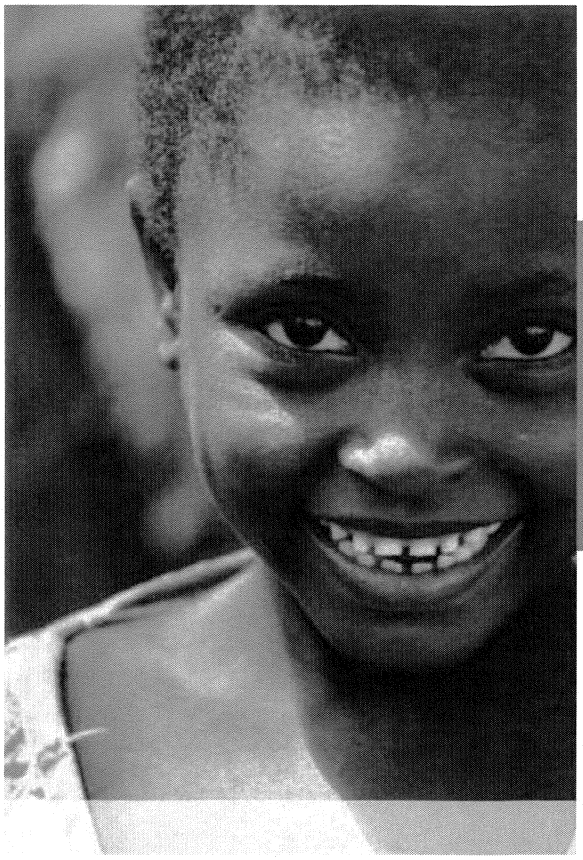
Studies done on the impacts of glyphosate on birds have found that this herbicide is moderately toxic. But indirect effects on bird communities have also been identified, because glyphosate affects the plants or insects that these animals depend on for their survival. Therefore, it could cause dramatic changes in the structure of the plant communities, affecting the bird populations, because they depend on the plants for food, protection and nesting. This has been documented in studies on populations of birds exposed to glyphosate on the northern coast of the United States.

Summation

There is sufficient evidence in scientific literature on the environmental impacts of glyphosate and its additives.

The herbicide directly affects ecosystems, populations and individuals; and in other cases, destroys the ecological niches, nesting sites, feeding sites, etc., of biological populations.

These impacts could be even greater than those reported in scientific literature in the case of eradication of illegal crops under Plan Colombia due to the high concentrations of the active compound, the presence of additives that have not been assessed in the environment where they will act, and the very fragility of the tropical ecosystems.



VII. THE PRECAUTIONARY PRINCIPLE AS A SCIENTIFIC, ETHICAL AND LEGAL CORE

The validity of the charges of impacts raised by the affected towns on the northern border (CEDHU, 2007; Inter-American Platform for Human Rights, Democracy and Development, 2007) has been established from the rigorous perspective of a group of scientific, ethical and legal precepts that allow us to evaluate the evidence accumulated in the existing scientific bibliography and the basic sufficiency of the local evidence, and support the request for immediate application of the Precautionary Principle as inalienable and non-negotiable.

Scientific precepts

The Ecuadorian Scientific Commission first assumes, along with the vanguard of world scientific thought, a comprehensive interpretive model that recognizes the multidimensional complexity of the determination of health and life (variant of the WHO model); second, it assumes a comprehensive notion of the assessment itself, without reducing it to a quantitative analysis of the

uncertainties and also assessing the accounts and data provided by the communities; and third, it reconsiders the weight that should be given to uncertainty, at least so that it does not work to conceal knowledge that actually exists as a pretext for inaction or as a way to demand an interminable search for certainties, which never arrive, or do so when it is already too late to prevent massive damage.

The role of science in a life-threatening scenario is to work as an early warning and in the direction of immediate precautionary measures based on available knowledge, and not wait for an interminable accumulation of absolute responses and statistical "certainties" to control the suffering and damage caused. The role of science is to provide knowledge for the coherent formulation of precautionary terms and the dimensions of the demands for protection and remediation. In a scenario where there are elements of uncertainty, the role of science is to incorporate those elements as input for ongoing improvement, but not as a restraint on the ethical precept of precaution.

Science is a system of concepts for interpreting nature and gaining reliable knowledge that allows us to lead sustainable lives. Therefore, science cannot separate itself from moral values. It is for this reason that Elsa Nivia, coordinator of the Action Network for Pesticides and their Alternatives in Latin America has said that we must assess the fumigations done in her country to eradicate coca and poppy crops using science, knowledge and heart (Nivia, 2002).

The accumulation of scientific evidence against the alleged harmlessness of products in the "safe" range, as glyphosate is classified, has led national scientific communities, such as the one in Brazil, after a serious academic and political debate, to demand that Governments change the name of "pesticides," which perpetuates the false notion of specificity against pests, to "agrotoxins," which highlights their full and multiple dangers (Federal Law No. 7802 of July 11, 1989). This legal measure acknowledges the validity of the Paracelsus precept (16th Century): "Everything is poison, nothing is poison; the dose alone makes the poison." As explained above, there is sufficient evidence of the dangers of glyphosate and even more so the complete chemical package of the formulations used, and the impact of the aerial spraying system.

Ethical precepts

Life and human rights are critical to the strategic interests of any public or private, military or civil undertaking; and the evidence accumulated in the region and the world demand the immediate application of the rules of the precautionary principle.

In the world today, science has produced a great number of products and technologies that entail a high level of uncertainty and constitute a threat for health and the environment. Their impacts may be irreversible.

This means that science and the decisions on science cannot only be in the hands of the scientists. Now, science does not generate irrefutable data, but rather opinions that can be refuted. And in many cases, scientific progress creates new sources of threats. Therefore, science cannot remain detached from society; the participation and opinion of all those affected by a specific issue are required.

This a break with the notion of science as infallible, where there is no room for doubt, where there is a solution for all problems, and where it is inconceivable to pose the thought that there are several answers to the same question.

In this context, we find the concept of post-normal science developed by Funtowicz and Ravetz (1994), who propose a research methodology that is appropriate for scientific research involving uncertainties, social values in dispute and high environmental or human health risks. The post-normal science methodology should be used when uncertainties are involved that could lead to costly, or even fatal errors. The concept proposes a science in which society participates. Scientific progress is no longer just endorsed by a community of scientists that make peer reviews, but by a community of citizens concerned over the uncertainty that scientific progress can cause in their lives (Funtowicz and Ravets, 2000).

This methodology is even more urgent when, little by little, we see how industry begins to dominate scientific research. Industrial research parks have been created around certain universities linked to trade names and companies, such as Silicon Valley, Route 128, Research Triangle (Duke, North Carolina and North Carolina State Universities), Princeton Corridor, Silicon Hills Texas, the Medical Mile (Penn and Temple Universities), Optics Valley (University of Arizona) and the Golden Triangle (University of California at San Diego). This slowly turns academicians or researchers into corporate employees or leaders and makes the universities stop doing research for public interest and become increasingly involved in projects that serve the interests of their corporate clients. Thus, the possibility of public benefit through research begins to fade, replaced by research to serve the corporate benefit.

The possibility of independent research is also being lost.

Under this scenario - what happens when a product of one of these companies that finance scientific research in universities and other research centers creates a controversy because its use can generate negative impacts on health and the environment? Why, evidence is manufactured at the request of the client companies! That is why science must be analyzed ethically. Science produced under the auspices of industry maintains that it cannot be analyzed from an ethical perspective, and that the issue of risk has nothing to do with it.

Thus, we are dealing with a poor quality science that defends its "neutrality" and is divorced from moral values. This science frequently ignores scientific evidence; it has been co-opted by those who sponsor it, and with increasing frequency, these are the transnational companies and their scientists who make "science by contract." This kind of science can do damage to our health and produce negative impacts on the environment.

This does not only happen at the company level. There are recent charges which indicate that the United States Government has interfered in scientific results that go against its policies.

The magazine "Democracy Now" (2006) reports on a New York Times article that stated:

- *"Union leaders representing thousands of scientists from the Environmental Protection Agency (EPA) are accusing the agency's directors of yielding to political pressure and allowing the use of harmful chemicals in agricultural pesticides. The call is taking place before the term expires this Thursday for Congress to approve thousands of chemicals that the scientists say pose serious risks for fetuses, pregnant women, children and the aged." The article adds that "In some cases, the EPA ignored independent scientific studies that contradicted those sponsored by the pesticide industry." (Janofsky, 2006).*

By way of an illustration, let us look at how Solomon, a scientist at the service of the CICAD, attempts to refute Cox's conclusions based on certain supposed principles of scientific rigor. In the report that the CICAD commissioned from Solomon et al. (2005) to analyze the impacts of the program for the eradication of illegal crops in Colombia, the following footnote appears:

- *"We should note that several publications have appeared on glyphosate, focusing on its adverse effects. A pamphlet/brochure by Cox (1999) was produced on behalf of an activist organization. The pamphlet was very brief and not reviewed by peers. Moreover, an article that attempts to pass itself off as a scientific review was published in 1998 (Cox, 1998) in the Journal of Pesticide Reform. It should be stressed that the Journal of Pesticide Reform does not publish original articles and is not peer-reviewed. It is produced by a group of activists, and the editor is frequently the author of the articles. Because of this, these articles are not used in this report."*

In view of these statements, we must ask whether we should disqualify all publications produced by civil organizations whose purpose is to defend public welfare. The Journal of Pesticide Reform is published by the Northwest Coalition for Alternatives to Pesticides, whose mission is "to protect people and the environment by finding healthy solutions to the pest problem."

Like this coalition, there are many civil organizations such as the Action Network for Pesticides and their Alternatives, Pesticides Action Network, and others that have skilled scientists whose purpose is to work for the collective welfare. Should the work done by these organizations be disqualified?

Let us compare this with the references used in the report from Solomon *et al.* (2005).

Solomon takes a good part of the bibliographical references that he uses on the harmlessness of glyphosate, a Monsanto product, from research supported by Monsanto and done by Professor Gary Williams (Monsanto, 2005). According to the information from Monsanto, Professor Williams is the Director of Environmental Pathology and Head of the Program of Medicine, Food and Chemical Safety at New York Medical College. This research center (NYMC, 2007) has a Technological Development and Research Department financed by industry; it negotiates and maintains relationships with industry and transfers results for commercial application.

The protocol for the epidemiological studies on human health in Colombia and the questionnaire for assessing fertility/fecundity were approved by the Ethics Committee of the Santa Fé Foundation of Bogotá (Solomon *et al.*, 2005). The corporate benefactors of the Santa Fé Foundation of Bogotá are: Dupont of Colombia, Dow Chemical of Colombia, Cyanamid of Colombia, Johnson & Johnson, Abbot Laboratories, Merck, Sharp & Dohme Loboratories, Pepsi Cola, Phillip Morris de Colombia, S.A., Occidental of Colombia, Inc., Compañia Colombiana de Tabaco and Colgate-Palmolive, among others (Fundación Santa Fé, 2007).

Where is the impartiality of the Foundation that approved the protocols?

In this context, the sworn statements of Dr. Camilo Uribe, also a member of the Colombian Scientific Commission in 2003, are surprising. His words, reported by Pinzón (2003), who presents him as "*Director of Colombia's premiere Scientific Center in toxicology*," mention that:

- "*Orally administered (...) a lethal dose, i.e. a dose capable of producing death, of 5,500 mg/kg weight has been calculated [for rats]. This means that the average adult in Colombia weighing 60 kilograms would have to ingest approximately 15 to 18 liters of formulated product for severe acute toxicity to occur. In the case of children – we would be talking about those under 12 years old ... they would have to ingest between 6 to 8 liters...* (p. 71).

Aside from violating the FAO's Code of Conduct on the distribution and use of pesticides, Article 11 of which (on advertising) recommends avoiding words that raise confidence in toxins (CONAIE, 2001), statements such as

these, although sworn, are based on incorrect premises, and therefore the conclusions derived from them are inconsistent.

The first error is attributing the same level of lethality to people as that observed in rats, a false initial premise. But even following Dr. Uribe's line of thought, the CIF (2003) shows the seriousness of the error. According to Monsanto, Roundup contains 480 grams/liter of glyphosate as an active ingredient. If we follow Dr. Uribe's reasoning that 5,500 mgr/kg are needed to cause death in people as in rats, an average adult human in Colombia weighing 60 kilos would have to ingest approximately 330,000 mg or 330 gr of formulated product, i.e. 0.68 liters or 687 ml of glyphosate. If, according to several studies on animals, the intestinal absorption is 30% (and it takes 7 days to eliminate 99%), this means that of those 687 ml, 206 are going to be absorbed. Therefore, "in order for death to occur, or the person to be on the verge of death," the 687 ml would have to be the 30% absorbed by the intestines. This means that 100% of what was ingested would have to be 1,668 ml, i.e. 1.6 liters, and not the 16 liters mentioned by Dr. Uribe.

The CIF (2003) also describes how, if we accept that literature does, in fact, say that glyphosate + POEA is 22 times more toxic (and there are no studies with the addition of Cosmoflux, which increases its absorption), then according to the figures we are dealing with (1,668 ml / 22 times), 76 cubic centimeters (approximately one-third of a glass) would be enough to result in death or severe acute intoxication.

This quantity coincides with the amount found in the cases reported in Japan, where people died after ingesting it. In a review of intoxications, Nivia (2001b) calculated that the amount of concentrated Roundup intentionally ingested in cases of suicide was 184 cubic centimeters (85 to 200 range), although he noted that the ingestion of larger quantities in other cases only resulted in slight to moderate symptoms. Other studies report that ingesting an average of 104 to 120 cubic centimeters is not fatal, while ingesting 206 to 263 cubic centimeters results in death. In Brazil, the Unicamp Center for Intoxication Control (2001) reports that a 25 cubic centimeter dose can cause severe gastro-esophogeal damage; ingesting 5 ml – slight intoxication; 20 ml – moderate intoxication; and over 85 ml – serious intoxication. Stomach flushing is recommended up to 4 hours after ingesting 0.5 ml/kg, because this is the toxic dose. Endotracheal entubation is recommended in some cases to prevent aspiration and avoid chemical pneumonia. Cardiovascular, respiratory and renal monitoring of intoxicated individuals is recommended.

In an environment such as the border between Ecuador and Colombia, where intestinal parasitoses are rife, malnutrition among school-age children is 30% and there is a high incidence of tropical diseases, lower amounts can, however, be more toxic. As Unicamp says, 5 mg/kg produces irritation of the gastrointestinal mucous membrane, and can result in hypotension, metabolic acidosis, pulmonary insufficiency and oliguria – unlike

Dr. Uribe's claims at CIESPAL in Quito. They are on record in his sworn statement, although they have never been written or disseminated in a public document, because they would obviously not withstand scientific debate.

Legal precepts

There is a national and international legal framework that protects the inalienable right to health and orders that health be guaranteed and protected by the States whose populations are affected.

The Republic of Ecuador believes that in order to properly approach the issue of aerial spraying, we must take into account two aspects of vital importance that have specific legal bases: the centrality of the human being and the duty of the State to protect; and the validity of the precautionary principle.

ECUADORIAN LAW RELATED TO THE RIGHT TO HEALTH

*The Ecuadorian Constitution (Article 42) as guarantee of the right to health, its promotion and protection.

*The Health Code (J.M. Velasco Ibarra, 1971) and its successive amendments.

*The National Health System Act (2002) and its Regulations (2003); Obligations of the National Health System, Article 3 Objectives (numerals 2 and 3: 2. Fully protect people from health risks and damages; the environment from deterioration or alteration. 3. Create healthy living environments, lifestyles and living conditions; 5. Implementation mechanisms (numeral 2):

2. Actions to prevent and control collective health risks and damages, especially those related to the natural and social environment. Obligations established by the Health Code; Environmental Cleanup Rules (general provisions Chapter 1, Articles 7, 8, 11, 12). Article 7. Environmental cleanup is subject to the general health policy and the rules and regulations proposed by the National Health Office, establishing the powers given to the municipalities and other public or private institutions. Article 8. The National Health Office may temporarily assume the functions given to other institutions when there is a need to protect public health. Article 11. When a physical person or legal entity obligated to perform sanitary or health works delays them or executes them in a way other than that ordered, the health authority may carry out the execution on the account of said person, who shall be forced to pay the cost thereof plus ten percent overhead. Article 12. No person may discharge solid, liquid or gaseous wastes into the air, soil or water without prior treatment that makes them harmless for health. The regulations and provisions on public nuisances such as noise, offensive odors, smoke, toxic gases, atmospheric dust, emissions and others shall be established by the health authority.

Drinking water supply (Chapter 2, Articles 16, 17).

Article 16. All persons are obligated to protect the water sources and hydrographic basins that serve as the water supply, and are subject to the provisions of this Code, special laws and their regulations.
Article 17. No one shall directly or indirectly discharge harmful or undesirable substances in a way that might contaminate or affect the sanitary quality of the water and totally or partially obstruct supply channels. Pesticides (Title VIII). Article 149. Companies that manufacture or market pesticides and those engaged in the disinfection, deratting and fumigation of residences, collective environments and rural areas must have prior permission to operate, and shall be subject to periodic control of their operations. Article 150. Pesticides shall not be stored, transported or sold without the use of proper packaging that carries a danger warning.

The centrality of the human being and the Ecuadorian State's duty of protection.

Several findings from international jurisdictional bodies have underscored State responsibility for protecting the basic attributes of the human being by protecting human rights and, if applicable, restricting government actions. For example, according to the Inter-American Court of Human Rights:

- *"... protection of human rights (...) is based on the affirmation of the existence of inviolable attributes of the human being which cannot be legitimately diminished by the exercise of government power. These are individual spheres that the State cannot violate, or into which there can only be limited penetration. Thus, the protection of human rights necessarily includes the notion of restricting the exercise of State power."*

Moreover, according to the same Court, the obligation to ensure respect for or guarantee human rights:

- *"(...) implies the duty of the Member States to organize the entire government apparatus and, in general, all the structures through which the exercise of government power manifests itself, so that they are able to legally ensure the free and full exercise of human rights. As a result of this obligation, the States must prevent, investigate and penalize all violations of the rights recognized by the Convention, and also procure, if possible the reestablishment of the violated right and, if applicable, the redress of the damages produced by the violation of human rights."*

International law, the Ecuadorian Constitution and international jurisdictional findings impose an obligation on the

Republic of Ecuador to act to protect and prevent the impairment of the human rights of those under its jurisdiction, as is the case of the Ecuadorian citizens whose rights have been affected by the aerial spraying conducted by the Government of the Republic of Colombia in its territory, the effects of which reach Ecuadorian territory.

The precautionary principle

The Ecuadorian State, through different administrative and judicial channels, has received multiple reports and accounts from inhabitants of Ecuadorian territory claiming that they have suffered damage from the fumigations in Colombian territory. Ecuador has an extensive catalog of such evidence, both from scientific studies and from the accounts of townspeople, as well as the international findings of experts from the United Nations and other independent organizations.

Reports on the health and environmental risks of the Colombian Program are confirmed by findings such as the 2006 Report of the United Nations Committee on the Rights of the Child, which expresses its concern over:

- *"the environmental health problems created by the use of the substance glyphosate in the aerial fumigation programs against the coca plantations (which are part of the Plan Colombia), because this practice affects the health of vulnerable groups, children among them."*

THE PRECAUTIONARY PRINCIPLE IS APPLICABLE AS AN INALIENABLE OBLIGATION AND CONDITION FOR OBJECTIVITY WHEN

(1) There is a reasonable suspicion of the destructive process, and
(2) There is a scientific uncertainty; then
(3) There is a duty to take preventive action by
(4) Transferring the burden of proof from the community suffering the problem to those whose activities caused the suspected damage in the first place, and by assessing the available alternatives to find the one offering the least possible damage, using a transparent, informed and democratic decision-making process which includes the victims.

The Committee also recommends that Colombia:

- *"...carry out independent, rights-based environmental and social-impact assessments of the fumigations in different regions of the country and ensure that, when affected, prior consultation is carried out with indigenous communities and that all precautions be taken to avoid harmful impact on the health of children."*

Moreover, in a report on his mission to Colombia, the United Nations Special Rapporteur on Indigenous People (Stavenhagen, 2005) told the Human Rights Commission that

- *"the expansion of drug production and trafficking and the fight against it, especially through aerial crop fumigations, has negatively impacted the environment, economy, and social and cultural life of the indigenous peoples,"* and recommends that *"except where expressly requested by an indigenous community which has been fully apprised of the implications, no aerial spraying of illicit crops should take place near indigenous settlements or sources of provisions."*

In his report to the Human Rights Council on his mission to Ecuador, the same Special Rapporteur (Stavehagen, 2006), stated:

- *85. The Special Rapporteur recommends that the Governments of Ecuador and Colombia appoint an independent international commission to study the effects of aerial spraying on indigenous border populations. Corresponding binding measures are also recommended, to provide compensation for the damages caused.*
  86. The Special Rapporteur recommends that Colombia definitively halt the aerial spraying of illicit crops in the border region with Ecuador.
  87. The Special Rapporteur recommends that the Ecuadorian Government draw up and apply an emergency plan (in consultation with the region's indigenous peoples) on the critical situation of indigenous border communities (particularly the Awá), as a result of the impact of the internal conflict in Colombia, illicit drug production and trafficking activities, environmental degradation, the influx of indigenous refugees from Colombia and the situation of violence and insecurity in the area. Concessions granted to oil and mining companies must be reviewed. The State must shape public policies aimed at protecting the various sectors, peoples and communities who live on the northern border, with their full participation, including the right to free, prior and informed consultation.

The Constitutional Court of the Republic of Ecuador has found that the impacts of

the fumigations in Ecuadorian territory have caused "extremely serious problems" which the Government of Ecuador must not fail to address from its different jurisdictions. In response to a complaint against the Ministry of Foreign Relations, demanding that it take all diplomatic measures within its reach to see that fumigation is not carried out within a 10 kilometer area measured from the borderline into Colombian territory, the judgment issued by the highest court of constitutional control resolved that:

- *"measures intended to remedy the damages caused and prevent them from continuing to be caused must be adopted immediately, for which purpose the defendant Ministries and competent bodies of the Executive Branch, in their respective spheres of action, shall execute the necessary protection and compensation orders, because the actions taken up to this point have not, to date, definitively solved the extremely serious problems charged."*

This Constitutional Court decision that invoked the precautionary principle, among other principles and rights, is not the only one of its kind. There are rulings from other international courts which have prevented actions that could entail health risks, even without scientific evidence.

THE INCLUSION OF THE PRECAUTIONARY PRINCIPLE IN INTERNATIONAL LAW

In international environmental law, there is abundant legislation related to the precautionary principle. Moreover, we find regulations and even prohibitions with regard to the use of glyphosate, which underscores the relevance of applying the precautionary principle. Following is a systematization of the most important bodies of law:

* World Charter for Nature, 1982
  Activities which are likely to pose a significant risk to nature shall be preceded by an exhaustive examination; their proponents shall demonstrate that expected benefits outweigh potential damage to nature, and where potential adverse effects are not fully understood, the activities should not proceed (Principle 11.b).

* Montreal Protocol on Substances that Deplete the Ozone Layer
  The Parties to this Protocol ... are determined to protect the ozone layer by taking precautionary measures to control the emissions of substances ... that deplete it, with the ultimate objective of their elimination on the basis of developments in scientific knowledge, taking into account technical and economic considerations.

* Economic Statement, Economic Summit of Industrialized Nations, 1990
  We agree that, in the face of threats of irreversible environmental damage, lack of full scientific certainty is no excuse to postpone actions which are justified in their own right.

* Recommendations of The Hague on International Law, 1991
  In developing environmental policies at the national or international level, States should apply, among others: principles that take precautionary actions. (Principle 1.3d)

* Agenda 21, 1992
  In the face of threats of irreversible environmental damage, lack of full scientific understanding should not be an excuse for postponing actions which are justified in their own right. The precautionary approach could provide a solid basis for policies relating to complex systems that are not yet fully understood and whose consequences cannot yet be predicted. (Paragraph 35.3).

* Convention on Biological Diversity, 1992
  Noting that where there is a threat of significant reduction or loss of biological diversity, lack of full scientific certainty should not be used as a reason for postponing measures to avoid or minimize such a threat (Preamble).

* Rio de Janeiro Declaration on the Environment and Development, 1992
  In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation (Principle 15).

* Framework Convention on Climate Change, 1992
  The Parties should take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures, taking into account that policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost (Article 3.3).

* Cartagena Protocol on Biosafety
  Lack of scientific certainty due to insufficient relevant scientific information and knowledge regarding the extent of the potential adverse effects of a living modified organism on the conservation and sustainable use of biological diversity in the Party of import, taking also into account risks to human health, shall not prevent that Party from taking action in order to avoid or minimize such potential adverse effects.

The Convention on Biodiversity

The Convention on Biodiversity establishes that the States have the obligation to ensure that the activities carried out inside their jurisdiction or under their control do not damage the environment of other States or areas situated outside all national jurisdiction (Article 3).

Both Colombia and Ecuador are Parties to this international convention.

Official reactions in Colombia

There are numerous statements from Colombian authorities that speak of the far-reaching impact of aerial spraying in that country:

In February 2007, Alejandro Vélez, interim director of the DNE, acknowledged that almost 7,000 complaints had been filed in Colombia over the aerial spraying; that proceedings were underway in 772 (11%); and that favorable rulings had been handed down in 33 (0.47%), although not one of them for health problems (the proceeding was created for damage to legal assets, not to health) (CIF, 2007).

The Office of the Human Rights Ombudsman of Colombia (Defensoría del Pueblo de Colombia – DPC, 2002) has concluded that:

- *"the execution of the Program for Aerial Eradication of Illegal Crops is not in keeping with the mandates of the Colombian Constitution (...) it is not appropriate for the intended purpose and its effects on the basic rights of the Colombian people far exceed the alleged benefits that it would provide."*

That same year, in Resolution No. 26, the Office of the Human Rights Ombudsman of Colombia (DPC, 2002) found:

- *3.9.1. Damage to the food crops of the campesinos and indigenous people put their dietary safety at risk because, with the destruction of their yucca, plantain, corn and fruit tree crops, the population is not ensured a food supply that meets their nutritional needs.*

In DPC Resolution No. 28 (DPC, 2003), the Ombudsman acknowledged that "in addition to the fact that they have not proven effective in the fight against illegal drugs, the fumigations have favored the objective of fighting against crime, without harmonizing their consequences with other constitutional precepts." Against this background, in his study on the coffee growing region, he maintained that:

- *107. The application of the Program for Eradication of Illegal Crops with Glyphosate would aggravate the violations of the right to food and dietary safety as a result of the following effects of the program in question:*
  a. *the destruction of legal crops by the use of Glyphosate.*
  b. *the pollution of water sources and, therefore, effects on hydric resources*
  c. *the impacts on productive projects,*

whether intended to ensure a self-sufficient food supply (food crops[9], animal husbandry and fish farms, among others) or to create new income (long-term and diversification crops, such as fruit orchards).

d. The possible loss of credibility in the international market with regard to the quality of Colombian coffee.

In a special report on the spraying policy, the Office of the Auditor General of the Republic (Contraloría General de la República – CGR, 2001) concluded:

- *After verifying the evidence, and in keeping with an equitable and responsible approach, we find that an urgent change is needed in the strategy of chemical eradication of illegal crops that involves: stopping the fumigation with herbicides and implementing an alternative and coordinated strategy that must, among other things, be voluntary, manual, shared and gradual (...) Due to the current strategy's high environmental, social and economic costs, the CGR suggests creating an international inspectorate to actually verify and continuously assess the execution of these policies, as suggested by Resolution No. 04 of February 2001 from the Office of the Human Rights Ombudsman."*

The Office of the Auditor General of Colombia stated (Ossa, 2003):

- *"The cost of decreasing the coca, poppy and marijuana crops is extremely high in terms of the dignity of those who live in these regions, of the offenses committed against them and, naturally, a considerable, scandalous economic cost (...) there is collateral damage from the fumigation for the environment and the campesinos; otherwise, there would be no need for an environmental management plan (...) Here fumigation is done above any other consideration, violating the people's rights, trampling down the environment with impunity."*

In the 2005 report, the Office of the Auditor General of the Republic (CGR, 2005) recognizes that:

- *"spraying with glyphosate has been done without a license or an environmental management plan for 16 years (...) on the average, they have sprayed 22% more than the existing hectares of coca planted in the country (...) these aspects are very important when we consider the fact that parts of the country are subjected to double residual effects and repercussions because of the herbicide, with no certainty as the whether there is a low residual level of the herbicide in the soil, since the country does not have laboratories that can perform these analyses."*

A 2001 report by the police in Valle Guamués (department of Putumayo in southern Colombia on the Ecuadorian border) (Pabón, 2001) recognized that after the fumigations of 29,000 hectares of coca in

January and February of that year, over 4,420 hectares of other crops were affected (15.27% over what was planned for coca crops, was used on survival crops); charges were filed by 1,791 affected persons and there were confirmed losses of 96,222 dead or very sick animals.

In 2005, Senator Carlos Moreno Caro submitted an initiative to the Senate to use the 'coca eating' moth as a natural alternative in the eradication of illegal crops. The Bill, which was ultimately defeated and tabled, was unquestionably aimed at achieving a legal ban on the eradication with glyphosate of illegal crops. In fact, Article one ordered that eradication of illegal crops be done using "*alternative natural methods that do not entail harmful effects for the health of the population and ensure the preservation and equilibrium of the country's ecosystem.*"

Beyond how debatable the use of this type of moth for biological control of illegal crops would be from the environmental point of view, the preamble to the bill makes it clear that Senator Moreno Caro recognizes that aerial spraying has harmful effects on the health of the population and the ecosystem, while the 'coca-eating' moth supposedly does not; a presumption under which the author attempts – and this is stressed by those in charge of evaluating the bill – to eliminate the eradication of illegal crops by aerial spraying with glyphosate through a federal law.

Citing the study prepared for the Inter-American Commission for the Control of Drug Abuse (Comisión Interamericana para el Control de Abuso de Drogas - CICAD), those who were in charge of analyzing the Bill, Senators Rafael Pardo Rueda and María Isabel Cruz Velasco, argue that aerial spraying does not put either the health of the population or the ecosystem at risk. And they shrewdly add that if "the initiative understands alternative natural methods to be "*those that do not involve the use of chemicals which put health and the ecosystem at risk*" (paragraph in Article 1), then alternative natural methods could even include chemicals, but those that do not "*put health and the ecosystem at risk.*" Hence, they conclude, it would not be appropriate to legally prohibit the aerial spraying of illegal crops with glyphosate.

Reactions from International Organizations

Numerous international organizations have expressed their concern over the impacts:

The International Federation for Human Rights (IFHR, 2003), headquartered in Paris, has exhorted the Colombian Government, based on the precautionary principle, to halt aerial fumigations throughout Colombian territory and use other methods to fight against coca crops, given the devastating effects of spraying (with United States funds) on the people and the environment, and its ineffective results.

The American Medical Association (AMA, 2004) issued a resolution requesting that:

- "*Whereas, fumigation with the herbicide glyphosate, provided by the US company Monsanto, is reported to be reckless and inaccurate and is causing widespread illnesses, destroying pastures, destroying food crops, poisoning livestock, displacing thousands of small farmers, and killing birds, mammals, aquatic life, and natural plants (...) IT IS RESOLVED, that our American Medical Association issue a public statement requesting the immediate cessation of aerial herbicide spraying in the South American country of Colombia and its neighboring countries, until the health effects on the local populations are properly studied...*"

Professors from the University of Massachusetts (Massey et col., 2003) stated that the fumigation program in Colombia poses clear risks to human health and the environment, and that what is uncertain is the magnitude and specific nature of those risks. They recommend that spraying be halted.

The Center for International Policy (Isacson, 2003) has stated that, given the great number of complaints, the lack of certainty in the areas where spraying is used should not be an obstacle to halting it, based on the precautionary principle and the recognized damaging effects of the commercial formula of Roundup, which the company itself prints on the labels.

VIII. GENERAL CONCLUSIONS

1. The aerial spraying with an herbicide package used by the Colombian government since 2000 has been causing a series of environmental, agro-ecological, health and socio-economic problems in Ecuador's northern border region.

2. The broad spectrum herbicide package used in the aerial spraying on the Ecuador-Colombia border has several chemical compounds (glyphosate, POEA, Cosmoflux, etc.) which, alone or in combination, are responsible for part of the harmful effects on the sprayed region.

3. The herbicide package is part of a harmful system that, in addition to the chemical impacts, triggers terror, migration, breakdown of community supports, destruction of food sources and economic support, and impact on the biota and beneficial species.

4. The interpretation and analysis of the problems of aerial spraying done by the Colombian government and its technical experts are based on scientific criteria which are questionable from the current epistemological perspective. They favor argumentation based on quantifiable factual evidence and proof, reducing the range of observation to the element glyphosate and its drift, while discarding other empiric elements that serve as proof, such as the arguments and accounts of the communities, and even ignore national (from Colombian academic institutions themselves) and international studies that question the system of aerial spraying with the broad spectrum herbicide package (which includes glyphosate) because it is highly destructive to humans and the environment.

5. There is scientific, technical and methodological evidence which casts doubt on the CICAD report, used as a basis for justifying or prolonging aerial spraying with the herbicide package.

6. There are sufficient international studies which prove the harmful effect of aerial spraying systems of the type implemented, and of glyphosate itself and its agents. These also demonstrate the ecological damages at different levels: ecosystems and their interactions, plants, animals, microorganisms, cells, hormones, genes and chromosomes.

7. The scientific studies conducted in Ecuador on the impact of aerial spraying with the herbicide package confirm the damage done by this spraying in our territory. The evidence of this damage has been verified by several Ecuadorian governmental and academic institutions, and points to the hazards for crops, damage to animals, effects on the biodiversity and beneficial species, soil pollution and impact on physical and mental human health. Many of the damages have been immediately verified by official commissions, but some of them, involving long-term effects (cancers, fertility problems, deformity problems, ecosystem destruction, irreversible environmental changes, among others) will only be provable in the future, and are currently just becoming perceptible.

8. The aerial spraying problems have led to related phenomena such as migration, insecurity, diminished quality of life, disadvantages in obtaining food and housing, mental health problems in exposed individuals and social problems resulting from these phenomena.

9. The scientific and technical evidence of the hazards of aerial spraying with the herbicide package support the Ecuadorian position that this methodology should not be used due to the problems it creates, because it goes against all standards of respect for human rights, violates all standards of ethics and peaceful co-existence, and breaches the Precautionary Principle recognized by the highest-ranking multinational organizations: the United Nations, the World Health Organization, the International Human Rights Agency, and the Convention on Biological Diversity.

10. Based on all the arguments outlined above, the Ecuadorian Scientific-Technical Commission questions and objects to the use of the aerial spraying system with the herbicide package sprayed, which reaches Ecuadorian territory causing the harmful effects described, and recommends an immediate request that it stop.

11. The Ecuadorian Scientific Commission has systematized innumerable accounts of the different impacts that have been gathered in the affected regions, which require calling for compensation for the damages caused.

With all the facts outlined above, it is clear that aerial eradication affects the population, its physical and psychological health, and its legal crop economy, as well as the ecosystems. If the Colombian Government still persists in its policy of aerial spraying on its own people despite this, we repeat the request that the Government of Ecuador has made since July 2001, as a precautionary measure: that in order to safeguard the health and economy of the Ecuadorians living on the border, a buffer zone of at least 10 km be established from the border with Ecuador to inside Colombian territory, where illegal crops are not eradicated aerially, but using other eradication methods.

BIBLIOGRAFÍA

1. Abdel- Malle, A.Y., *et al.* (1994). Effect of glyphosate on fangal population, respiration and the decay of some organic matter in Egyptian soil. Microbiological Research 149: 69 – 73

2. Abdelghani, A.A. (1997). Toxicity evaluation of single and chemical mixtures of Roundup, Garlon-3A, 2,4-D, and Syndets surfactant to channel catfish (*Ictalurus punctatus),* bluegill sunfish (*Lepomis michochirus*), and crawfish (*Procambarus spp.*). Environmental toxicology and water quality. 12(3): 237-243

3. Acción Ecológica, (2001). "Reporte de la investigación de los impactos por las fumigaciones en la frontera ecuatoriana". Quito, Junio 2001.

4. ADUC (2003). Asociación Departamental de Usuarios Campesinos) et col. 2003. Informe de la Comisión de Verificación de las fumigaciones en el departamento de ARAUCA. Bogotá.

5. AIDA (2006). Programa de fumigación aérea del Plan Colombia – Análisis y crítica del informe del Departamento de Estado al Congreso de EE.UU. sobre el riesgo para los anfibios y especies amenazadas.

6. AMA, Resolución 420 (A-04). 30 de abril del 2004.

7. Andalo, V., *et al.* (2004). Compatibilidade de *Beauveria bassiana* com agrotóxicos visando o controle da cochonilha-da- raiz-do-cafeeiro *Dismicoccus texensis* Tinsley (Hemíptera: Pseudococcidae). Neutropical Entomology. 33(4): 463-467

8. Ashraf Haidari, M. (2007). Prohibition of Use of Fumigation (Glyphosate or Roundup) in Afghanistan. Washington: Official Memorandum of the Embassy of Afghanistan in the USA.

9. Asteraki, E. J., *et al.* (1992). The imoact of chemical removal of the hedge-base flora on the community structure of carabid beetles (COL., Carabidae) and spiders (Araneae) of the field and hedge bottom. Journal of Applied Entomology. 113: 398 – 406.

10. Astudillo, Y. *et al.* (2006). Análisis del daño al ADN por exposición a Glifosato. Libro de Resúmenes. XXX Jornadas de Biología, Quito. Genet: 04.

11. Austin, A. P. *et al.* (1991). Impact of an organophosphate herbicide (glyphosate) on periphyton communities developed in experimental streams. Bulletin of Environmental Contamination and Toxicology 47: 29-35

12. Barriga, R. (2001). Peces del Parque Nacional Yasuní. Pp. 139-142. En JP Jorgenson and M Coello Rodriguez (Eds.). Conservación y desarrollo sostenible del Parque Nacional Yasuní y su área de influencia. Memorias del Seminario-Taller 2001. Ministerio del Ambiente/UNESCO/Wildlife Conservation Society. Editorial SIMBIOE: Quito, Ecuador.

13. Bawa, K.S. y Hadley M. (1990). Reproductive Ecology of Tropical Forest. Plants Man and Biosphere Series. Volumen 7. UNESCO.

14. Bell, F. W. *et al.* (1997). Motor-manual, mechanical, and herbicide release affect early successional vegetation in northwestern Ontario. Forestry Chronicle 73.

15. Bellé, R. (2007). El Glifosato Formulado es el que Provoca las Primeras Etapas del Cáncer. Red de Acción en Plaguicidas en América Latina. http://webs.chasque.net/~rapaluy1/glifosato/Glifosato_cancer.html

16. Bezbaruah, B., *et al.* (1995). Effect of pesticides on most probable number of soil microbes from tea (*Camellia sinensis*) plantations and uncultivated land enumerated in enrichment media. India J. of Agric. Sciences 65(8): 578 – 583.

17. Bidwell, J.R. y Gorrie, J.R. (1995). Western Australia. Dept. of Environmental Protection. Acute toxicity of a herbicide to selected frog species. Final

report. Technical Series: 79 (9) Western Australian Dept. of Environmental Protection.

18. Bigwood, J. (2002). Breve Resumen de la Literatura Científica con Respecto a los Efectos Nocivos de Formulaciones Que Contienen Glifosato en Biotas Acuáticas y Suelos. Consultoría para el Ministerio del Ambiente, 6 de marzo. Quito.

19. Boada, C. (2006). El Ecuador biogeográfico. Ecuador Tierra Incógnita. No. 40.

20. Bode, R., *et al.* (1986). Comparative studies on the enzymological basis for growth inhibition by glyphosate in some yeast species. Biochemie Und Physiologie Der Pflanzer 181: 39-46

21. Breilh, J. (2004). Epidemiología Crítica. Editorial FIOCRUZ. Buenos Aires.

22. Bruce, P. (1996) Environmental Contaminants and Amphibians in Canada. Pesticides and Behaviour in Tadpoles. FROGLOG 16.

23. Brust, B.E. (1990). Direct and indirect effects of four herbicides on the activity of carabid beetles (Coleoptera: Carabidae). Pestic. Sci. 30: 309-320.

24. Cabrera, M.L. (2003). Informe a la Personería Municipal de Buesaco. Nariño.

25. Campaña, A.(2004). Misión de observación a los efectos del Plan Colombia en el Departamento de Nariño. Efectos sobre la Salud.

26. Campaña, A. (2005). Misión de observación a los efectos del Plan Colombia en el Cantón San Lorenzo. Efectos sobre la salud.

27. Castro, J. F., (2000). "Los cultivos ilícitos, política mundial y realidad en Colombia". Defensoría del Pueblo de Colombia. Bogota.

28. CCME (1989). Canadian water quality guidelines, Ottawa, Ontario. *Environment Canada.* Canadian Council of Ministers of the Environment.

29. CEDHU (2007). Reseña de los materiales que ha producido el Comité Interinstitucional contra las fumigaciones. http://www.cedhu.org/html/modules.php?name=Content&pa=showpage&pid=95

30. CEEA (2004). Comisión Ecuatoriana de Energía Atómica. Reporte de análisis de glifosato en agua. CEEA. Ecotoxicología. Quito.

31. CEEA (2004). Comisión Ecuatoriana de Energía Atómica (2004). Reporte de análisis de glifosato en sedimentos. CEEA. Ecotoxicología. Quito.

32. CGR (2001). Auditoría especial a la política de erradicación de cultivos ilícitos. Contraloría General de la República – Contraloría Delegada para el Medio Ambiente. Julio de 2001

33. CGR (2005). Plan Colombia: quinto informe de Evaluación. CGR. Bogotá

34. Chaim, A. (2004). Tecnologia de Aplicação de Agrotóxicos: Fatores que Afetam a Eficiência e o Impacto Ambiental. In: Silva CMMS e Fay EF. Agrotóxicos & Ambiente. Brasília. Embrapa, 289-317.

35. Chiverton P. A. and Sotherton N.W. (1991). The effects on beneficial arthropods of the exclusion of herbicides from cereal crop edges. Journal of Applied Ecology 28: 1027 – 1039.

36. CIF (2003). Amicus Curiae: Impactos en Ecuador de las fumigaciones a cultivos ilícitos en Colombia. CIF (Comité Interinstitucional sobre Fumigaciones). Quito.

37. CIF (2007). Entrevista realizada el 21 de febrero del 2007 en la DNE de Bogotá con el Sr. Alejandro Vélez (Director Encargado de la DNE y Elena Hani Jalam, Subdirectora de Asuntos Regionales y Erradicación de la DNE.

38. Claro, J. y Paganella, F. (2000). Roundup ou Glifosato: Agrotóxicos Que Asfetam a Vida. Sobradinho: Cámara Técnica para Atividades Agrossilvipastorais.

39. Comisión Científica Ecuatoriana. (2007). Evaluación del impacto de las aspersiones aéreas de febrero del 2007 sobre los habitantes de Mataje.

40. Comisión Interministerial. (2001). Informe Conjunto de la Comisión Interministerial a Lago Agrio. Ministerio de Salud, Ministerio de Ambiente, Ministerio de Defensa, OPS. Quito.

41. Coloma, L. (2005). Ecuador, Tierra de Sapos y Ranas. Ecuador Tierra Incognita No. 33.

42. Coloma, L. (1991). Anfibios del Ecuador: Lista de especies, ubicación altitudinal y referencias bibliográficas. Reportes Técnicos de EcoCiencia. Quito.

43. Comisión Científica Ecuatoriana (2007). Evaluación del impacto de las aspersiones aéreas de febrero del 2007 sobre la salud y el ambiente de los habitantes de Mataje. Febrero.

44. Commission on Social Determinants of Health (2005) Towards a Conceptual Framework for Analysis and Action on the Social Determinants of Health. Geneve: Discussion Paper for the Commission on Social Determinants of Health, May 2005

45. CONAIE, (2001) Informe Tecnico de la Comisión Internacional sobre los Impactos en Territorio Ecuatoriano de las Fumigaciones Aéreas en Colombia y Recomendaciones de las Organizaciones Indígenas, Campesinas y Sociales. CONAIE, Confeunasscc, FENOCIN, 19-22 de Julio del 2001

46. Constitución Política de la República de Colombia, Art. 80.

47. Constitución Política del Ecuador. 1998. (Art. 42).

48. Consejo de Europa, 98/256/CE: Decisión del Consejo de 16 de marzo de 1998 relativa a medidas de emergencia en materia de protección contra la encefalopatía espongiforme bovina y por la que se modifica la Decisión 94/474/CE.

49. Consejo de Europa 96/239/CE: Decisión del Consejo de 5 de mayo de 1998. Ver sentencia "Reino Unido/Comisión, pág. I-2265

50. Convenio sobre Diversidad Biológica (1992). Artículo 3.

51. Corte Interamericana de Derechos Humanos, La expresión "leyes" en el artículo 30 de la Convención Americana sobre Derechos Humanos, Opinión Consultiva OC-6/86 del 9 de mayo de 1986. Serie A No. 6, párr. 21.

52. Corte Interamericana de Derechos Humanos, Caso Velásquez Rodríguez Vs. Honduras, Sentencia de 29 de julio de 1988, Serie C No. 4, párr. 166.

53. Cosmoagro. (2004). Cosmo-Flux 411F, Coadyuvante de la aplicación de Agroquímicos. Lic. ICA 05.4-2186 – Colombia. Hoja Técnica 313.03. Mayo 30/94. Palmira.

54. Cox, C. (1991). Glyphosate Fact Sheet. Journal of Pesticide Reform 11(2).

55. Cox, C. (1995). Glyphosate, Part 2: Human Exposure and Ecological Effects. Journal of Pesticide Reform 15(4): 14-20.

56. Craye, Matthieu (2006). Reflexively Dealing with Uncertainty and Complexity in Policiy Related Knowledge. En: Interfaces Between Science and Society. Guimaraes, Guedes and Tognetti, Editores. Sheffield: Greenleaf Publishing, p. 54-63

57. Cummins, J. (2002). Acrylamide In Cooked Foods: The Glyphosate Connection, 1 August 2002. ISIS Report. http://www.i-sis.org.uk/acrylamide.php.

58. Cummins, J. (2007). The Mysterious Disappearance of Honey Bees. The Permaculture Archives. http://lists.ibiblio.org/pipermail/permaculture/2007-March/026349.html

59. D`Anieri, P., *et al.* (1987). Small mammals in glyphosate treated clearcuts in Northern Maine. Can Field Nat. 101 (4): 547 – 550.

60. Defensoría del Pueblo de Colombia DPC (2002). Las fumigaciones y los derechos humanos. Amicus Curiae. Defensoría del Pueblo. Bogota.

61. Defensoría del Pueblo de Colombia DPC, (2002). Derechos Humanos y Derecho Internacional Humanitario en el marco del conflicto armado y de las fumigaciones de los cultivos de coca en el departamento del Putumayo. Resolución Defensorial Nacional Nº 26. 9 de octubre. Bogotá. p. 25.

62. Defensoría del Pueblo de Colombia DPC, (2003). La crisis cafetera y las fumigaciones en el departamento de Caldas. Resolución Defensorial Nacional Nº 28. Caldas. p.22-23. 21 de mayo.

63. Dewar A.M., *et al.* (2000) Glyphosate applied to genetically modified herbicide-tolerant sugar beet and 'volunteer' potatoes reduces populations of potato cyst nematodes and the number and size daughter tubers. Ann. Appl-Biol. 136(3): 179-187.

64. Democracy Now (2006). Científicos de la EPA: El organismo aprueba pesticidas perjudiciales ante presión de la industria. 2 agosto de 2006.

65. Descalzo, R.C. *et al.* (1996). Identification and role of Pythium species as glyphosate synergists on bean (*Phaseolus vulgaris*) grown in different soils. Mycol Res. 100 (8): 971-978

66. Didhám, R.K. (2007). La Influencia de los Efectos del Borde y de la Fragmentación de Bosques en los Invertebrados de la Hojarasca en Amazonia Central. In Tropical Forest Remnants: Ecology, Management, and Conservation of Tropical Forest Remnants: Ecology, Management, and Conservation of Fragmented Communities. Editado por William F. Laurance y Richárd O. Bierregaard, Jr.

67. Dinham, B. (1999). "Life sciences" take over. En: Pesticides News 44: 7. The Pesticides Trust. PAN-Europe. London, UK.

68. Dirección Nacional de Estupefacientes (2007). Carta dirigida el 17 de enero del 2007 al Colectivo de Abogados José Alvear Restrepo con el nº 085 y

firmada por el Brigadier General Jorge Alirio Barón Leguizamon como Director Antinarcóticos.

69. Dood, J. C. y Jeffries, P. (1989) Effects of herbicides on tree vesicular-arbuscular fungi associated with winter wheat (*Triticum sativum* L). Biol. Fertl. Soils 7:113-119

70. Dos Santos M., J., *et col.* (2006). Efeitos do glifosato sobre microrganismos simbiotróficos de soja, em meio de cultura e casa de vegetação. Pesq. Agropc.bras. 41(2): 285 – 291.

71. Dunfield, K.E. y Germida, J., (2001). Diversity of bacterial communities in the rhizosphere and root interior of field-grown genetically modified *Brasica napus*. Microbiology Ecology 38: 1-9.

72. Eberbach, P.L. y Douglas, L.A. (1983). Persistente of glyphosate in sandy loam. Soil Biol. Biochem. 15(4).

73. Embera-Katío (2006)- Denuncia pública presentada por el Cabildo Embera del Alto San Jorge frente a la problemática ambiental generada por las fumigaciones de la policía antinarcóticos a las comunidades de Dochama (San Antonio y La Danta) en el alto Uré y Nejondó (San Juan Medio).

74. Environmental Protection Agency (1993). Glyphosate (CASRN 1071-83-6) Integrated Risk Information System. http://www.epa.gov/iris/subst/0057.htm

75. Environmental Protection Agency (1999). Technical Fact Sheets on: Glyphosate. National Primary Drinking Water Regulations.

76. Evans, D.D. y Batty, M.J. (1986). Effects of high dietary concentrations of glyphosate (Roundup) on a species of bird, marsupial and rodent indigenous to Australia. Environmental Toxicology and Chemistry 5: 399-401

77. Farm Chemicals Handbook, (1990). Meister Publishing Co. Willoughby, USA

78. FIDH (2003). Comunicado de prensa: la FIDH a favor de la suspensión de las fumigaciones

79. Folmar, L.C. *et al.* (1979). Toxicity of the Herbicide Glyphosate and several of its formulations on fish and aquatic invertebrates. Arch. Environ. Contam. Toxicol. 8: 269-278

80. Forestry Commission (1991). Ash dieback. Bulletin 93. HMSO. London. Reportado en ENDS Report: 193, 1991.

81. Forlani G. *et al.* (1995). Differential sensitivity of plant-associated bacteria to sulfonylurea and imidazonline herbicides. *Plant and Soil.* 176: 243-253.

82. Freed, K. (1989) "Anti-drug Effort Sows Bad Blood; Guatemala: Farmers Complain That Legitimate Crops Are Being Damaged by a U.S. Spraying Program Designed to Cut into Heroin Production." Los Angeles Times, October 15, 1989, Sunday, Home Edition

83. Fundación Santa Fe de Bogotá. Sitio web.Visitado el 11 de marzo del 2007. www.fsfb.org.co/cms/

84. Funtowicz, S. y Ravetz, J.R. (1994). The worth of a songbird - ecological economics as a post-normal science. Ecological Economics 10: 197-207

85. Funtowicz, S. y Ravetz, J. (1990). Uncertainty and Quality in Science for Policy. Dordrecht: Kluwer Academic Publishers.

86. Funtowicz, S. y Ravetz, J.R. (2000) Ciencia con la gente. La ciencia posnormal, Editorial Icaria, Barcelona.

87. Guimaraes, A., Guedes, S. y Tognetti, S. (2006). Interfaces Between Science and Society. Sheffield: Greenleaf Publishing.

88. Giolo, F.P. *et al.* (2005). Selectividade de formulações de ghyphosate a *Trichogramma pretiosum* (Hymenoptera: Trichogrammatidae). Planta Daninha, 23(3): 457-462.

89. Griffith, G., *et al.* (1993). Autecology and Evolution of the Witches' Broom Pathogen (*Crinipellis perniciosa*) of Cocoa. In: Ecology of Plant Pathogens.

90. Groot, H. *et al.* (2005). Glifosato: Riesgo Humano? Hipótesis. Apuntes Científicos Uniandinos, Diciembre No 6.

91. Gerritse, Beltrán y Hernández, (1996). Adsorption of atrazine, simazine, and glyphosate in soils of the Gnangara Mound, Western Australia. Aust. J. Soil Res. 34: 599-607.

92. Haney, R.L. *et al.* (1999). Effect of glyphosate on soil microbial activity. Proc-S-Weed-Sci-Soc. 52: 215.

93. Hartman, W.A. y Martin, D.B. (1984). Effect of suspended bentonite clay on the acute toxicity of glyphosate to *Daphnia pulex* and *Lemna minor.* Bull. Environ. Contam. Toxicol. 33: 355-361

94. Hassan, S. A. *et al.* (1988). Results of the Fourth Joint Pesticida Testing Programme carried out by the Internacional Organization for Biological Control / WPRS – Working Group "Pesticides and Beneficial Organisms". Journal of Applied Entomology 105: 321 – 329

95. Hotakainen, R. (2000) "Colombian Police Spray Herbicide on Coca, Wellstone," Minneapolis STAR TRIBUNE December 1, 2000. Available at http://webserv5.startribune.com/stOnLine/cgi-bin/article?thisSlug=WELL01&date=01-Dec-2000&tword=hotakainen

96. Hutchinson, G.I. (1995). Nitrogen Cycle Interactions with Global Change Processes. In Niertenberg, W.I. Encyclopedia of Environmental Biology. San Diego, Academic Press. Volume 2: 583-587.

97. INAMHI (2006). Comportamiento Del Viento En La Zona Fronteriza Ecuador – Colombia. Instituto Nacional De Meteorologia E Hidrologia, Direccion Gestión Meteorologica, Estudios E Investigaciones Meteorologicas. 19 de diciembre.

98. Instituto Nacional de Investigaciones Agropecuarias, (2007). Manejo integrado de malezas en cultivo de arroz. En: Manual de arroz. INIAP

99. Isacson, A. (2002). Cumplimiento con las Condiciones de Fumigación en la Iniciativa Antidrogas Andina. Center for International Policy.

100. Isacson, A. (2003) Carta al Consejo de Estado de Colombia por Acción Popular Fumigaciones del Plan Colombia. Suscrita por 9 de septiembre del 2003.

101. Jave, O. (2001). *Fusarium oxysporum*. La micosis emergente. En: El uso de armas biológicas en la guerra contra las drogas. Memorias de la conferencia. Ed. Gallardo, L., *et al*. Quito.

102. Janofsky. (2006). Unions Say E.P.A. Bends to Political Pressure, New York Times, 2 de agosto de 2006.

103. Joensen, L. y Semino, S. (2004). OMGs en Argentina ¿a qué precio?. Estudio de Caso del Impacto de la Soja Modificada Genéticamente del Grupo de Reflexión Rural de Argentina. Informe publicado por Econexus y The GAIA Foundation. Londres.

104. Johal, G.S., *et al*. (1984). Effect of soilborne plant-pathogenic fungi on the herbicidal action of glyphosate on bean seedlings. Phytopathology 74(8): 950-955

105. Junior, P.T. Z. y Zambolin, L. (1994). Efeito de fungicidas e de herbicidas sobre a microrrrización de *Eucaplytus grandis* por *Glomus etunicatum*. Fitopatol. Bras. (19) 2: 173-177.

106. Kaczewer, J. (2002). Toxicología del Glifosato: Riesgos para la salud humana, 15 enero del 2007: http://www.mamacoca.org/FSMT_sept_2003/es/doc/kaczewer_toxicologia_del_glifosato_es.htm

107. Kapos, V., *et col*. (1997). Cambios Relacionados al Efecto del Borde en el Ambiente y en las Respuestas de Plantas, como consecuencia de la Frag-

mentación del Bosque en la Amazonia Central. En: Tropical Forest Remnants: Ecology, Management, and Conservation of Tropical Forest Remnants: Ecology, Management, and Conservation of Fragmented Communities. Editado por William F. Laurance y Richard O. Bierregaard, Jr.

108. Kjær, J. *et al.* (2003). The Danish Pesticide Leaching Assessment Programme (PLAP). Monitoring results May 1999 - June 2002. Third report.

109. Kremer, R.J. and Donald, P. (2003) Herbicide impact on *Fusarium spp.* and soybean cyst nematode in gliphosate tolerant soybean. American Society of Agronomy (573) 882-2716.

110. La Hora, Confirman fumigación con hongo, 23 de agosto del 2000. Quito.

111. Ley Orgánica del Sistema Nacional de Salud (2002) y su Reglamento (2003). Art. 3.

112. Lacera-Rúa, A. (2000). Enfermedades asociadas con aspersión aérea de agroquímicos en áreas de cultivos ilícitos. Universidad de Magdalena. Santa Marta. Colombia.

113. Legarth Schmidt, A. (2003) Poisonous Spray on a Course Towards Drinking Water. Politken, Denmark.

114. Costa, M. D.L. *et al.* (2003). Alterações de neuroimagem no parkinsonismo: estudo de cinco casos. Arq. Neuro-Psiquiatr. 61: 2B. São Paulo, Brazil

115. Leiva, P.D. (2007). Calidad de aplicación de plaguicidas. I Jornada de Control Químico de enfermedades del Trigo. Centro Internacional de Capacitación INTA –CIMMYT. http://www.argenpapa.com.ar/img/Calidad%20aplicaci%C3%B3n%20agqcos..pdf CDRom interactivo Bayer – División Agrícola.

116. Levesque, C.A., *et al.* (1992). The effect of soil heat treatment and microflora on the efficacy of glyphosate in seedlings. Leed Res. 32 (5): 363-373.

117. Levesque, C.A., *et al.* (1993). Pathogenicity and DNA restriction fragment length polymorphisms of isolates of *Pythium* spp. from glyphosate-treated seedlings. Mycol Res 97 (3): 307-312.

118. Levesque, C.A., *et al.* (1993). Fungal colonization of glyphosate-treated seedlings using a new root plating technique. Mycol Res 97 (3): 299-306.

119. Levidow, L. (2004): Sound Science as Ideology. In Science, Technology and Innovation, http://www.cid.harvard.edu/cidbiotech/comment/comment91.htm

120. MacKinnon, D. S. y Freedman, B. (1993). Effects of silvicultural use of the herbicide glyphosate on breeding birds of regenerating clearcuts in Nova Scotia, Canada. Journal of Applied Ecology 30: 395-406

121. Maldonado, A. *et col.* (2001). Reporte de Acción Ecológica sobre la Investigación de Impactos de las Fumigaciones en la Frontera Ecuatoriana. Acción Ecológica. Quito.

122. Maldonado, A., *et al.* (2002) Segundo informe Misión de Verificación "Impactos en Ecuador de las fumigaciones realizadas en el Putumayo dentro del Plan Colombia". Acción Ecológica. Quito.

123. Maldonado, A., *et al.* (2006) Estado de la Nutrición en Escuelas Ecuatorianas de la Frontera Norte Afectadas Por las Aspersiones Aéreas del Plan Colombia. Quito. Acción Ecológica, IETM, CIF. Quito.

124. Mann, R.M., *et al.* (2004). The Toxicity of Glyphosate and Several Glyphosate Formulations to Four Species of Southwestern Australian Frogs. Archives of Environmental Contamination and Toxicology 36 (2).

125. Mañas-Torres, F. *et al.*, (2006) La genotoxicidad del herbicida Glifosato evaluada por el ensayo cometa y por la formación de micronúcleos en ratones tratados. Theroria 15(2):53-60

126. Marassas, W.F.O., *et al.* (1984). Toxigenic *Fusarium* species: Identity and Mycotoxicology. Pennsylvania State University Press.

127. Marc, J., *et al.* (2004a). Formulated glyphosate activates the DNA-response checkpoint of the cell cycle leading to the prevention of G2/M transition. Toxicological Science 82:436-442.

128. Marc, J,. *et al.* (2004b) Glyphosate-based pesticides affect cell cycle regulation. Biology on the Cell 96:245-249.

129. Marmot, M. (2005). Social Determinants of Health. Ed. Michael Marmot and Richard Wilkinson. Oxford: Oxford University Press.

130. Marrs, Williams, Frost y Plant. (1989) Effects of herbicides on higher plant. In *Pesticide drift and impact* (ed. B.N.K. Davis), pp. 5-27. NERC contract report to Nature Conservancy Council/Department of Environment). NERC, Swindon.

131. Massey, R., *et col.* (2003). Amicus Curiae desde Estados Unidos. Plicación del Principio de Precaución al Programa de Fumigación en Colombia. Declaración ante el Consejo de Estado, Bogotá, Colombia. 18 de septiembre del 2003.

132. Mekwatanakarn, P. y Silvassithamparam, K. (1987), Effect of certain herbicides on soil microbial populations and their influence on saprophytic growth in soil and pathogenicity of take-all fungus. Biol. Fertil. Soils 5: 75 – 180.

133. Messina J.P. y Delamater, P.L. (2006). Defoliation and the war on drugs in Putumayo, Colombia. International Journal of Remote Sensing. 27(1)121 -128.

134. Mestanza, V. (2002). Carta dirigida al Ing. Roger Mera, Jefe Regional en Sucumbíos del Ministerio del Ambiente. 14 de octubre del 2002

135. Minard, A. (2007). Plaguicidas flotan desde fincas distantes a bosques protegidos, según estudio en Costa Rica. National Geographic News. http://infoagro.net/es/apps/news/record_view.cfm?vsys=a2&tid=12823

136. Monqueiro, P. A., *et al.* (2003). Dinâmica do banco de sementes em áreas com aplicação freqüente do herbicida glyphosate. *Planta Daninha* 21(1): 63-69.

137. Monroy, C.M. *et al.* (2005). Cytotoxicity and genotoxicity of human cells exponed in Vitro to glyphosate. Biomedica 25(3):335-345

138. Monsanto (2005). Summary of the Health Risk Assesssment and Safety Evaluation on Glyphosate and Roundup Herbicides. Updated on May 2005.

139. Morillo, Undabeytia y Maqueda (1997) Adsorption of Glyphosate on the Clay Mineral Montmorillonite: Effect of Cu(II) in Solution and Adsorbed on the Mineral. Environ. Sci. Technol.

140. Naranjo, C. (2006). Comportamiento del Viento en la Zona Fronteriza Ecuador – Colombia. Quito: Dirección de Gestión Meteorológica, Instituto Nacional de Meteorología e Hidrología (INAMHI).

141. Nemoto, M. C., *et al.* (2002). Germinação de canídeas y crescimento micelial de *Bipolartis euphorbiae* influenciados por herbicidas e surfactantes. Brasil. Journal of Microbiol. 33: 352-357.

142. Neskovic N.K., *et al.* (1996). Biochemical and histopathological effects of glyphosate on carp, Cyprinus carpio L. Bull. Environm. Contam Toxicol. 5: 259 – 302.

143. New Herald, Washington experimenta en Ecuador con un hongo peligroso. 17 de julio del 2000. Miami.

144. New York Medical Collegue. Office of Research Administration. Technology Development & Industry Sponsored Research. Visitado el 11 de marzo del 2007. www.nymc.edu

145. Newell D.W., Barth A., Ricciardi T.N., Malouf A.T. (1997). Glycine causes increased excitability and neurotoxicity by activation of NMDA receptors in the hipocampus. Exp. Neurol. 145: 235-244.

146. Nivia, E. (1999). Efectos sobre la salud y el ambiente de herbicidas que contienen glifosato. Seminario-Taller "Medio ambiente, cultivos ilícitos y desarrollo alternativo: Herramientas para la evaluación y la toma de decisiones". 1 y 2 de julio. Bogotá.

147. Nivia, E., (2001a) Efectos sobre la salud y el ambiente de herbicidas que contienen glifosato. Boletín electrónico de la UITA. http://www.rel-uita.org/Agrotoxicos

148. Nivia, E. (2001b). Las fumigaciones aéreas sobre cultivos ilícitos si son peligrosas – Algunas aproximaciones. Ponencia presentada en: Conferencia "Las Guerras en Colombia: Drogas, Armas y Petróleo". Instituto Hemisférico de las Américas - Universidad de California, Davis, Mayo 17-19.

149. Nivia, E. (2002). Evaluando las fumigaciones con ciencia, conciencia y corazón. Ponencia presentada en: Foro Internacional: 3 de diciembre, Día Mundial del no uso de Plaguicidas. Bogotá – Colombia.

150. ONIC (2007). Fumigaciones y pueblos indígenas. Ponencia presentada en: Preaudiencia del Tribunal Permanente de los Pueblos. 22 de febrero del. Medellín.

151. Ordoñez, J. Carta a Acción Ecológica. Septiembre 2002.

152. Organizaciones Ecuatorianas (2007). Informe Misión de Verificación "Impactos en Ecuador de las fumigaciones realizadas en el Putumayo dentro del Plan Colombia": http://derechos.ecoportal.net/content/view/full/21564

153. Ossa Escobar, C. (2003). Informe de la Contraloría General de la República sobre el Plan Colombia. Recogido en Plan Colombia Hoy: Seminario internacional "Plan Colombia-No, impactos de la intervención". Edit. Colectivo de Abogados José Alvear Restrepo. Noviembre. Bogotá.

154. Pabón, A. (2001). Consolidado general de las pérdidas por la fumigación hasta el 31 de enero de 2001. Municipio Valle del Guamués. Inspección de Policía Municipal.

155. Panus, D.P. (1980). Vesicular-Arbuscular Mycorrhizae Affect Lowland Tropical Rain Forest Plant Growth. Ecology 61(1): 151-162

156. Pazmiño, J.L. (2003). Laboratorio de Suelos, Aguas y Plantas del Vicariato Apostólico de Aguarico -Francisco de Orellana- Informe 1923

157. Paz-y-Miño, C. *et al.* (2000). Monitoreo citogenético en población ecuatoriana expuesta ocupacionalmente a pesticidas. Rev. Fac. Cs. Med. 25(1):15-21

158. Paz-y-Miño, C. *et al.* (2002). Cytogenetic Monitoring in a population occupationally exponed to pesticidas in Ecuador. Environ Health Pespect 110:1077-1080

159. Paz-y-Miño, C. *et al.* (2002). Genética Toxicológica y Carcinogénesis. PUCE-FUNDACYT. Quito

160. Paz-y-Miño, C. *et al.* (2002). Should gaps be included in chromosomal aberration análisis? Evidence based on the comet assay. Mutation Research 516:57-61.

161. Paz-y-Miño, C., *et al.* (2004). Chromosome and DNA damage analysis in individuals occupationally exposed to pesticides with relation to genetic polymorphism for CYP 1ª1 gene in Ecuador. Mutation Research 8:562(1-2):77-89

162. Paz-y-Miño, C., *et al.* (2005). Chromosomal aberration, comet assay and CYP 1A1 gen evaluation in individually exposed to 27 kinds of pesticides and glyphosate in Ecuador, South America. Pacific Basin Consortium Conference. Pesticides an Human Health. Abstracts Book, Honolulu.

163. Paz-y-Miño, C., *et. al.* (2007) Evaluation of choromosome and DNA damage related to glyphosate mixture exposure in Ecuadorian population. Genetics and Molecular Biology (in press MS2006/100).

164. Paz-y-Miño, C. et al (2007) Efecto del Glifosato en diversas concentraciones sobre cultivos de linfocitos humanos de sangre periférica. Informe del Proyecto Daños genéticos por glifosato. PUCE. Quito.

165. Pérez, H. (s.f.). Manual de Técnicas de Aplicación. Principios y fundamentos, Syngenta. Colombia.

166. 166. Peterson H.G., *et al.* (1994). Aquatic phyto-toxicity of 23 pesticides applied at expected environmental concentrations. Aquatic Toxicology 28(3-4): 275- 292

167. Piccolo, A.; Celano, G.; Arienzo, M.; Mirabella, A.; J. (1994) Adsoption and desorption of glyphosate in some european soils. Environ. Sci. Health, Part B 1994, 29, 1105.

168. Pimiento, S. (2001). El uso de armas biológicas en la erradicación de cultivos y el Convenio sobre Diversidad Biológica. En: El uso de armas biológicas en la guerra contra las drogas. Memorias de la conferencia. Ed. Gallardo, L., *et al.* Quito.

169. Pinzón, C.A. (2003). Recurso de Apelación a la Sentencia de junio 13 de 2003, por el Tribunal Administrativo de Cundinamarca a la Acción Popular Nº 01-022 presentada por Claudia San Pedro y Otros, contra el Ministerio del Medio Ambiente y la Dirección Nacional de Estupefacientes y fallada por la Dra. Ayda Vides Paba.

170. Plataforma Interamericana de Derechos Humanos, Democracia y Desarrollo (2007). Informe publicado en sitio web. http://www.pidhdd.org/article.php3?id_article=248

171. Plazas, L. A. (2004). Oficio Nº CMFS-46-2004 Rad. DNE E-2004-19728DE 23/03/04 dirigida al Dr. Juan Carlos Palacios Burneo como Presidente de la Comisión Científico Técnica Ecuatoriana con fecha 14 de abril del 2004 y firmada como Director de la Dirección Nacional de Estupefacientes.

172. Potts G.R. y Vickerman G.P. (1994). Studies of the cereal ecosystem. Advances in Ecological Research 8: 107 – 197

173. Prata, F., *et al.* (2003). Glyphosate Sorption and Desorption in Soils with Distinct Phosphorus Levels. Scientia Agricola 60(1): 175 – 180.

174. Puyana, A.M. (2007). Fumigaciones químicas como estrategia anti narcóticos en Colombia: tres décadas de perversidad e ineficacia. Ponencia de la autora en la Preaudiencia sobre biodiversidad, fumigaciones y militarización en Colombia. Medellín.

175. Rahe, J.E., *et al.* (1997). Synergistic role of soil fungi in the herbicidal efficacy of glyphosate. A-C-S-Symp-Ser-Am-Chem-Soc. (439): 260-275

176. Relyea, R. (2005). The Impact of Insecticides and Herbicides on the Biodiversity and Productivity of Aquatic Communities. Journal Ecological Applications.

177. Richard, S. *et al.* (2005). Differential effects of Glyphosate and Roundup on human placental cells and aromatase. Environ Health Perspect 113: 716-720.

178. Richie, D.C., *et al.* (1987). Glyphosae treatment and deer mice in clearcut and forest. Northwest Sci. 61(3): 199 – 202.

179. Rizzardi, M. A., *et al.* (2003). Ação de herbicidas sobre mecanismos de defesa das plantas aos patogenos. Ciência Rural. 33(5):957-965.

180. Rodríguez, E. (2003). Sierra Nevada, significado de la hoja de coca, fumigaciones y situación del pueblo Kankuamo. Recogido en Plan Colombia Hoy. En: Seminario internacional "Plan Colombia-No, impactos de la intervención". Edit. Colectivo de Abogados José Alvear Restrepo. Noviembre. Bogotá.

181. Sanogo, S., *et al.* (2000). Effects of herbicides on Fusarium solani f. sp. glycines and development of sudden death syndrome in glyphosate-tolerant soybean. Phytopathology 90 (1): 57-66.

182. Santillo, D. J., *et al.* (1989). Response of songbirds to glyphosate-induced habitat changes on clearcuts. J. Wildl. Manage. 53:64-71.

183. Santos, A. y Flores, M. (1995) Effects of glyphosate on nitrogen-fixing of free living heterotrophic bacteria. Letters in Applied Microbiology 20(6): 349 – 352.

184. Sedell, J.R., *et al.* (1989). The River Continuum Concept: A Basis for Expected Ecosystem Behavior of Large Rivers?. Can. Spec. Publ. Fish. Aquat. Sciences 106: 49 – 55.

185. Sicard, T.L., Burgos J., Toro, C., Luengas, C., Ruiz, C., Romero, C.P. (2005). Observaciones al "Estudio de los efectos del programa de erradicación de cultivos ilícitos mediante aspersión con herbicida Glifosato (PECIG) y de los cultivos ilicitos en la salud humana y e http://www.idea.unal.edu.co/public/docs/Observ_IDEA_a_doc_CICAD.pdf

186. Smiley, R.W. (1992). Influence of glyphosate on *Rhizoctonia* root rot, growth, and yield of barley. Plant Dis 76: 937 – 942

187. Solomon, K., *et al.* (2005). Estudios de los Efectos del Programa de Erradicación de Cultivos Ilícitos Mediante la Aspersión Aérea con el Herbicida Glifosato (PECIG) y de los Cultivos Ilícitos en la Salud Humana y en el Medio Ambiente. Washington: CICAD, División de la Organización de los Estados Americanos (OEA), 31 de marzo.

188. Souza, I.F. (1982). Comportamento dos herbicidas no solo. Informe Agropecuario 87: 38-44.

189. Sparling, D.W., *et al.* (2006). Toxicity of glyphosate as Glypro and LI700 to red-eared slider (*Trachemys scripta elegans*) embryos and early hatchlings. Environmental Toxicology and Chemistry 25 (10): 2768-74.

190. Springett J. A. y Gray R.A.J. (1992). Effect of repeated low doses of biocides on the earthworm *Aporrectodea caliginosa* in laboratory culture. Soil. Biol. Biochem 24 (12):1739-1744.

191. St. Clair, Jeffrey. (2002). The Drug War According to Dr. Mengele. Agent Green Over the Andes. December 24, 2002.

192. Stavenhagen (2005). Sobre su misión a Colombia (8-12 de marzo de 2004). E/CN.4/2005/88/Add.2. 10 de noviembre.

193. Stavenhagen (2006). Informe del Relator Especial sobre la situación de los derechos humanos y las libertades fundamentales de los indígenas, Sr. Rodolfo Stavenhagen. Misión a Ecuador: A/HRC/4/32/Add.2. 28 de diciembre de 2006.

194. Stephen M., *et col.* (1997). Efecto del borde y del Aspecto del borde en el Microclima de un Bosque Fragmentado en Atherton, Tableland, Nor-Este de Australia. En: Tropical Forest Remnants: Ecology, Management, and Conservation of Tropical Forest Remnants: Ecology, Management, and Conservation of Fragmented Communities. Editado por William F. Laurance y Richard O. Bierregaard, Jr.

195. Suárez, L. y Ulloa, R. (1993). La Diversidad Biológica del Ecuador. En : La investigación para la conservación de la diversidad biológica del Ecuador. P.A. Mena y L. Suárez (Eds) EcoCiencia. Quito.

196. Supliguicha, V., *et col.* (2006). Consecuencias psicológicas en niños y niñas del cordón fronterizo afectados directamente por el conflicto del Plan Colombia: Escuelas: Leonidas Plaza, Cinco de Agosto, y Manuelita Sáenz GIA-MB

197. Tate T.M., *et al.* (1997). Effect of Glyphosate on the Development of Pseudo-succinea columella snail. Arch. Environ. Contam. Toxicol. 33: 286 – 289.

198. Tirira, D. (1999). Mamíferos del Ecuador. Publicación Especial 2. PUCE. Quito.

199. Tribunal Constitucional del Ecuador, Caso No. 0371-04-RA.

200. Tribunal Constitucional, Resolución del 15 de marzo de 2005, Caso No. 0371-04-RA.

201. Tuffi Santos, L. D., *et al.* (2005). Exsudação radicular do glyphosate por Brachiaria decimbens e seus efeitos em plantas de eucalipto e na respiração microbiana do solo. Planta Daninha. 23(1):143-152

202. Unicamp. (2001). Glifosato: Herbicida, Mas ñao Só. 13 de septiembre del 2001. www.boasaude.com

203. Velasco, J.M. (1971) El Código de Salud. Quito

204. Velasco, V. (2002). Oficio Nº 511-GS-2002, dirigida a Lourdes Luque, Ministra del Ambiente, con fecha 16 de octubre del 2002.

205. Victoria, R. L., *et al.* (2004). Biogeochemistry of the Amazon River Basin: the role of aquatic ecosystems in the Amazon functioning. Smithsonian/NASA ADS Physics Abstract Service

206. Vides, A. (2003). "Claudia Sanpedro y otros". Sentencia Tribunal Administrativo de Cundinamarca en el expediente Nº 02-022, 13/junio/2003

207. Von Weizsäcker, C. (2006). Precaution Goes Without Saying, but Comes with Controversies Opening. Presentation Vienna: Expert Conference "The Role of Precaution in GMO Policy" initiated jointly by the Austrian Federal Ministries, of Agriculture, Forestry, the Environment and Water Management and of Health and Women within the framework of the Autrian EU-Presidency. Hofburg, 18 – 19 April.

208. Wan, M.T. (1989) Effects of different dilution water types on the acute toxicity to juvenile Pacific salmonids and rainbow trout of glyphosate and its formulated products. Bulletin of environmental contamination and toxicology. 43 (3): 378-385

209. Wan, M.T. (1991). Acute toxicity to juvenile Pacific Northwest salmonids of Basacid Blue NB755 and its mixture with formulated products of 2,4-D, glyphosate, and triclopyr. Bulletin of Environmental Contamination and Toxicology. 47(3): 471-478

210. Wan, M. T., *et al.* (1998). A New Technique for Determining the Sublethal Toxicity of pesticides to the Vesicular-Arbuscular Mycorrhizal Fungus *Glomus intrardices.* Environmental Toxicology and Chemistry 17(7): 1421 - 1428

211. Williams, J. (2003). Entrevista grabada como representante de la Embajada de los EEUU en Bogotá y publicada en el documental "Plan Colombia: Guerra Anti-Drogas o Pro-Petróleo" distribuída por Free-will Productions y firmada por Ungerman, G. y Brío, A.

212. World Helath Organization. (2005). Glyphosate and AMPA in drinking-water. WHO/WSH/03.04/97

213. Wynne, B. (1992). Uncertainty and Environmental Learning: Reconceiving Science and Policy in the Preventive Paradigm. Global Environmental Change. 2.2: III-27

214. Wynne, B. (2001) Managing Scientific Uncertainty in Public Policy. Cambridge: Presented at Biotechnology and Global Governance: Crisis and Opportunity. April. www.cid.harvard.ecu/cidbiotech/comments91 visitado en marzo 2007.

215. Yousef, M.I., *et al.* (1995). Toxic effects of carbofuran and glyphosate on semen characteristics in rabbits. J. Environ. Sci. Health B 30: 513-34.

216. Zablotowicz, R.M. y Reddy, K. N. (2004). Impact of Glyphosate on the *Bradyrhizobium japonicum* Simbiosis with Glyphosate-Resistant Transgenic Soybean: A Mini review. J. Environ. Qual. 33: 825–831.

OTRA BIBLIOGRAFÍA CONSULTADA

217. Agencia Nacional de Vigilancia Sanitaria (2005). Relatorio do Seminario Nacional Sobre Agrotóxicos, Saude e Ambiente em Brasil. Pernambuco: octubre 6 e 7.

218. Arbuckle, T.E. *et al.* (2001). An exploratory analysis of the effect of pesticide exposure on the risk of spontaneous abortion in an Ontario farm population. Environ Healt Perspect. 109:851-857.

219. Burger, M. y Fernández, S. (2004). Exposición al herbicida glifosato: aspectos clínico toxicológicos. Rev Med Uruguay 20:202-207.

220. Carlisle, S. M. y J. T. Trevors (1988) Glyphosate in the environment. Water, Air Soil Pollut. 39:409-420.

221. Comunidad Andina. (2000) Autoridades ambientales rechazan utilización del hongo *Fusarium oxysporum* en territorio de Comunidad Andina. Notas de prensa.

222. De Roos, A. J. *et al.* (2005). Cancer incidence among Glyphosate-exposed pesticide applicators in the agricultural health study. Environ Health Perspect 113:49-54.

223. Departamento de Salud y Servicios para personas mayores de New Jersey (2003). Hoja Informativa sobre Substancias Peligrosas: Isopropilamina.

224. Gamboa, E.N. *et al.* (2005). Efectos toxicos causados por la exposicion al glifosato en roedores tipo hamster. Universidad Industrial de Santander. Facultad de Salud. Bucaramanga.

225. Garcés, E. *et al.*, (2001) Fusarium oxysporum, el hongo que nos falta conocer. Acta Biológica Colombiana.

226. Garry, V.F. *et al.* (2002). Birth Defects, season of Conception, and sex of children born to pesticide applicators living in the Red River Valley of Minnesota, USA. Environ Health Perspect 110 (3):441-449.

227. Ho, M.W. (1997) The Unholy Alliance. The Ecologist 27(4)

228. Hua-Van, A., *et al.* (1998). Three highly divergent subfamilies of the impala transposable element coexist in the genome of the fungus *Fusarium oxysporum* Mol. Gen Genet. 259: 354-62.

229. Hua-Van, A., *et al.*, (2000) Genome organization in *Fusarium oxysporum:* clusters of class II transposons. Curr Genet 37: 339-47

230. Julie, M., *et al.* (2004). Formulated Glyphosate Activates the DNA-Response Checkpoint of the Cell Cycle Leading to the Prevention of G2/M Transition. Toxicological Sciences 82: 436-442, September 16.

231. Kale, P.G., *et al.* (1995). Mutagenicity testing of nine herbicides and pesticides currently used in agriculture. Environ Mol Mutagen 25(2):148-153.

232. Kastan, M.B. y Bartek, J. (2004). Cell-cycle checkpoints and cancer. Nature 432:316-323

233. King, C.A. (2001). Plant growth and nitrogenase activity of glyphosate-tolerant soybean in response to foliar glyphosate applications. Agronomy Journal 93: 179-186.

234. Kissmann, K. (1997). Adjuvantes para caldos de produtos fitosanitarios. XXI Congresso Brasileiro para o Controle de Plantas Daninhas. Caxambu-Mg.

235. Kistler, H.C. (1997). Genetic diversity in the plant-pathogenic fungus Fusarium oxysporum. Phytopathology 87:474-479.

236. Marc, J. *et al* (2005) A glyphosate-based pesticide impindes on transcription. Toxicol Appl Phramacol 203(15):1-8.

237. Ministerio del Ambiente *et al.*, (2003). Misión de Verificación: Impactos en el Ecuador de las fumigaciones realizadas en el Departamento del Putumayo dentro del Plan Colombia. Art. 16.

238. Monsanto Europe SA (2004). Ficha de Datos de Seguridad Producto Comercial: http://www.monsanto.es/monsantoes/FUSTA%2004.rtf

239. Montemayor, C. (2006). Universidad pública y privatización del conocimiento. La Jornada 20/12/06.

240. Nivia, E. (2004). Ecosistemas colombianos en peligro por cultivos de uso ilícito y estrategias de fumigación. Boletín de Ecofondo (25):19-25.

241. Rippon JW. (1988). Medical Mycology. 3rd ed. W.B.Saunders Co., Philadelphia, pp. 797.

242. Rodrigues, N. B., *et col.* (1998). Guía de Herbicidas. 4ª Ed.

243. Romo, L.A. (2006) Fumigaciones aéreas de plantaciones ilícitas. Ciencia y Tecnología 5(1): 65-72

244. Sanderson, J.B., *et al.* (1999). Glyphosate application and timing of tillage of red clover affects potato response to N, soil N profile, and root and soil nematodes. Can Journal Soil Sci. Ottawa. 79 (1): 65-72

245. Servizi, J.A., *et al.* (1987). Acute toxicity of Garlon 4 and Roundup herbicides to salmon, *Daphnia* and trout. Bull. Environ. Contam. Toxicol. 33: 355 – 361

246. Sivikova, K., and Dianovsky, J. (2006). Cytogenetic effect of technical glyphosate on cultivated bovine peripheral lymphocytes. Int J Hyg Environ Health 209(1):15-20

247. Stanton, K., *et al.* (2002). Cumplimiento con las Condiciones de Fumigación en la Iniciativa Antidrogas Andina. RFK Memorial, Latin America Working Group, Amazon Alliance, Center for Internacional Policy. Abril/2002.

248. Taylor, J., *et al.* (1999). The evolution of asexual fungi. Annual Rev. Phytopath 37,197-246. Citado en Cunning, J. ISIS report, 2000.

249. Tu, M. *et al.* (2001). Glyphosate. Weed Control Methods Handbook. The Nature Conservancy. USA

250. USDA Forest Service. Forest Health Protection (2003) Glyphosate. Human Health and ecological risk assessment. Final report. http://www.fs.fed.us/foresthealth/pesticide/risk_assessments/04a03_glyphosate.pdf

251. Vicente, C. (2001). Informe sobre la reunión interministerial del Protocolo de Cartagena sobre Bioseguridad llevada a cabo en Montpellier. Biodiversidad en América Latina. http://www.biodiversidadla.org

252. Viqfusson, N.V. y Vyse, E.R. (1980) The effect of the pesticides Dexon, Captan and Roundup, on sister-chormatid exchanges in human lymphocites in vitro. Mutat. Res 79(1): 53-57

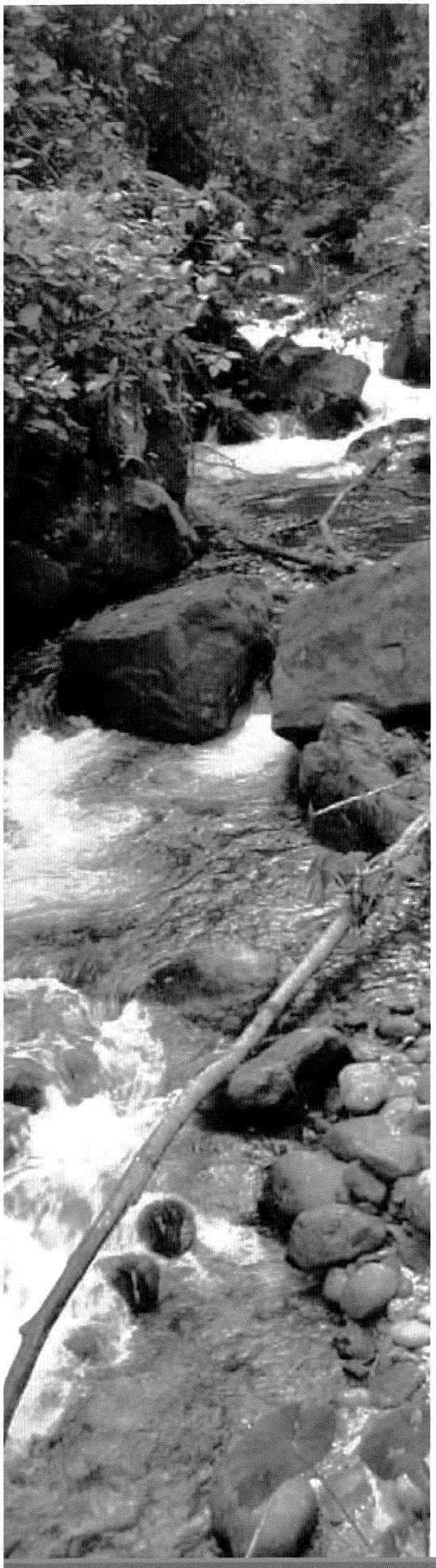
253. Wang, Y.S. (1994). Accumulation of 2,4-D and glyphosate in fish and water hyacinth. Water, Air and Soil Pollution Apr. 74 (3/4): 397-403

254. Weed Science Society of America. (2006). Herbicide Resistant Weeds Summary Table. Monday, June 26.

MEMORIAL DE ECUADOR

ANEXO 157

Comisión Científica Ecuatoriana,
El Sistema de Aspersiones Aérea del Plan Colombia y sus Impactos sobre el Ecosistema y la Salud en la Frontera Ecuatoriana (abril 2007)



COMISIÓN CIENTÍFICA ECUATORIANA

EL SISTEMA DE ASPERSIONES AÉREAS DEL PLAN COLOMBIA Y SUS IMPACTOS SOBRE EL ECOSISTEMA Y LA SALUD EN LA FRONTERA ECUATORIANA

QUITO-ECUADOR, ABRIL 2007

COMISIÓN CIENTÍFICA ECUATORIANA

DR. RAMIRO ÁVILA

DRA. ELIZABETH BRAVO

DR. JAIME BREILH

DR. ARTURO CAMPAÑA

DR. CÉSAR PAZ-Y-MIÑO

ING. LUIS PEÑAHERRERA

DR. JOSÉ VALENCIA

Ramiro Ávila Santamaría, LLM, Dr.
Abogado especialista en Derecho Internacional de los Derechos Humanos
Docente de la Universidad Andina "Simón Bolivar"
Asesor de la Clínica de Derechos Humanos de la PUCE

Elizabeth Bravo, Ecóloga. PhD.
Docente de la Universidad Politécnica Salesiana
Experta en biodiversidad.
Investigadora de Acción Ecológica

Jaime Breilh, Md. MSc. PhD
Epidemiólogo y especialista en Medicina Social
Director del Área de Salud, Universidad Andina "Simón Bolívar"
Director Ejecutivo, CEAS

Arturo Campaña, Md., Psiquiatra
Especialista en Salud Mental
Docente de la Universidad Central del Ecuador
Director Científico del Centro de Estudios y Asesoría en Salud

César Paz-y-Miño, Md. Ph.D.
Director del Laboratorio de Genética Molecular y Citogenética Humana
Pontificia Universidad Católica del Ecuador

Lus Peñaherrera Colina. Ing. Agr. MSc.
Especialista en Fitotecnia y Herbicidas
Responsable de Melezología
Estación Experimental de Boliche, INIAP

José Valencia, Abg.
Master en Ciencias Políticas
Profesor de Derecho Internacional Público
U. Católica; U. San Francisco y FLACSO

El Sistema de Aspersiones Aéreas del Plan Colombia y sus Impactos Sobre el Ecosistema y la Salud en la Frontera Ecuatoriana

ISBN-978-9978-45-961-4
Quito - Ecuador
2007

Fotografía: Cristina Herdoíza, Green Peace, Acción Ecológica y Archivo Manthra • Diseño gráfico: Manthra Editores • info@manthra.net • Quito-Ecuador

CONTENIDO

Resumen

Introducción

I. Antecedentes
Orígenes de las aspersiones aéreas en Colombia

II. Los procesos determinantes de las aspersiones aéreas
Modelo para su caracterización
La riqueza biológica amenazada por las aspersiones
Características de los componentes de las aspersiones

III. Disensos científicos sobre la noción de "evidencia"
Un paradigma científico actual y transdisciplinario

IV. La falsa noción de inocuidad del roundup
Una cadena de errores científicos y desentendimientos éticos
Hacia un manejo ético y científico de la incertidumbre

V. El sistema de aspersiones aéreas y su impacto en las condiciones de vida y salud
La noción de determinantes de la vida y la salud como marco de estudio
Destrucción agro-social y pérdidas de recursos alimentarios
Impactos en la salud mental
Impactos en la salud orgánica y genética

VI. El sistema de aspersiones aéreas y su impacto en el ambiente
Impactos en el ecosistema boscoso
El efecto de borde
Impactos en las redes tróficas, sucesión ecológica, fenología
Efectos en las interacciones ecológicas
Surgimiento de super malezas
Efectos sobre los sistemas acuáticos y sus comunidades biológicas
Impactos sobre otras especies animales

VII. El principio de precaución como eje científico, ético y jurídico

VIII. Conclusiones Generales

Bibliografía

LISTA DE TABLAS

Tabla 1
Situación de los cultivos de coca en la franja de 10 Km. de frontera con Ecuador (Nariño y Putumayo) 2000 – 2007.

Tabla 2
Arrastre o deriva de una gota lanzada a 3 metros de altura según Syngenta.

Tabla 3
Tiempo de duración de las gotas de agua en el aire en diferentes condiciones según Syngenta.

Tabla 4
Velocidad de sedimentación de las gotas en función de su tamaño según Syngenta.

Tabla 5
Puntos de GPS y distancia a la frontera desde Colombia.

Tabla 6
Daños a cultivos y animales en Sucumbíos (Ecuador) 2001.

Tabla 7
Impactos de las aspersiones en la vida cotidiana de la población de Mataje. Febrero 2007.

Tabla 8
Distribución de afectados por comunidad estudiada.

Tabla 9
Tipos de cometa visibles en la población expuesta aspersiones aéreas.

Tabla 10
Alteraciones celulares en mujeres expuestas a aspersiones aéreas.

Tabla 11
Alteraciones celulares en mujeres del grupo control.

Tabla 12
Evolución de las plantaciones de coca en los departamentos fronterizos con Ecuador.

Tabla 13
Hongos patógenos aislados en muestras de plantas en zonas afectadas.

PRÓLOGO

Las operaciones de aspersión aérea en los territorios colombianos fronterizos con el Ecuador han marcado las relaciones bilaterales entre Ecuador y Colombia. Como parte de una solución definitiva a este problema, el rol de la ciencia es fundamental para aportar los conocimientos, la información y el análisis necesario. La información científica debe conducir a la formulación de términos de precaución, de protección y remediación, frente a los efectos conocidos y potenciales que se desprendan de dichas operaciones.

En esta línea de razonamiento y objetivos ha venido trabajando la "Comisión Científica Ecuatoriana", con rigor, y con el sólido sustento que proveen una investigación y trabajo de campo serio, sumados a la vasta experiencia y rica calificación académica que acredita cada uno de los integrantes del equipo transdisciplinario que conforman la Comisión.

El producto de esa labor es este sustancioso documento, que también constituye un aporte valiosísimo al esclarecimiento de las inquietudes que la utilización de paquetes herbicidas de amplio espectro genera en la comunidad científica internacional. La peligrosidad del sistema de aspersiones aéreas no se agota en la nocividad del glifosato aislado y su potencial deriva. Trasciende esa esfera con efectos sobre todo organismo vivo y sus habitat, y por ello el presente estudio sistematiza las dimensiones del problema, y expone y explica los preceptos bioéticos y metodológicos en que sustenta su visión.

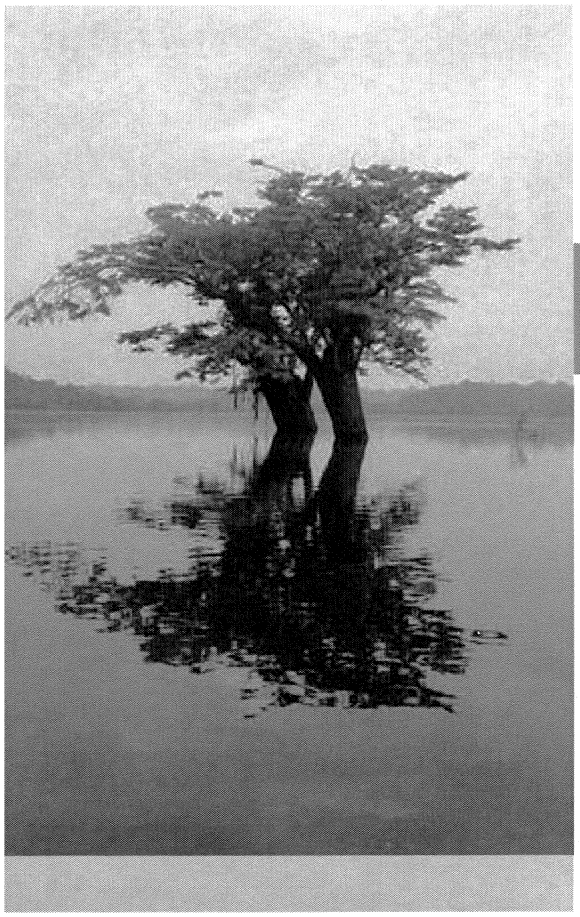
Este trabajo ofrece un amplio estudio sobre los principales disensos en los criterios de lo que es una "evidencia válida" sobre el daño, y sobre la responsabilidad de asumir medidas de precaución. Esta cuestión es central para arribar a entendi-

mientos que consoliden la buena vecindad. Sin embargo, corresponde registrar que, en coherencia con el acuerdo binacional ecuatoriano-colombiano que dio paso a la creación de la Comisión, es importante señalar que se trata de un análisis estrictamente científico, libre de influencias, y de responsabilidad exclusiva de sus autores.

La "Comisión Científica Ecuatoriana" es merecedora de honroso reconocimiento publico, por la labor que ha cumplido.

Quito, abril 2007

María Fernanda Espinosa,
Ministra de Relaciones Exteriores, Comercio e Integración



RESUMEN

El presente documento aborda el problema de las aspersiones aéreas del Plan Colombia y sus efectos en la frontera ecuatoriana. El Gobierno del Ecuador liderado por el Presidente Rafael Correa conformó la Comisión Científica para realizar una evaluación del impacto de tales aspersiones que en su paquete herbicida contiene glifosato, entre sus componentes, y que Colombia ha venido utilizando desde el año 2000, para el combate de plantaciones ilícitas en su territorio.

La problemática científica técnica en torno al asunto se resume en dos posiciones encontradas.

El gobierno de Colombia, con su argumentación sustentada en un documento elaborado por la CICAD (Comisión Interamericana para el Control del Abuso de Drogas), el que ha sido cuestionado por varias instituciones académicas y gremiales del propio país vecino, por no constituir una investigación de campo, tener una metodología inapropiada, llegar a conclusiones teóricas tan sólo fundamentadas en recopilaciones bibliográficas, omitir las posi-

ciones y testimonios de la población, utilizar términos ambiguos y dubitativos e incluso originarse en una institución de control de estupefacientes y no científica. En el centro de su defensa el gobierno de Colombia insiste en esgrimir la tesis de que las aspersiones aéreas -siempre reducidas por éste al tema del glifosato- son absolutamente inocuas e inofensivas, de tal manera que las quejas de los afectados, a uno y otro lado de la frontera, son apreciadas como actitud exagerada y desprovista de fundamento.

Frente a esta problemática, la Comisión Científica del Ecuador realizó constataciones y verificaciones; receptó testimonios de la población afectada y determinó una inobjetable afectación en su territorio. También recopiló y sistematizó los conocimientos generados, en gran volumen en los últimos años, acerca del glifosato, por investigadores e instituciones de todo el mundo, muchos motivados por el seguimiento crítico de las prácticas de aspersión aérea masiva. En esta publicación se expresan los resultados de los estudios sobre el impacto del sistema de aspersiones aéreas en las colectividades de la zona fronteriza y sus ecosistemas en territorio ecuatoriano, con sus consecuencias agro-sociales, ecológicas, económicas, en salud humana y animal, que sustentan científicamente el reclamo que el Ecuador hace a Colombia para que cesen definitivamente las aspersiones aéreas con el paquete herbicida, en la zona fronteriza en una franja de seguridad de por lo menos 10 km.

El presente documento asumió como ámbito de estudio, las evidencias del caso ecuatoriano así como el conjunto de argumentos emitidos por la comunidad científica internacional acerca de esta problemática. La decisión del colectivo de autores fue no incorporar las evidencias sobre los impactos en el pueblo de Colombia por considerar que su tratamiento corresponde a las entidades científicas colombianas; se hizo excepción con aquellas recogidas en documentos públicos en dicho país y por observadores ecuatorianos que han participado en misiones binacionales. El documento recoge los datos de estudios del impacto de las aspersiones a nivel de daño de plantaciones lícitas agrícolas y endémicas (medido entre 2 a 10 km de distancia a la frontera y a las aspersiones), daño en animales domésticos (medido en porcentaje de muerte y enfermedad igualmente por distancia a la frontera), impacto en la ecología (respaldado en abundante material bibliográfico y comparación con problemáticas similares, así como evaluado indirectamente por pruebas genéticas en plantas), afectación a la salud humana (verificada por médicos), correlacionadas a estudios de vientos en la zona, estudios en suelos y estudios de daño en el material genético de la población expuesta directa o indirectamente al paquete herbicida utilizado en las aspersiones aéreas originadas en Colombia.

Para sustentar la posición científica, la Comisión presenta un escrito que inicia con los antecedentes de las aspersiones aéreas que afectan al Ecuador. Se describen los componentes químicos del paquete herbicida y sus efectos en los diferentes niveles; luego se presenta una argumentación epidemiológica sobre las concepciones actuales sobre el estudio y medición de impacto de un problema de salud pública, así como sus compo-

nentes éticos. Se confrontan dos paradigmas de análisis: el de la lógica del mercado, que promueve la duda razonable, el impacto aceptable y el no reconocimiento del rol humano o ecológico, y el de la lógica humanista que defiende la ecología, valida el testimonio humano, protege el ambiente y la salud y relaciona la problemática a determinantes sociales y derechos humanos.

Con estos argumentos el documento profundiza en los efectos ecológicos, trata sobre la afectación de los ecosistemas y su no recuperación satisfactoria, habla sobre la extinción de especies, contaminación de agua, suelo, plantas y aire. Destaca estudios realizados por investigadores ecuatorianos sobre el daño a nivel celular en plantas, que demuestran que el glifosato, reconocido componente del paquete herbicida, produce alteraciones durante la división de las células y además en su material genético (cromosomas), estudio comparado con pruebas de no exposición al producto.

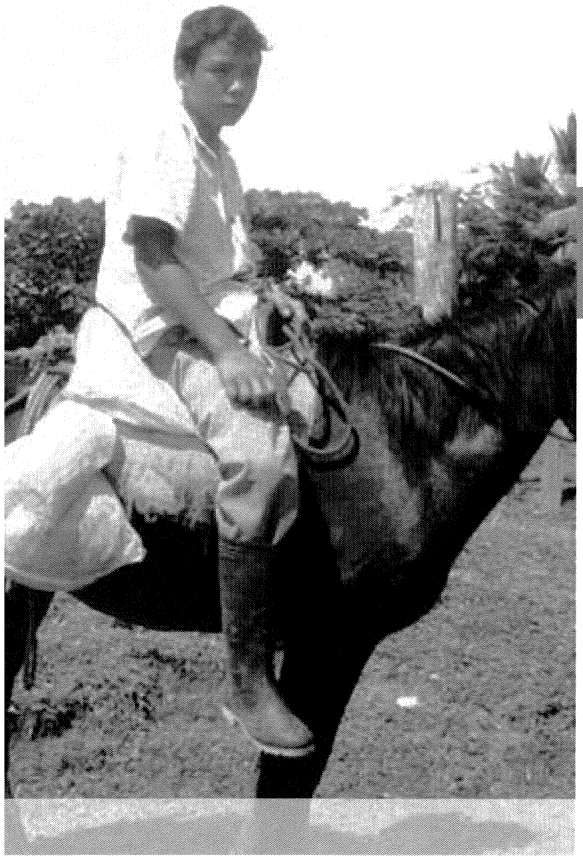
Las verificaciones del daño a cultivos y animales que han recibido el impacto de las aspersiones según la zona próxima o lejana a la frontera, concluyen que la cuantía del daño es muy elevada y está relacionada con la distancia.

Los estudios de campo realizados a nivel de salud, muestran un incremento grande de patologías, distribuidas según distancia, las cuales aumentan a mayor proximidad de los sitios asperjados. Sobre salud mental de los habitantes de la zona, la Comisión reconoce los problemas suscitados por la lógica de aplicación, por el temor ante el volumen y capacidad de daño de los productos usados, por la migración forzada, y la presencia de trastornos de comportamiento, atención y rendimiento en escolares y su angustia e inseguridad de vida.

Los estudios genéticos de campo, realizados en la población expuesta al paquete herbicida, muestran que existe daño a nivel cromosómico de los individuos, en un rango del 26% comparado con una población no expuesta al paquete herbicida u otro agente genotóxico conocido con rango de 4%. Los estudios de fragmentación del material genético de los individuos expuestos, evaluados por la prueba cometa (electroforesis de células únicas) muestran un incremento de alteración del material genético en el orden de 4 veces más (26% de daño medio), si se compara con el grupo control no expuesto.

El documento recoge los argumentos jurídicos nacionales e internacionales, fundamentados en instrumentos normativos vigentes, acuerdos legales, sustentados por la ONU, OMS, Convenio sobre Diversidad Biológica y Convenios sobre Derechos Humanos y otros, que resaltan, promueven y legitiman el Principio de Precaución como sustento del reclamo ecuatoriano ante el gobierno colombiano, y el pedido de cese definitivo de las aspersiones aéreas con paquetes herbicidas nocivos.

Se presentan conclusiones científico-técnicas que resumen los daños que el paquete herbicida produce a todo nivel: ecológico, ambiental, social, económico, en salud mental y física. Además, sustenta la posición de que uno de los componentes del paquete herbicida, el glifosato, es nocivo solo o con sus coadyuvantes.



SUMMARY

The aerial spraying of glyphosate - initiated as part of the Plan Colombia - is having direct impacts on Ecuadorians and has become a major social, health and ecosystem hazard for communities living in the north of our country. The Ecuadorian Government, now represented by President Rafael Correa, has set up a transdisciplinary Scientific Commission to perform an evaluation of the impact of the wide spectrum herbicide mixture being sprayed which contains glyphosate among other harmful components. Colombia has been using this herbicide compound system since 2000, in order to eliminate illicit Coca plantations in its territory. The debate generated about this matter can be summarized in relation to the opposing positions of the Columbian and Ecuadorian government – the former assuring its safety; and the latter drawing on reliable scientific arguments and data that confirm glyphosate toxicity.

Unfortunately, the Colombian Government has ignored all scientific and ethical precautionary arguments and has appar-

ently decided to maintain its strategy of herbicide aerial spraying. It sustains its position based on a document elaborated by CICAD (Interamerican Commission for the Control and Abuse of Drugs / Comisión Interamericana para el Control del Abuso de Drogas). This same document has been questioned by several academic institutions and associations, some of which are Colombian. The argument of the Colombian government on aerial spraying at our border has generated considerable scientific criticism: it incorporates no field research; was based on documents generated by a political rather than scientific institution; it shows inappropriate methods and methodological flaws; and its conclusions are based on secondary sources and bibliographic information which not only neglect key elements of scientific observation but also omits the testimonies of affected Colombian communities. Based on inconsistent methodological and empirical evidence, the Colombian Government insists that the aerial spraying is innocuous and harmless and that all the testimonies of the affected populations on both sides of the border are overlooked and discarded for supposed lack of objectivity.

In order to face these problems, Ecuador's Scientific Commission traveled and interviewed the affected populations in the Ecuadorian side of the border, to reconfirm and verify the diverse impacts in our territory. The commission compiled information contained in previous research projects; databases on impact monitoring gathered by national researchers; and literature published by academic institutions from other parts of the world focused on health impact assessment of the aerial application of glyphosate-based herbicide compounds. Our Commission organized and analyzed this collection of scientific evidence as well as qualitative data and testimonies reflecting health and ecosystem impacts over the 5 to 7 years since spraying began.

In broad terms, our scientific analysis encompasses a multiplicity of negative outcomes provoked by pesticide spraying that is operated within unsafe distances and through inappropriate spraying practices in the vicinity of vulnerable Ecuadorian communities and ecosystems on the border. These negative outcomes include: socio economic and agricultural impacts; impact on beneficial plant and animal species and related ecosystems components and services; impact on support systems required for family and community health; and related physical, mental and genetic impacts on human populations.

The Commission has decided not to incorporate evidence related to impacts in the Colombian population, because this problem is the concern of Colombian scientific institutions. Nevertheless, some exceptions were made – including reference to information already published by Colombian researchers or that which is included in the proceedings of bi-national meetings.

Aerial spraying of glyphosate-based compounds is considered a very hazardous and potentially destructive procedure. The safety requirements outlined in the instruction manuals of glypho-

sate producers note that air spraying should be conducted at an altitude of 3 meters over plants and only when spraying can be conducted under favorable and controlled weather conditions. Unfortunately, these are not the standards that have been applied in practice by the military logic of Colombian government spraying in our northern border. Rather, the spraying has been fulfilled at heights of up to 60m and in a manner that allows for the drifting of chemical droplets in Ecuador as well as the contamination of water, soil, animals and vegetation of the bordering area. Our evidence indicates that these practices have resulted in impact on endemic vegetation and legal agricultural crops; damage to domestic animals (as measured by high morbidity and death rates); damage to fish and aquatic fauna; and multiple indicators of human health impact, with impact gradients diminishing with increasing distance to the border.

Although not all evidence and variable correlations have been fully established, the available geographic, meteorological, epidemiological and ecological information gathered has revealed concerning impacts on the determinants of health as well as specific illness and disease. It is our scientific opinion that the available evidence is sufficiently comprehensive and systematic as to recommend the immediate cessation of all aerial spraying and the application of the precautionary principle.

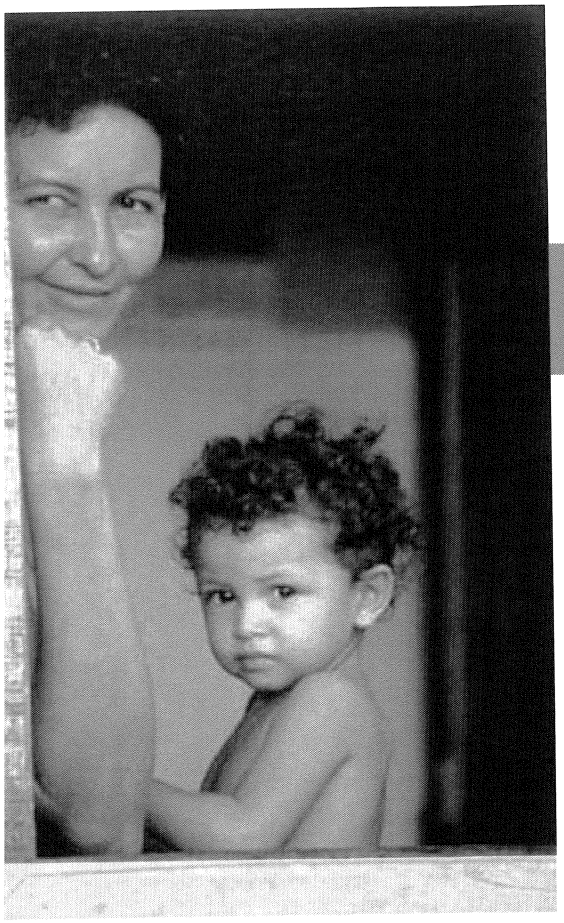
Our Commission's report presents a range of scientific information in support of this position. Specifically the report presents current scientific knowledge and factual evidence on the chemical residual environmental dynamics and effects of glyphosate as well as human health and ecosystem outcomes - including the psychosocial impacts of aerial military attack strategies and their association with the harmful impacts on environmental and epidemiological conditions.

The report also outlines basic ethical and juridical aspects related to the application of precautionary principle. As in all scientific debates of this kind, two opposing positions can be identified. On one side, those who produce and utilize wide spectrum herbicide systems argue in favor of its safety, not only by claiming the specificity of herbicide effect on coca crops and the innocuous nature of this compound for the human beings and the ecosystem, but also through reference to a calculation model based on minimal likelihood of chemical drift. Under those premises, the Colombian Government justifies their military strategy of aerial spraying and does not recognize any possibilities of harming human beings and the ecosystem in our territory. Furthermore, this viewpoint systematically neglects any concern for the testimonies and evidences presented by affected communities, discarding them as non scientific. On the contrary, our approach places the protection of human life and nature in the center, as non negotiable human rights; promotes a humanistic logic; and focuses on an integrated model of epidemiological and ecological research which prioritizes human and ecological protection.

Our report considers ecosystem damage in relation to impact on vulnerable species and water, soil, plant and air contamination. We also synthesize key studies conducted by Ecuadorian scientists who identify significant cellular damage (including cell cycle and genomic material alterations) in cells exposed to Glyphosate compounds, when compared to non-exposed. We also document a decline of plant and animal species which increases with proximity to the northern border - suggesting correlation with pesticide exposure.

Human impact studies are also articulated in our report. Our studies have identified that frequency of symptoms associated with glyphosate exposure increase with proximity to the border spraying zones. Psychosocial research has compared mental health symptoms before and after fumigations. Local communities have expressed increased fear, intimidation and sense of insecurity after repeated spraying, associated with forced migration from some communities, as well behavioral disorders and decreased educational performance in children. Human genetic damage was also assessed through lymphocyte DNA alterations (comet assay). This study found 26% chromosomal alterations in women exposed to glyphosate spraying. The level of chromosomal damage was approximately four-times higher than the damage found in the control or non exposed group.

In summary, our report outlines a complex profile of health and ecological aggression resulting from the aerial spraying at the Ecuadorian-Colombian border. The technical, legal and ethical arguments and findings we have compiled are congruent with international norms and prohibitions approved by UN and WHO, including the Biological Diversity and Human Rights Agreements. These international standards promote and legitimize the need for urgent application of the precautionary principle in the face of herbicide mixture sprayings and support Ecuador's demand for at least a 10 km security zone within the Colombian border.



INTRODUCCIÓN

La instauración de un sistema de lógica militar de alto impacto para control de los cultivos ilícitos de coca por medio de aspersiones aéreas con un paquete herbicida -Plan Colombia-, ha desencadenado no solamente efectos nocivos, temor y malestar en las poblaciones ecuatorianas de la frontera, sino también la crítica de la comunidad científica internacional.

La evaluación científica de la peligrosidad del sistema de aspersiones aéreas, no se reduce al tema de la nocividad del glifosato aislado y su potencial deriva (transporte por viento) al territorio del Ecuador; es, por el contrario, un problema científico y humano mucho más complejo, cuyas diferentes facetas sólo podrían ignorarse por motivos extracientíficos o por desconocimiento de los paradigmas de investigación y bioética actuales.

En la presente publicación se sistematizan las dimensiones del problema ocasionado, se explican los preceptos bioéticos

y metodológicos en que se sustenta la visión integral que el equipo transdisciplinario de la Comisión Científica del Ecuador ha elaborado, y se destacan algunas recomendaciones urgentes para el Gobierno Nacional.

Se expone una breve historia del problema y las contribuciones que a su conocimiento han ofrecido distintos centros de investigación del país, de Colombia y del mundo, así como los pasos logrados por quienes integraron comisiones anteriores.

Para orientar la sistematización de las evidencias de daño disponibles y el propio trabajo científico de la Comisión, se formula un modelo interpretativo y de análisis científico cuyos elementos centrales son expuestos para mostrar las dimensiones de los procesos determinantes de impacto en nuestro país, sus componentes químicos, las vulnerabilidades de nuestra gente, la destrucción agro-social, los mecanismos de daño en la ecología y la biodiversidad, la afectación de soportes comunitarios y los mecanismos de atemorización, respecto a los impactos humanos, tanto orgánico genéticos, como psico-sociales.

Punto central de nuestra caracterización científica de las aspersiones es que, desde luego, no se reducen a un simple problema de asociación factual tipo "x → y": "glifosato aislado – enfermedad". Un modelo científico robusto de determinación de la salud por las aspersiones abre la mirada de su evaluación en varias dimensiones cruciales:

a. Que opera bajo una lógica militar de alto impacto

b. Que no se reduce al glifosato solo, sino a un paquete herbicida de amplio espectro, formado al menos por glifosato, POEA y Cosmo-Flux 411 y eventualmente integrado por otros recursos herbicidas, incluso microbiológicos, ya justificados en contextos semejantes

c. Que las operaciones de aspersión aérea no sólo desencadenan procesos químicos o químico-biológicos que generan directamente enfermedad humana, fitopatología y daño en los ecosistemas sino que encarnan también procesos de afectación alimentaria, socio-agrícola, impacto en los soportes bióticos y la biodiversidad y hasta impacto psicosocial y lesión a los soportes de vida familiar y comunitaria

d. Que por lo anterior, la evaluación científica del impacto necesita abarcar todas dichas mediaciones y consecuencias que van acumulando un daño diverso en nuestra población y ecosistemas.

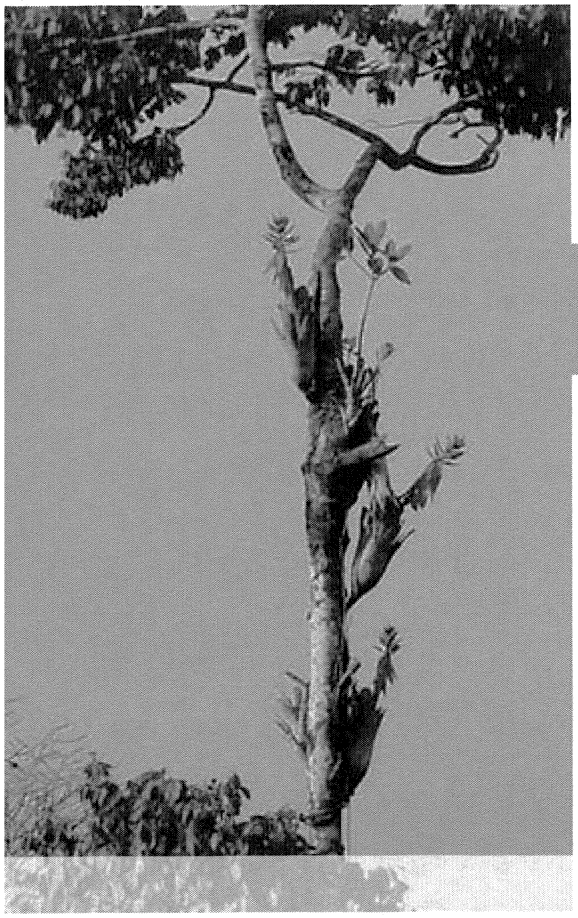
Se sistematizan los principales disensos sobre los criterios de lo que es una "evidencia válida" sobre el daño, y sobre la responsabilidad de asumir medidas de precaución, lo cual no solamente se aplica a este caso particular de los efectos en Ecuador del plan del Gobierno de Colombia, sino que constituye uno de los grandes temas de la discusión actual sobre la ética de procesos similares, que ha sido colocada por la comunidad científica mundial en el tapete de discusión frente a las frecuentes justificaciones y dilatorias

que plantean algunos sectores para expiar su irresponsabilidad humana y ecológica, justificar sus fines estratégicos y soslayar el cumplimiento del principio de precaución.

También sintetiza algunas de las principales evidencias de esa diversidad de impactos en la sociedad que producen las aspersiones aéreas, incluyendo las que genera el propio glifosato (aunque no solamente dicho agro-tóxico) y las constataciones de afectación en la salud mental, física y genética de la población ecuatoriana.

Más adelante se sistematizan, en base a estudios realizados en otros países, los posibles impactos en los ecosistemas del territorio ecuatoriano fronterizos con Colombia.

El documento reúne un robusto conjunto de argumentos científicos, dirigidos a apoyar a las autoridades en el despliegue de todos los esfuerzos nacionales e internacionales, para exigir las compensaciones y reclamos del caso y poner freno inmediato a la aplicación de un sistema destructivo, cuyos "beneficios" son relativos y cuestionados incluso por los datos de quienes los auspician. Además, no son sustentables, pues reemplazan la adopción de medidas sociales, económicas y culturales de fondo, que son el mejor y único antídoto frente a toda forma de actividad ilícita que florece remplazando la lógica del desarrollo solidario bajo equidad.



I. ANTECEDENTES

Orígenes de las Aspersiones Aéreas en Colombia

Las aspersiones aéreas en Colombia han seguido el siguiente patrón (Puyana, 2007):

Aspersiones discontinuas desde 1978 a 1991, cuando se inician los primeros ensayos con Paraquat, 2,4-D y Glifosato, en la Sierra Nevada de Santa Marta.

Aspersiones sistemáticas desde 1992 a 1999. El Consejo Nacional de Estupefacientes (CNE) reglamenta el procedimiento y se le otorga el rango de política pública sistemática de Estado. En ese período, se asperjaron 187.858 ha., pero la producción se incrementó en 243%. Durante este período la Defensoría del Pueblo de Colombia denuncia el uso de Tebuthiuron, Velpar (hexazinona) e Imazapyr (Castro, 2000).

Incremento de las aspersiones desde el 2000 al 2006. Hasta diciembre del 2005 se habían fumigado 690.700 ha. A finales de ese año se registran 144.000 hectáreas de coca, lo que hace

suponer que hubo una reducción de 19.289 ha. (Puyana, 2007). En este último período destacan las denuncias de ensayos con *Fusarium oxisporum* variedad *eritroxylum*, en los programas de erradicación (La Hora, 2000; New Herald, 2000; St. Clair, 2002).

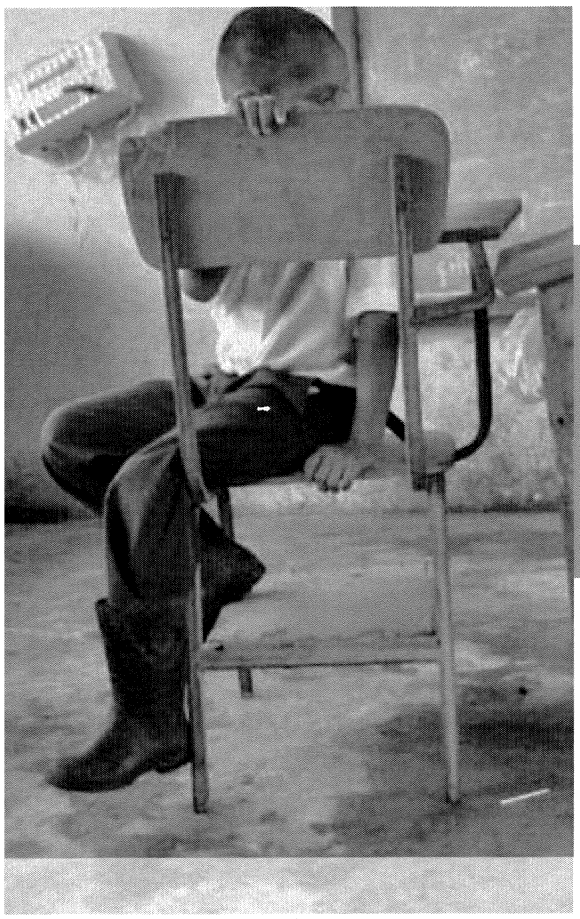
Esto, a pesar de que en 1984 el Instituto Nacional de Salud de Colombia convocó a un comité de expertos en herbicidas con el propósito de analizar el método de aspersión aérea masiva para el control de cultivos de coca y marihuana que el gobierno pensaba implementar. De acuerdo al informe (citado en Vides, 2003), los expertos concluyeron que:

1. Desde el punto de vista de la salud humana y el impacto al medio ambiente, el método químico debe ser el último en considerarse.

2. Con la información disponible sobre glifosato, 2,4-D y paraquat, sobre implicaciones a la salud e impactos al ambiente, no es aconsejable el nuevo uso masivo y por aplicación aérea propuesto por el Consejo Nacional de Estupefacientes.

3. Cualquier método que se proponga para la destrucción de estos cultivos, deberá estar precedido de estudios sobre los efectos en la salud de las personas, y del impacto sobre el ambiente.

Estas afirmaciones fueron ratificadas por los expertos científicos con los siguientes argumentos: "El glifosato no se recomienda su uso por vía aérea (...) pues su toxicidad aguda en humanos es poco conocida, no hay en la literatura información sobre toxicidad crónica y tampoco hay información con respecto a sus efectos mutagénicos y teratogénicos..." (Vides, 2003). No obstante, el Gobierno de Colombia, un mes después, el 22 de mayo de 1984, ordenó el uso del glifosato en aspersiones aéreas de cultivos de coca, amapola y marihuana.



II. LOS PROCESOS DETERMINANTES DE LAS ASPERSIONES AÉREAS

Modelo Para su Caracterización

El conocimiento científico acumulado sobre las aspersiones aéreas con glifosato y otros agrotóxicos y la información disponible acerca del sistema empleado en la frontera norte, llevan a dos argumentos centrales: en el problema que enfrentamos no se trata de la aplicación del glifosato aislado y la salud no es sólo afectada por impacto tóxico, sino por la destrucción o deterioro de un conjunto de soportes y determinantes (agrosociales, ecológicos y psicosociales) que conforman un sistema destructivo con diversos componentes:

* Un paquete químico, compuesto por lo menos de glifosato, POEA y Cosmo Flux 411F, y eventualmente comprometedor con un agregado microbiológico (*Fusarium oxysporum*). Todos estos con evidencias de fitopatogenicidad no específica y patogenicidad humana; máxime en poblaciones como las de nuestra frontera, con evidente vulnerabilidad y debilidad en sus recursos de afrontamiento. Pero, además, las aspersiones aéreas, en su condición de "arma" en un escenario de "guerra"

o conflicto entre sectores armados, constituyen un mecanismo de alto impacto y desencadenan otros determinantes de la salud, con su efecto destructor sobre los soportes vitales de las comunidades:

- Un sistema de destrucción agro-social, que afecta las cadenas alimentarias agrícolas y acuáticas, determinando impacto por contaminación y pérdida de fertilidad, con menor producción o destrucción de fuentes de subsistencia y alimentación, destrucción/deterioro de la vida acuática (reserva de agua y alimentos).

- Un sistema de impacto en los ecosistemas, en especies benéficas, animales y vegetales y en la biodiversidad, lo cual implica forzar la producción de ecosistemas insalubres, con destrucción de especies medicinales y de importancia cultural.

- Un sistema de amenaza a soportes comunitarios, por generar migración forzosa y descomposición de armonía comunitaria y familiar.

- Un sistema de agresión psicológico-social y atemorización.

En otras palabras, las aspersiones aéreas destruyen no por impacto tóxico directo de los residuos químicos del glifosato solamente, sino mediante la afectación del conjunto de procesos determinantes de la vida humana y ambiental que hemos descrito. El modelo se encuentra resumido en el Diagrama 1

Modelo para Estudiar Impacto del Sistema de Aspersiones Aéreas

La riqueza biológica amenazada por las aspersiones

Ecuador es considerado uno de los 12 países megadiversos (con mayor diversidad biológica). Con su reducido tamaño (0.17% del tamaño del plantea), alberga 9,2 especies por kilómetro cuadrado, lo que le convierte en el país con mayor diversidad biológica por unidad de área en el mundo.

En Ecuador existen alrededor de 18.000 especies de plantas con flores y 1.300 especies de helechos. Se calcula que el 20% de la flora ecuatoriana es endémica.

Con su pequeña extensión territorial, ocupa el 4to lugar en América del Sur en diversidad de mamíferos, y el 9no a nivel mundial. El número total de especies de mamíferos es de 369. Su región con más alta diversidad es la amazónica, con 191 especies, es decir el 52% de toda la diversidad de mamíferos del país. El 8% de los mamíferos ecuatorianos son endémicos (Tirira, 1999).

Se han identificado 1.616 especies de aves, lo que, para el tamaño de nuestro territorio significa uno de los valores más altos para especies de aves registrado en cualquier lugar del mundo (17% del total mundial). La mayor biodiversidad de aves se encuentra en los bosques húmedos tropicales. El 50% se encuentra en la región amazónica.

Según Coloma (1991) en el Ecuador se habían identificado 414 especies de anfibios hasta 1990, una de las más altas concentraciones de anfibios a nivel mundial. La mayoría de estas especies se conocen solamente en áreas de distribución restringidas y muchas de ellas están en peligro de desaparición. Datos igualmente altos se han registrado para reptiles. (Coloma, 1991; Suárez y Ulloa, 1993).

La Región del Chocó ecuatoriano alberga los últimos reductos de bosques tropicales de la costa del Pacífico. Estos bosques hacen parte de la región biogeográfica del Chocó, que se extiende desde el sur de Panamá hasta el norte de Esmeraldas. En esta zona hay unas 10.000 especies de plantas, de las cuales unas 2.500 son endémicas. Este es el hogar de los pueblos Awá, Chachi y Tsachila, así como de comunidades afroecuatorianas que mantienen formas de vida propias.

Adicionalmente, la región amazónica es el centro de origen del cacao, la yuca, el camote, la coca, la papa china, así como de frutas como papaya, chirimoya, entre otras. En los sitios donde se ha domesticado alguna especie, se encuentran los denominados parientes silvestres de los cultivos que son especies muy cercanamente relacionadas con las plantas cultivadas y en muchos casos son sus antecesoras.

Características de los componentes de las aspersiones: paquete herbicida de amplio espectro

Según fuentes oficiales se fumiga un promedio de 23,66 litros (6,25 galones) de esta mezcla por hectárea, lo que equivale a 10,4 litros de Roundup

(con POEA incluido) sin diluir, más 0,24 litros de Cosmo-Flux y 0,08 litros de Cosmo-InD[1], mezclados en 12,94 litros de agua. Sin embargo, los datos aportados por la misma Dirección Nacional de Estupefacientes (DNE, 2007) de Colombia, ante una petición de acceso a la información, son muy diferentes. Para la franja de 10 km de frontera con Ecuador, los cultivos y aspersiones han seguido la siguiente distribución:

Tabla 1
Situación de los cultivos de coca en la franja de 10 km de frontera con Ecuador (Nariño y Putumayo) 2000 - 2007

Año	Hectáreas de coca* detectadas	Operaciones erradicación en los 10 km	Galones Roundup usados ***	Galones Cosmoflux usados	Relación Rounup / Cosmoflux	Litros Glifosato/ha
2000**	20.185	3	8.958,7	206,7	43,34/1	1,67
2001	12.359	1-Nariño 4-Putumayo	22.170,5	511,6	43,33/1	6,78
2002	5.186,7	2N 2P	44.497,5	1.026,8	43,33/1	32,43
2003	2.830	3N 2P	18.205,7	420,1	43,33/1	24,31
2004	2.691,6	1N 3P	13.316,1	307,2	43,34/1	18,70
2005	3.975	2N 1P	25.695,5	592,9	43,33	24,43
2006	5.996	2P	24.402,9	563,1	43,33/1	15,38
2007	17.000	1N 1P				
Total		28	157.246,9	3.628,4	43,33/1=2,3%	

Elaboración: CIF, en base a datos de la DNE Colombia, del 2007.

*Detectadas por el SIMCI[2] a comienzos de cada año.
** En el 2000 comenzaron el último trimestre. No cubrieron todos los cultivos sino hasta el primer trimestre del 2001.
*** Galones usados al final del año.
N= Nariño y P= Putumayo

1. No sabemos si en la actualidad se esté usando este producto; después de unos estudios que hizo el Ministerio de la Protección Social, antes Ministerio de Salud, encontraron tan alta la toxicidad de este antiespumante que la recomendación del Ministerio y del ICA fue no usarlo. Con seguridad fue uno de los causantes de los peores problemas de salud a comienzos de 2001 en Putumayo.
2. Sistema Integrado de Monitoreo de Cultivos Ilícitos.

Estos datos indican que en la franja de 10 km de Colombia con Ecuador, después de haber rociado sobre ella 594.393,3 litros (157.246,9 galones) de roundup más POEA (en cantidades por hectárea muy superiores a las indicadas) y cerca de 13.715,3 litros (3.628,4 galones) de cosmoflux (a una concentración del 2,3%, que duplica la anunciada), en 6 años sólo se han erradicado 3.185 hectáreas.

La mezcla utilizada contiene: 44% de Roundup Ultra, mientras que la etiqueta de uso en los Estados Unidos para Roundup Ultra permite concentraciones de 1,6% a 7,7% para la mayoría de los usos y, como máximo, una concentración del 29%. La etiqueta de Estados Unidos indica que, en la mayor parte de las condiciones, la aplicación aérea no deberá exceder de 1 litro por acre del producto formulado. En Colombia, la tasa corresponde a casi 4,5 veces esa cantidad (Isacson, 2002).

Si se considera que un avión de 300 galones (1.137 litros) deposita 40 L/ha de la mezcla, con una descarga efectiva de 23,4 L/ha de Roundup Ultra, esta descarga equivale a 10,3 L/ha de glifosato en forma de sal isopropilamina (IPA). A esta situación se añade que el Cosmo Flux 411F, cuadruplica la acción biológica del glifosato (CIF, 2003).

El glifosato

El glifosato es un herbicida sistémico que se aplica en post emergencia; no selectivo, de amplio espectro, usado para eliminar malezas que pueden ser pastos anuales y perennes, hierbas de hoja ancha y especies leñosas.

El INIAP[3] (2007) recomienda el uso de glifosato en áreas agrícolas, considerando aplicaciones dirigidas con pantalla en cultivos perennes y totales sobre áreas no cultivas como en aquellas donde se practica la labranza cero o mínima con equipo acoplado al tractor, nunca con equipo aéreo. La dosis que se recomienda aplicar varía de dos a cuatro litros de producto comercial por hectárea, considerando dosis menores para especies anuales, y mayores para especies perennes.

De acuerdo al Farm Chemicals Handbook (1990), no se recomiendan aplicaciones aéreas.

La Agencia de Protección Medioambiental de Estados Unidos (EPA) ya reclasificó los plaguicidas que contienen glifosato, como clase II, altamente tóxicos, por ser irritantes de los ojos (EPA, 1993). La Organización Mundial de la Salud, sin embargo, describe efectos más serios; en varios estudios con conejos, los calificó como "fuertemente" o "extremadamente" irritantes.

El glifosato inhibe la síntesis de los aminoácidos aromáticos (fenilalanina, tirosina y triptófano), a través de interferir en la ruta metabólica del

3. Instituto Nacional de Investigaciones Agropecuarias del Ecuador.

ácido chiquímico. A partir del ácido chiquímico se producen además otros productos aromáticos como ligninas, alcaloides, flavonoides, ácidos benzoicos y fitohormonas propias del metabolismo secundario como los aleloquímicos. De hecho, un 20% del carbono que es fijado en la fotosíntesis es utilizado en esta ruta metabólica.

La ruta metabólica del ácido chiquímico está presente en plantas y micro-organismos. Estudios hechos por Bode y colaboradores (Bode, 1986) en 19 estirpes de levaduras Ascomicetes y Basidiomicetes, demostraron que el glifosato también inhibe la actividad de la enzima 5 enolpiruvilsikimato 3 fosfato sintasa (EPSA), como ocurre en las plantas.

En plantas, el herbicida, después de asperjado, es absorbido a través de las hojas y otras partes verdes transportado al resto, donde actúa en su sistema enzimático.

El glifosato es un ácido, pero se usa comúnmente como sal, siendo la forma más utilizada la sal isopropilamina (IPA) de N-(fosfonometil) glicina, o sal isopropilamina de glifosato. Es altamente soluble en agua y prácticamente insoluble en solventes orgánicos. Por ser hidrosoluble, se lo usa unido a un surfactante, que lo fija a la planta y mejora la penetración en los tejidos.

Como todo plaguicida, el glifosato, antes de salir al mercado pasa por un proceso de formulación comercial, durante el cual los ingredientes activos son mezclados con otras sustancias como solventes, coadyuvantes y más, denominados como "ingredientes inertes", sobre los cuales no se proporciona información en las etiquetas y en muchos casos son sustancias biológicas, químicas o toxicológicamente activas. Estas preparaciones confieren características diferentes a las encontradas en cualquiera de los componentes por separado. Los preparados comerciales, por lo tanto, pueden entrañar mayor riesgo o daño para la salud y el ambiente.

Su nombre comercial más conocido es Roundup, patentado por Monsanto. Existen varias formulaciones que se caracterizan comúnmente por contener 480 g/l de sal IPA de glifosato y el surfactante POEA (polioxietil amina). POEA pertenece a la familia de alquilaminas polietoxiladas sintetizadas de ácidos grasos de origen animal. Se ha reportado que el El POEA tiene mayor toxicidad (Kaczewer, 2002).

Según Nivia (2001a), no se conoce con exactitud la combinación que se utiliza en las aspersiones aéreas fronterizas. Sugiere que se estarían usando coadyuvantes nuevos, que potenciarían la acción del glifosato, aumentando también su toxicidad.

Destino ambiental del glifosato

El glifosato ha sido fabricado para ser aplicado directamente a las hojas de las plantas, pero "aunque el glifosato no se aplica directamente a los suelos, una concentración significativa del compuesto puede llegar al suelo durante una aplicación" (Haney, Senseman, Hons y Zuberer, 1999).

Una vez en el suelo, hay diferentes procesos que determinan el destino final del glifosato:

- La formación de complejos con agua de iones de Ca2+ y Mg2+
- Adsorción en sedimentos o partículas suspendidas en el agua y el suelo
- Entra en el metabolismo de las plantas
- Es biodegradado por micro-organismos
- Es arrastrado por escorrentia y llega a fuentes de agua

Algunas bacterias pueden degradar el glifosato usándolo como fuente de carbono, fósforo y nitrógeno. Uno de los principales metabolitos en la degradación del glifosato en ambientes terrestres es el ácido aminometilfosfónico (AMPA), que tiene una estructura similar al glifosato. Del AMPA se pasa a metilamina y de aquí a formaldehído, carcinógeno conocido. (Cox, 1991 y 1995; Dinham, 1999). Al combinarse con nitrato (presente en saliva humana o fertilizantes) el glifosato puede generar trazas de N-nitroso glifosato. La mayoría de compuestos N-nitroso son cancerígenos y no existe nivel seguro de exposición a ellos.

Movilidad del glifosato

Aunque se afirma que el glifosato es poco móvil en el suelo, algunos estudios científicos ponen en duda esta afirmación.

Por ejemplo, se ha encontrado que la adsorción del glifosato varía de acuerdo a los tipos de suelos. Hay una menor adsorción en suelos con bajos contenidos de óxido de hierro (Piccolo y Celano, 1994). El contenido de minerales en la arcilla puede jugar también un papel importante. Estos autores encontraron que en algunos tipos de suelos se libera el 80% del herbicida adsorbido, mientras que otros liberan entre el 15 – 35%.

Hay suelos que no pueden retener al glifosato el tiempo suficiente para que haya degradación microbiana, y en esos casos el herbicida es muy móvil. Este glifosato liberado puede penetrar en los niveles más bajos del suelo.

El glifosato puede unirse a substancias hidrosolubles del humus. Las substancias húmicas son las principales responsables de la movilidad de los pesticidas en el suelo. El glifosato transportado por las substancias húmicas, puede también entrar en los niveles más profundos del suelo (Piccolo y Celano, 1994).

Un estudio hecho por Morillo, Undabeytia y Maqueda (1997) revela que la adsorción del glifosato disminuye con la presencia de cobre, debido a la formación de complejos glifosato-cobre. Este estudio concluye que para entender la relación entre el glifosato liberado y su movilidad en el suelo, es necesario tener en cuenta el tipo de suelos y los elementos presentes en el suelo capaces de formar complejos con el glifosato.

Se ha encontrado también que la materia orgánica presente en el suelo, compite con el glifosato por los sitios de adsorción (Gerritse, Beltrán y Hernández, 1996). Un estudio brasileño conducido por Prata *et al* (2003), muestra que el glifosato compite con el fósforo por sitios

específicos de adsorción, especialmente en suelos con niveles elevados de fósforo. Los suelos del Ecuador se comportan diferentemente que otros suelos en países tropicales. El glifosato podría ser más móvil que en otros suelos tropicales. En el análisis de muestras de suelos extraídas en la zona de Mataje, se observan elevados contenidos de Fe, N y, en determiandos casos, de Ca y P. Estos elementos pueden, en determinadas circunstancias, modificar el comportamiento y destino del glifosato en el ambiente. Además, son suelos con altos de arena y limo, que también repercuten en su comportamiento.

El glifosato puede entrar en aguas superficiales cuando se aplica cerca de los cuerpos de agua, por efecto de la deriva o a través de la escorrentía. Puede haber un proceso de percolación hacia las aguas subterráneas. Dependiendo de los sólidos suspendidos y de la actividad microbiana, el glifosato puede transportarse varios kilómetros río abajo (CCME, 1989).

Persistencia del glifosato

Otra afirmación que se hace en relación al glifosato es que este herbicida se inactiva y degrada rápidamente en el suelo. La Agencia Ambiental de Estados Unidos ha reportado que la vida media[4] del glifosato en el suelo puede ser de hasta 60 días según (EPA, 1999). La EPA añade que en estudios de campo los residuos se encuentran a menudo al año siguiente.

A continuación se presentan algunos datos sobre la persistencia del glifosato en distintos ambientes, recopilados por Cox (1995):

- 249 días en suelos agrícolas de Finlandia
- Entre 259 y 296 días en 8 sitios forestales en Finlandia
- Entre 1 y 3 años en 11 sitios forestales en Suecia
- 335 días en un sitio forestal en Canadá
- 360 días en 3 sitios forestales de Canadá

Dos estudios canadienses encontraron que el glifosato puede persistir entre 12 y 60 días en un cuerpo de agua luego de una aplicación directa.

Se encontró residuos de glifosato en los sedimentos de una laguna un año después de su aplicación directa, en Estados Unidos.

Estudios hechos en bosques de Canadá sobre la persistencia del glifosato en el suelo, encontraron que en suelos de bosques canadienses, estos pueden persistir entre 45 y 60 días. Luego de 360 días se encontró aún una presencia del 6 al 18% de los niveles iniciales, tanto en el suelo como en los residuos vegetales (Bell *et al.*, 1997).

El glifosato puede adherirse a partículas del suelo y puede todavía ser tóxico y biodisponible a organismos que se alimentan por filtración, tales como crustáceos y moluscos, así como a otros organismos que ingieren cantidades significativas de suelo durante su alimentación normal, incluyendo

4. tiempo que tarda en desaparecer la mitad de un compuesto en el ambiente

peces, aves que se alimentan en las playas de los ríos, anfibios y algunos mamíferos.

Se ha encontrado que el AMPA es más persistente que el glifosato. Se han reportado vidas medias para este compuesto de entre 199 y 958 días (WHO, 1995). Aunque el efecto del glifosato como químico por sí solo ha sido investigado en algunos tipos de suelos, los efectos de los surfactantes y otros aditivos utilizados en las formulaciones de aspersión no han sido investigados en suelos y mucho menos el Cosmoflux usado en la erradicación de los cultivos ilícitos en Colombia.

Poliacrilamida

Como el agua colocada en el ambiente forma gotas grandes debido a la tensión superficial, en la formulación de muchos herbicidas se adicionan poliacrilamidas, para disminuir la tensión de los líquidos y aumentar la superficie de contacto entre el agroquímico y las hojas de las plantas, aumentando su adsorción.

Las evidencias parecen indicar que la acrilamida es liberada en forma de poliacrilamida ambiental.

La cocción de vegetales que han estado expuestos al glifosato utilizado en cultivos transgénicos tolerantes a herbicidas, o usados durante la preparación del suelo en cultivos convencionales, resultaría en una adicional liberación de acrilamida.

En los EE.UU., los aditivos tipo poliacrilamida se consideran "secreto comercial" y la información sobre la composición de las fórmulas herbicidas no está al alcance del público.

En un informe publicado por el Institute of Science in Society de Inglaterra, el Profesor Joe Cummins (2002) analiza una alerta sanitaria producida por la presencia de acrilamida tóxica en alimentos cocidos. Esta emergencia estuvo relacionada con el glifosato. El hallazgo tuvo una repercusión masiva, porque la acrilamida es un potente tóxico neural en humanos y también afecta la función reproductiva masculina y causa malformaciones congénitas y cáncer en animales.

Surfactantes y Adherentes Asociados con Herbicidas

Polioxietileno amina (POEA)

POEA es un surfactante que se usa para que el glifosato pase a través de la cutícula de las plantas, ya que esta tiene características no polares (lipofílicas), lo que dificulta la absorción del químico. Los llamados "elementos inertes" actúan como solventes y humectantes capaces de aumentar la permeabilidad y atravesar la barrera cuticular vegetal.

Los diferentes fabricantes de herbicidas en base de glifosato, no colocan en sus etiquetas la presencia de estos "elementos inertes" y muchos de ellos son conservados como secreto de formulación. Adicionalmente, el proceso de registro, por lo general, se realiza sobre el ingrediente activo y no sobre el producto final.

POEA (polioxietileno amina) tiene una toxicidad aguda mucho mayor que la del glifosato, causa daño gastrointestinal, alteraciones del sistema nervioso central, problemas respiratorios, destrucción de los glóbulos rojos, daños al hígado y riñones, es corrosivo de ojos y fuerte irritante de piel. Además está contaminado por 1-4 dioxano, el cual ha causado cáncer y daño a hígado y riñones en humanos (Nivia, 2001a).

La toxicidad aguda del surfactante POEA es entre 4 y 5 veces mayor que la de glifosato y Roundup. Las DL50 oral (ratas) y dermal (conejos) reportadas son de >1200 y >1260 mg/kg respectivamente.

Cosmoflux

Del Cosmoflux nada se sabe, sólo que con su adición al Roundup es más tóxico (categoría III, moderadamente tóxico). El compuesto utilizado tendría una vida media entre 60 días hasta tres años (Cox 1991 y 1995).

Se describe químicamente como una mezcla de aceite mineral y surfactantes especializados no-iónicos con agentes de acoplamiento. El ingrediente activo es descrito como una mezcla de ésteres de Hexitan: alcoholes lineales + aryl etoxilado (Cosmoagro, 2004).

Contiene además isoparafinas líquidas: aceite isoparafínico de alta pureza, de muy baja fitotoxicidad, de muy bajo contenido de aromáticos y baja tensión superficial que mejora la humectabilidad, promoviendo así la eficacia de los ingredientes activos.

No forma parte de la formulación comercial, pero se le añade para aumentar el nivel de acción del herbicida. Se ha demostrado que aumenta en 4 veces el efecto del Roundup al incrementar el poder de penetración del glifosato.

Es irritante de piel y conjuntivas.

Un componente especial que se adiciona en las aplicaciones en la frontera es el surfactante Cosmo-Flux 411F, cuyo uso ha sido aprobado en Colombia sin que se hayan hecho estudios sobre sus posibles efectos. Es un líquido amarillento a 25°c; punto de llama (flash point) mayor de 149°c; gravedad específica 0.89; viscosidad 60 mPa a 25°c; pH en solución al 1% en agua destilada entre 6.3 y 6.8 y concentración de aceite 80-85 (% w/w). Soluble en aceites minerales, aceites vegetales y solventes orgánicos usados en la formulación de agroquímicos. Dispersable en agua e insoluble en etanol. Coadyuvante estereoespecífico de carácter no-iónico formado por la combinación de aceite parafinado más un tensoactivo adyuvante estereoespecífico; mejora la adherencia y uniformidad de las preparaciones de agroquímicos, controlando la evaporación e hidrólisis del activo con cubrimiento total, garantizando concentración homogénea del activo por unidad de área y extendiendo el espectro de actividad biológica de los agroquímicos.

Herbicidas Biológicos

Fusarium oxysporum

Fusarium oxysporum Schlecht es un hongo esencialmente necrotrófico y vascular. Sus distintas

formas especiales parasitan a una gran cantidad de cultivos. Tiene una distribución cosmopolita.

Este hongo invade las células radicales, ocasionando la pudrición radicular y muerte de plántulas. La tasa de velocidad de la infección depende de factores como el tiempo de la infección inicial, la virulencia y las condiciones climáticas.

Este hongo penetra en las raíces a través de heridas y continúa hacia el xilema o por los tejidos conductores de agua. Los retoños y las hojas se marchitan durante el día, pero ganan turgencia durante la noche. Cuando la infección progresa, los tallos se palidecen. Las toxinas producidas por el hongo decoloran el tejido del huésped y precipitan el marchitamiento de las hojas, las que pueden presentar una coloración amarillenta o rojiza. El xilema es obstruido, causando la muerte de la planta.

El tallo cortado transversalmente presenta en los haces vasculares una coloración amarillenta o marrón con la muerte y deshilachamiento de los tejidos, sin afectarse la médula; este es un aspecto muy importante para diagnosticar la enfermedad y distinguirla de otras enfermedades vasculares.

Las raíces y los tallos no presentan daño inicial importante, pero luego se afectan severamente con la formación de cavidades, presentándose una pudrición seca en la base de las plantas y en las raíces.

En el Ecuador una de estas formas especiales, conocida como Mal de Panamá acabó con la variedad de banano Gross Michel.

Aunque se dice que las formas especiales de *Fusarium* pueden ser muy específicas para el tipo de cultivo que va a parasitar, este hongo como cualquier ser vivo puede mutar y convertirse en patógeno de otros cultivos. La pérdida de especificidad en especies patógenas se ha registado aun en hongos altamente específicos, como es el caso de hongos biotróficos (Griffith *et al.*, 1993).

Se arguye que el *fusarium oxysporum* variedad *erytroxylum* es especializado en producir el marchitamiento vascular a las plantas de coca, pero una serie de factores, incluyendo la cantidad de inóculo que se usaría en un programa de erradicación de este cultivo, puede convertirlo en patógeno de otras especies, constituyéndose en un riesgo potencial para las 200 especies que son parientes silvestres de la especie *erytroxylum*. En Colombia, 4 especies de *erytroxylum* están incluidas en las listas rojas de especies en peligro de extinción (Pimiento, 2001).

La alta sobrevivencia de sus clamidosporas, resistentes a la degradación química y microbiológica, hace que el hongo pueda permanecer en el suelo por muchos años.

Se ha reportado que el *fusarium oxysporum* puede convertirse en patógeno de humanos, especialmente en poblaciones inmunocomprometidas, prevalentes en las zonas de influencia de los programas de erradicación (Jave, 2001).

III. DISENSOS CIENTÍFICOS SOBRE LA NOCIÓN DE "EVIDENCIA"

Un Paradigma Científico Actual y Transdisciplinario

La literatura científica sobre el empleo de aspersiones con glifosato y las correspondientes evidencias acerca de la destrucción causada a la salud y sus determinantes, tanto a nivel internacional como de la zona afectada, es fundamental para cuestionar los estudios pro-aspersiones y nos llevan a argumentar la necesidad urgente de reclamar, como punto de partida, la inmediata aplicación del Principio de Precaución, como obligación irrenunciable y condición de objetividad científica, base para demandar de los causantes la remediación y compensación inmediatas.

Los detractores de dicho Principio se sitúan en la orilla de las productoras y aplicadoras de sustancias o mecanismos peligrosos, mientras las instituciones cuya misión es la protección de la vida, han desarrollado una poderosa argumentación a favor. El principio se ha discutido en foros internacionales y en los debates, el argumento de "las pruebas científicas rigurosas" que los detractores demandan a los afectados antes de

acceder a suspender acciones y aplicar medidas correctivas, resultan una maniobra para convertir la "ciencia dura" en un concepto legal que corre en sentido inverso al del Principio de Precaución, argumentando, en definitiva, que es lícito demorar cualquier medida preventiva o prohibición de procesos peligrosos, hasta que no se hayan demostrado concluyentemente todos los eslabones de la llamada "cadena causal" y hasta que no se haya logrado el consenso científico (Von Weizsäcker, 2006).

De ahí que en esta parte del documento se plantean cinco elementos:

a. Adoptar un modelo interpretativo integral, para evitar el error científico de la noción reduccionista de asociación causal glifosato-enfermedad
b. Poner al descubierto los errores científicos y éticos de quienes abogan por las aspersiones
c. Sistematizar las evidencias científicas internacionales sobre la peligrosidad de las aspersiones en cuestión
d. Presentar las evidencias de impacto, recogidas por organizaciones ecuatorianas en las comunidades agredidas de nuestra frontera norte.

IV. LA FALSA NOCIÓN DE INOCUIDAD DEL ROUNDUP

Una Cadena de Errores Científicos y Desentendimientos Éticos

Las pruebas fraudulentas o sesgadas de la supuesta inocuidad para la salud de las formulaciones con glifosato.

La historia de los litigios relativos a la salud entre las empresas públicas o privadas que provocan contaminación u otros impactos y las comunidades afectadas, muestran un mismo patrón ampliamente documentado en la literatura científica y el cual parece repetirse ahora en el litigio por las aspersiones: las empresas –en este caso Monsanto- forjan datos de prueba favorables para sustentar la inocuidad de sus productos. Una vez en fase de utilización, las empresas recurren a operaciones de propaganda y, en caso de efectos nocivos, contratan o convencen a científicos para que las respalden y "demuestren" la inocencia de su producto. Las comunidades, siempre en desventaja, acuden a sus aliados para recoger pruebas de la destrucción causada, las cuales casi siempre terminan aceptándose tardíamente, cuando ya se ha provocado la destrucción masiva de la

salud (i.e. un caso demostrativo del tiempo que toma la lucha por corregir agresiones masivas es el del asbesto: en Inglaterra la minería comenzó en 1879 y recién 120 años más tarde las empresas reconocieron su peligro y fue prohibido (von Weizsäcker, 2006).

El caso citado recuerda el efecto de "quema de tiempo", mediante el argumento, recurrente en casos como éste, de que "hasta ahora no se ha demostrado con pruebas científicamente sólidas el daño producido". Las llamadas "pruebas científicamente sólidas" operan como un recurso para dilatar las cosas y se transforman en instrumento político ideológico, antes que científico (Levidow, 2004).

Con estos antecedentes miraremos el caso del Roundup, pues es urgente impedir que se consume ese mismo ciclo y se demoren las acciones de prohibición y remediación.

Tanto la vendedora (Monsanto) como el ente aplicador del sistema (Plan Colombia), sostienen estos argumentos:

a. Que se requieren mayores pruebas que contradigan las pruebas de inocuidad ya realizadas por el productor

b. Que se exageran los efectos por motivos extra científicos

c. Que de cesar la aplicación de los productos cuestionados, se estarían favoreciendo amenazas mayores, como el narcotráfico.

Procedimientos extra-científicos alrededor del registro y calificación del glifosato.

Mientras universidades y centros de investigación acumulan crecientes evidencias sobre la peligrosidad del glifosato para el ser humano y el medio ambiente, que han sido sistematizadas en revisiones de la literatura internacional (Bigwood, 2002), la empresa se ha empeñado en forjar una imagen de inocuidad de su producto.

En primer lugar, se registra una historia oscura desde el propio registro y calificación farmacológica del Roundup con glifosato. Los estudios toxicológicos requeridos oficialmente para su registro y aprobación estuvieron asociados con prácticas fraudulentas. En 1976, una auditoría realizada por la EPA descubrió serios errores y deficiencias en estudios conducidos por uno de los más importantes laboratorios norteamericanos involucrados en la determinación toxicológica del pesticida, previa a su registro. La EPA acusó públicamente a Industrial Biotest Laboratories (IBT) -laboratorio que condujo 30 estudios sobre glifosato y fórmulas comerciales en base a glifosato (entre estos 11 de los 19 estudios realizados respecto de su toxicidad crónica)- de falsificación rutinaria de datos y omisión de informes sobre incontables defunciones de ratas y cobayos. La EPA denunció, en 1991, que Craven Laboratories, empresa que condujo determinaciones para 262 compañías fabricantes de pesticidas, había falsificado estudios, recurriendo a "trucos", tales como forjar anotaciones de registros de laboratorio y manipular manualmente el equipamiento científico para que brindara resultados falsos.

Estudios sobre residuos de Roundup en papas, uvas y remolachas fueron parte de las pruebas cuestionadas. (Kaczewer, 2002)

Hasta el advenimiento de los cultivos transgénicos tolerantes al glifosato, el límite máximo de glifosato residual en soya establecido en EE.UU. y Europa, era de 0,1 miligramos por kilogramo. Pero a partir de 1996, estos países lo elevaron a 20 mg/kg, un incremento de 200 veces con respecto al límite anterior. Semejante aumento responde a que las empresas productoras de glifosato están presionando para que se les extienda permisos y se apruebe la presencia de mayores concentraciones de glifosato en alimentos derivados de cultivos transgénicos. Monsanto, por ejemplo, ya fue autorizada para un triple incremento en soya transgénica en Europa y EE.UU. (de 6 ppm a 20 ppm).

Por otra parte, la empresa ha recurrido a estrategias dolosas de comercialización. En Francia donde Gilles-Eric Séralini y Robert Bellé han investigado los efectos tóxicos in vitro y cancerígenos del Roundup-, se ha producido una condena formal en el Tribunal de Lyon, tras la denuncia presentada en el 2001 por la Asociación de Aguas y Ríos de Bretaña (Eaux et Rivières de Bretagne - ERB), ante el Ministerio del Medioambiente; así mismo, el Secretariado de Estado para los Consumidores acusó a Monsanto Agriculture France y a Scotts France, distribuidora en Francia del Roundup, de mentir en su publicidad, y aportó pruebas sobre el engaño inscrito en las etiquetas de seis diferentes productos de Monsanto conteniendo Roundup, cuyo principio activo es el glifosato.

En sus considerandos, el fallo condenatorio a pago de multa del Tribunal de Lyon explica que el glifosato no es biodegradable ni siquiera según las especificaciones del producto incluidas por Monsanto en el embalaje y, por tanto, tampoco deja el suelo limpio, peor aún teniendo en cuenta que se recomienda su uso permanente. Además, señaló que Monsanto y Scotts France conocían las características ecotóxicas del producto, pero que a pesar de ello difundían mensajes publicitarios engañosos "conteniendo argumentos ecológicos erróneos con el objetivo de hacer creer falsamente en la existencia de una inocuidad total e inmediata para el ambiente de sus productos". Esto, a pesar de que en el 2001 la Comisión Europea clasificó al glifosato como "tóxico para los organismos acuáticos" y capaz de "provocar efectos nefastos para el ambiente a largo plazo". Las dos principales moléculas del glifosato se encuentran presentes en el 55 y 35 por ciento de las aguas superficiales francesas.[5] En 1999, el fiscal de Nueva York también enjuició a Monsanto por publicidad engañosa.

5. El Le Monde (Hervé Morin, Marzo 13 del 2005) difunde en el mundo entero la noticia de la condena a Monsanto y la existencia de estudios en Francia: Gilles-Eric Séralini, en un árticulo publicado el 24 de febrero, en la revista "Environmental Health Perspective", demuestra, con su equipo de la Universidad de Caen, varios efectos tóxicos del glifosato y de los coadyuvantes que se le asocian para facilitar su difusión; también Robert Bellé de la estación biológica de Roscoff (CNRS), estudia desde hace varios años el impacto del glifosato sobre las células de erizo de mar, mostrando fases precoces de cancerogénesis del Roundup e impacto en etapas claves de la división celular.

Se rebate la supuesta inocuidad de las aspersiones aéreas y la ausencia de deriva. Reconocidos científicos especializados en la investigación de esta problemática han denunciado la peligrosidad de las aspersiones **aéreas en Colombia (Nivia, 2001b) y Brasil (Claro y Paganella, 2000).**

El propio manual de instrucciones de utilización del "Roundup" (nombre comercial del glifosato), elaborado por la empresa Monsanto, dice:

> *las aplicaciones aéreas deben evitarse si existe peligro de que el químico se ponga en contacto con especies deseables... cantidades mínimas de este herbicida pueden causar daños severos o destrucción de cultivos y plantas hacia las cuales no estaba dirigido el tratamiento. El riesgo de daño por Roundup es mayor cuando la velocidad del viento excede de 8 kilómetros por hora. Igualmente señala dicho instructivo, que "debe evitarse la contaminación de semillas y alimentos de consumo humano o animal".*

El estudio realizado en Colombia, por encargo de la Comisión Interamericana para el Control del Abuso de Drogas (CICAD), (Solomon et al., 2005), no sólo es producto de entidades con intereses vinculados –la propia CICAD, sino que, careciendo de un criterio independiente, contiene sesgos de diseño que han sido denunciados por el propio Instituto de Estudios Ambientales de la Universidad Nacional de Colombia (Sicard, et al., 2005). En efecto, según esta entidad, el estudio adolece de:

- Errores metodológicos generales: no posee una estructura científica con hilo conductor entre preguntas, hipótesis y demostración; excluye sorpresivamente los elementos sociales y económicos; se basa en estudios secundarios para estudiar los impactos del herbicida en la salud humana, y aún más, lo hace desestimando los estudios que reconocen su peligrosidad.

- El estudio desestimó expresamente los expedientes de más de 8.000 quejas interpuestas formalmente ante la Defensoría del Pueblo por comunidades afectadas en Colombia y que abarcan daños sobre la vegetación (87%), salud humana (6.9%) y el resto en especies animales y agua.

- El eje metodológico lo constituyen líneas de búsqueda destinadas a invisibilizar los impactos negativos más agudos y extensos: se escogió la fertilidad humana cuya latencia rebasa el período cubierto para ponderar efecto en la salud; no se enfoca el impacto en especies de cultivos lícitos; se soslaya el impacto en la destrucción del suelo; se esconde el hecho de que las zonas de cultivo ilícito son las que corresponden a áreas de alta biodiversidad; no proveen de datos sobre la concentración de glifosato en las aguas superficiales de la zona afectada. En definitiva el estudio cuestionado centra su mirada en efectos ecosistémicos poco estimables en lugar de concentrase en efectos directos y fácilmente estudiables como: destrucción de biodiversidad, eliminación de especies benéficas y erosión de suelos.

- Errores técnicos puntuales: para la valoración de impacto en aguas superficiales no se explican los criterios de selección de zonas de aplicación del herbicida; no se explicitan los parámetros de agrología y ecológicos que permitan valorar la dinámica del herbicida, ni los tiempos entre aspersión y toma de muestras.

En una comunicación oficial reciente (26/02/2007) del Gobierno de Afganistán, se explican las razones científicas de impacto humano, social y ecológico, por las que dicho Estado negó radicalmente el sistema de aspersiones aéreas con glifosato para el control de cultivos ilícitos de adormidera o amapola (Papaver somniferum) (Ashraf, 2007).

El problema de la deriva

La Empresa Brasileña de Investigación Agropecuaria (EMBRAPA), ha demostrado que existe normalmente una "deriva técnica" y que los actuales equipos de aspersión, con calibración, temperatura y vientos ideales, distribuyen sus aspersiones así: cerca de 32% son retenidas por las plantas blanco; 49% van al suelo, 19% van por el aire a otras áreas vecinas. De esta manera, las aspersiones afectan cultivos próximos y zonas habitadas, con lo cual se violan las normas de contacto en áreas con fuentes de agua, ríos y residencias, como lo prohibe el Código Forestal y la Ley de Agrotóxicos del Brasil (Chaim, 2004). Además, en dicho país han medido la deriva, estableciéndola, para vuelos de baja altura (4 metros sobre la capa vegetal), en 800 metros de distancia (Claro y Paganella, 2000). Tómese en cuenta que en Colombia se fumiga a una altura de entre 60 y 100 metros, según lo reconoce la misma Embajada de los EEUU. (Williams, 2003).

Leiva (2007), en su trabajo para la empresa Bayer, recuerda que, en 1974, Himel decía que "sólo el 25% del volumen (de herbicidas) aplicado llega a las plantas" y cómo este bajo porcentaje se debe a los problemas de la endo y exoderiva. La primera es la que cae en el suelo dentro del cultivo objeto, sin llegar a la planta, y la segunda es la que se desplaza fuera del área tomada como objetivo.

Los elementos que respaldan el argumento ecuatoriano sobre la derivan son:

El Tamaño de la gota

Las gotas con menor diámetro, si bien actúan mejor sobre las plantas, se mantienen más tiempo en el aire y sobre ellas puede actuar el viento que las puede desplazar a largas distancias, mientras simultáneamente sufren la evaporación. Las gotas gruesas si bien caen con más fuerza y rapidez disminuyendo la deriva, sin embargo, pueden rebotar en las hojas y perder el objetivo de actuar sobre ellas cayendo por escurrimiento. En este sentido se ha definido el llamado Diámetro Volumétrico Medio (DVM), como el tamaño de gota que divide la aspersión en dos volúmenes iguales; es decir, que el 50% del volumen asperjado lo hace en este tamaño de gota, mientras que el restante 50% es de tamaños muy diferentes. En cada aspersión es imposible que todas las gotas formadas tengan el mismo tamaño. El volumen que se ha demostrado más adecuado para aspersiones de cultivos lícitos (realizados apenas a 3 metros de altura) aconseja

el uso de gotas con un diámetro entre 200-250 µ, pues a partir de 350 "no hay adherencia y la gota escurre" como lo señala Leiva en su trabajo para la Bayer (2007). Pero sin embargo en Colombia, Solomon (2005) refiere que en el programa de aspersiones del PECIG[6] se utilizan gotas con un DVM entre 300 y 1.500 µ, margen demasiado amplio; además, a la altura real de las aspersiones y bajo las condiciones atmosféricas imperantes, con toda seguridad alta proporción de gotas será de menor tamaño y, por ende, de mayor deriva que el cálculo promedio teórico reportado.

La eficiencia del depósito de la gota

Dependerá de su tamaño y de la superficie de la lámina foliar vegetal. Por ello, se evitan las aspersiones aéreas en época de lluvia. Ya se ha comentado por qué las condiciones mesológicas alteran dicha eficiencia sobre la vegetación blanco, que es la de la coca, a expensas de otras vegetaciones.

La estabilidad atmosférica

En este apartado no sólo hay que tener en cuenta la velocidad del viento, donde según diferentes empresas se prohiben aspersiones entre 2.8 y 4.2 m/s (10 y 15km/h) (Bayer-Leiva), o entre 1.7 y 2.2 m/s (6-8 km/h) como lo reporta Pérez en su trabajo para la Syngenta: *Por grande que sea el DVM, si la velocidad del viento excede los 1.7 m/s (6 km/h), el arrastre es muy fuerte y en este caso es mejor parar la aplicación.* Lamentablemente, según los informes del INAMHI (Naranjo, 2006), se constata que en puntos representativos de la zona de frontera se dan vientos superiores a los que recomienda el modelo Syngenta. Así, en Nuevo Rocafuerte son de 1.8 a 2.4 m/s; en Lago Agrio de 1.5 a 2 m/s; y en Tulcán de 3.5 a 4.5 m/s, con predomnio de la dirección norte en los tres casos. Es decir, se están realizando aplicaciones con vientos que condicionan la deriva. Según datos promediales, en la zona norte de la región interandina y oriental se localiza, entre diciembre y febrero, una dorsal de alta presión continental del Atlántico Sur y del Caribe, que favorece la presencia de los vientos del norte, en el nivel de 850 hPa (1500m), con intensidad promedio de 12 m/s.

Hay que valorar también la temperatura y la humedad relativa que actúan directamente sobre las aspersiones con sustrato acuoso, como las del PECIG, que sufren de un mayor proceso de evaporación, el cual aumenta en ambientes más secos. Las aspersiones del PECIG suelen hacerse preferentemente en las épocas secas, entre diciembre y febrero, cuando la humedad es menor. Sirva como ejemplo que a igualdad de temperatura ambiente (30ºc) y humedad relativa (50%), una gota de 200 µ demora 42 segundos en reducirse a la mitad, mientras una de 100 µ tarda apenas 14 segundos en evaporarse (Leiva, 2007). Por esto, como medida de seguridad, se ha establecido que las aspersiones aéreas se realicen con temperaturas inferiores a 25ºc o con humedad relativa superior al 60%. Sin embargo, estas condiciones no siempre se cumplen en el PECIG.

6. Programa de Erradicación de Cultivos Ilícitos con Glifosato que aplica el Gobierno de Colombia.

Los campesinos refieren que las aspersiones se hacen incluso a medio día, cuando el sol es más fuerte. Un último punto a tener en cuenta es que a veces se pueden dar los denominados fenómenos de inversión térmica. En la atmósfera la temperatura disminuye aproximadamente un grado cada 100m de altura; esto hace que el aire frío, al bajar, ayude a asentar las aspersiones. En las inversiones térmicas, cuando las capas de aire caliente se mantienen arriba, las aspersiones pueden permanecer suspendidas en el aire por períodos prolongados y derivar largos trayectos en presencia de pequeñas brisas. Sin embargo, Solomon (2005) plantea que la velocidad del viento, medida desde los helicópteros por el humo generado de las aeronaves de aspersión, es suficiente indicador para medir derivas.

La evaporación

Depende, en las mezclas con agua, de las altas temperaturas, de la baja humedad relativa y del tamaño de la gota. Syngenta reconoce que *"la evaporación también trae como consecuencia la disminución en el tamaño de la gota, lo cual permite un mayor arrastre y puede ocasionar: contaminación humano ambiental y daño a cultivos susceptibles"*. Se ha de tener en cuenta que la disminución del peso de la gota por unidad de tiempo, tiene relación con la disminución del tamaño de la gota por la evaporación.

La altura de vuelo del avión

Normalmente las aspersiones aéreas se realizan entre 1,5 y 4metros sobre la capa vegetal a asperjar, altura que se pretende sea la menor posible, pues a mayor altura las posibilidades de deriva aumentan. La propia DNE recomienda una altura de vuelo de menos de 25metros para la coca. No obstante, debido a la orografía y al temor de que las avionetas sean derribadas, este parámetro nunca se cumple, y las aspersiones se realizan, según la DNE, por encima de los 30metros de altura. Las filmaciones y fotografías demuestran, sin embargo, que estas se realizan a no menos de 60 metros e incluso, según la Embajada de Estados Unidos en Bogotá (Williams, 2003), entre 60 y 100metros de altura.

El motivo de que en el programa del PECIG se estén utilizando concentraciones tan altas de químicos (23,65 l/ha) se debe precisamente a lo que Bayer (Leiva, 2007) reconoce como máximo volumen, aplicable cuando, por razones de deriva incontrolada, debe asegurarse la cobertura requerida, solo que en el PECIG este máximo volumen es lo que se usa sistemáticamente. Obtener una cobertura de 30 gotas/cm2 se puede hacer con un volumen de 5,3 litros/ha, asperjando gotas de 150µ o con 42,4 litros/ha, utilizando un tamaño de 300µ (Leiva, 2007). Así, mientras la Bayer, citando a Leiva (2007) aconseja que a más de 25ºc y menos de 70% de humedad, se suspendan las aspersiones por las altas pérdidas de producto por la evaporación, Syngenta (Pérez, sf) sin embargo, aconseja que para asegurar la cobertura de las aspersiones a temperaturas entre 28ºc y 32ºc con humedades relativas menores al 70%, no se deben utilizar volúmenes de aplicación por debajo de 9 galones/ha.

En definitiva, por parámetros de vuelo, por elementos climáticos, por volúmenes y concentraciones

intencionalmente altos, y por las características del paquete que se asperja, hemos establecido la falacia de los cálculos de inocuidad y poca deriva, que se han argumenrtado sobre bases de análisis equivocadas.

Contrariando argumentos científicos probados, en una carta dirigida por el coronel Plazas Vega (2004), como director de la Dirección Nacional de Estupefacientes de Colombia, a la entonces Comisión Científica del Ecuador, menciona que se adopta el modelo matemático recogido por Syngenta (Pérez) para medir la deriva (D), donde ésta es proporcional a la altura (H) y a la velocidad horizontal del viento (U), e inversamente proporcional a la velocidad terminal de la gota (Vt), aplicando la siguiente fórmula:

$$D = \frac{H \times U}{Vt}$$

La fórmula, no tiene en cuenta la temperatura ambiente ni la humedad, ni mide el proceso de evaporación a una altura de entre 60 y 100metros, ni las inversiones térmicas, ni la velocidad del avión en marcha, que influyen en la velocidad inicial de la gota. Además, uniformiza el tamaño de las gotas, sin tener en cuenta que sólo la mitad del volumen (DVM) corresponde con el indicado. Presentada como verdad incuestionable, llega a afirmar que la deriva máxima, para una altura de 25m x 1,3 m/seg (equivalente a un viento de 4,8 km/h), dividido por una velocidad terminal de 2,7 m/seg, para una gota promedio de 650 µ, da un máximo de deriva de 12 metros.

Sin embargo, la misma empresa Syngenta (Pérez), en el documento consultado por el coronel Plaza, reconoce que gotas de 5µ pueden permanecer en el aire 66 minutos y desplazarse 4.827 metros siendo lanzadas a una altura de 3 metros:

Tabla 2
Arrastre o Deriva de una gota lanzada a 3 metros de altura

Tamaño de gota (µ)	Tiempo necesario para caer 3 metros	Arrastre con una velocidad de 4,8 km/h
5	66 minutos	4.827 m
20	11,58 min	338,2 m
50	72,8 seg	54,29 m
100	11 seg	14,64 m
400	4 seg	2,59 m
1000	0,75 seg	1,48 m

Fuente: Pérez, Horacio. Syngenta

Estos tiempos y distancias son para una altura de 3 metros. En el PECIG, donde se usan alturas de 60 a 100 metros, se pueden esperar mayores distancias en condiciones atmosféricas apropiadas. Estas condiciones son tan determinantes que en cada unidad de tiempo la gota puede disminuir su tamaño. Syngenta sostiene, en la siguiente tabla, que la influencia de la temperatura y la humedad es importante:

Tabla 3
Tiempo de duración de las gotas de agua en el aire en diferentes condiciones

Tamaño de la gota en µ	Temp. 20°c – 22°c y Humedad relativa 80%	Temp. 30°c y HR de 50%
50	15 seg	3,5 seg
100	50 seg	14 seg
200	200 seg	56 seg

Fuente: Pérez, Horacio. Syngenta

La fórmula a la que se refería el coronel Plaza iba acompañada, en su documento, de la ley de Stokes para la velocidad terminal (Vt) de la gota, expresada en la siguiente fórmula:

$$Vt = \frac{G \times D2 \times W}{18A}$$

Esta ley establece que las gotas alcanzan una velocidad constante de caída en función de la aceleración de la gravedad (G) en m/sg, el diámetro de la gota (D) en µ, y la densidad de la gota (W) en kg/m^3, siendo inversamente proporcional a la viscosidad del aire (A) en newton-seg/m^2.

Sobre esta velocidad terminal Syngenta (Pérez) establece un cuadro orientador:

Tabla 4
Velocidad de sedimentación de las gotas en función de su tamaño

Tamaño de las gotas en micras (µ)	Velocidad terminal (cm/seg)
1.000 = 1mm	400
500	220
200	72
150	48
100	26
90	21
50	7
20	1,2
10	0,3

Fuente: Pérez, Horacio. Syngenta

Sin embargo, la empresa advierte que estas son las características para una gota lanzada con aire en calma y sin evaporación; y lo que pretende demostrar es que las gotas menores de 100 µ alcanzan el equilibrio entre la fuerza de gravedad y el rozamiento con el aire en menos de 25cm de caída, manteniendo una velocidad constante, mientras que en las gotas superiores de 500 µ la velocidad terminal se alcanza a los 70 centímetros. Pero, la caída desde la altura que está siendo utilizada en Colombia, debería aplicar correcciones, dado que el tamaño de la gota es diferente desde que es asperjada hasta que cae al suelo, medición que la fórmula no incluye, como tampoco incluye la influencia de la velocidad inicial de la gota ni las condiciones atmosféricas, cuando queda demostrado que son determinantes.

Las afirmaciones del Director de la DNE a la Comisión Ecuatoriana sorprenden, dado que son posteriores al ensayo realizado en el 2000 ante la prensa y el congresista norteamericano Paul Wellstone, quien recibió un "baño de glifosato" cuando fue invitado a presenciar la demostración de las "precisiones técnicas" de las operaciones aéreas de la fumigación. El escaso viento arrastró el herbicida hasta el sitio en el que se encontraban todos los invitados, a unos 200 metros, demostrando la poca fiabilidad en la precisión de las fumigaciones (Hotakainen, R., 2000).

Sorprenden también porque cinco años antes, Nivia (1999) describe cómo en aplicaciones terrestres, entre el 14% y el 78% del glifosato aplicado sale del sitio, describiendo muertes de plantas a más de 40 metros y encontrando residuos a 400 metros de una aplicación terrestre. En aplicaciones con helicóptero describe cómo las pérdidas de glifosato desplazado fuera de sitio oscilan entre el 41 y 82%, encontrándolo en mediciones a más de 800 metros de su punto de aplicación. Situación que se agrava con los aviones pues un estudio en California encontró residuos a 800 metros, que fue la mayor distancia estudiada.

En recientes estudios, en Costa Rica y California se han encontrado residuos de pesticidas en zonas de bosques lluviosos a más de 20 km de distancia de donde se encuentran los granjas agrícolas (Minard, 2007). Los estudios han encontrado no sólo niveles 10 veces más altos de pesticidas en las charcas de las ranas, sino en los cuerpos de las mismas, lo que supone que puede ocasionar la muerte de más del 90% de esas poblaciones. Lo cual se explica por la vaporización de estos productos, que al ser utilizados y llegar a las capas más frías de la atmósfera, vuelven a la fase líquida y, con la lluvia, se concentran en lugares en donde habitan estos anfibios.

En un boletín reciente de la Red de Acción sobre Plaguicidas en América Latina (Bellé, 2007), se publica una entrevista realizada a uno de las mayores autoridades científicas en la investigación de los impactos del glifosato, el Dr. Roberte Bellé, del Centro Nacional de la Investigación Científica de la Universidad Pierre y Marie Curie, de Francia, quien sostiene textualmente:

El problema es que cuando se pulveriza en avionetas o hasta con un atomizador manual, la mezcla es cien veces más concentrada que aquella que puede desregular el funcionamiento de la célula. Cada microgota puede tocar miles de células simplemente cuando las respiramos, y si esas microgotas son pulverizadas en avión pueden viajar cientos de kilómetros. Cuando se fumiga en un jardín, las gotas pueden recorrer entre 2 y 3 km, si hay viento. Monsanto recomienda no fumigar cuando hay viento, pero es imposible porque siempre hay viento. También recomienda el uso de máscara, encauchado, botas y guantes. El que fumiga está protegido, pero los que están a 500 m no lo están.

Una fumigación aérea es otra cosa. Es una catástrofe. Se ha demostrado que hay arena del Sahara en el Polo Norte, y un grano de arena es más grande y pesado que una microgota. Las microgotas de pulverización son casi como el vapor de agua, que viajan simplemente con el movimiento de la tierra, como las nubes. Es una locura pulverizar con avión.

Hacia un manejo ético y científico de la incertidumbre

Hace aproximadamente tres décadas surgió en el mundo la preocupación sobre el desfase entre la ciencia y los problemas de salud y ambientales. La ocurrencia de episodios lamentables de impactos provocados por procesos industriales urbanos o agroindustriales con empleo de productos como ciertos agrotóxicos, que habían sido proclamados como seguros, más la creciente incertidumbre sobre nuevos procesos y productos hechos por el ser humano pero poco conocidos en sus efectos sobre la vida, pusieron en el debate un hecho que podría resumirse así: la ciencia raramente entrega evidencias concluyentes y, las decisiones para proteger la vida en el planeta y la salud deben tomarse antes de disponer de conclusiones definitivas basadas en pruebas reconocidas universalmente como concluyentes.

A partir de esa época se han multiplicado los conocimientos sobre este problema, en contextos más responsables en el plano social y ambiental y ha crecido una voluminosa base bibliográfica que empieza a ser sistematizada junto a la necesidad de revisar en forma crítica tanto los paradigmas científicos y las lógicas de gobernanza, cuanto los contextos institucionales que han defendido, hasta ahora, una ciencia desfasada e insensible. El escenario de los debates sobre políticas, normas constitutivas, fijación de estándares y regulaciones para protección de la vida de la Unión Europea, conforma una experiencia de enorme utilidad, pues más de una década de discusión y elevada polémica han permitido decantar los puntos clave de la crítica contra una visión científica ciega a las necesidades de

la sociedad y aferrada a un paradigma que usa la incertidumbre como herramienta para justificar la permisividad, anteponiendo el interés de empresas al bien común y a la protección de la vida (Guimaraes *et al.*, 2006).

En América Latina tampoco han sido solamente las organizaciones sociales pro salud y ambientalistas las que han alimentado una discusión sobre los problemas del vículo entre ciencia, sociedad y formulación de políticas, sino que un amplio conjunto de núcleos científicos y académicos constituyeron una importante corriente de reflexión crítica al respecto, una de cuyas expresiones ha sido la Asociación Latinoamericana de Medicina Social (ALAMES). En esta red académica y de reflexión socio médica toman parte varios de los más destacados centros de investigación de la región.

En el centro de este movimiento científico y social mundial está la crítica a un paradigma científico reduccionista y lineal que fragmenta y descontextualiza los problemas de salud y ambientales; empobrece la observación científica, reduciéndola a evidencias cuantitativas, supuestamente precisas, y reduce la noción de prueba científica a la demostración de asociaciones factuales (Breilh, 2004).

Dicho paradigma científico ha facilitado la hegemonía de un modelo estrecho de "toma de decisiones basadas en la ciencia" que utiliza la incertidumbre como recurso de expiación de culpa, como instrumento de maniobras ligadas a intereses estratégicos y como obstáculo para la aplicación del principio de precaución (Craye, 2006).

El modelo cuestionado opera así: la adopción de políticas se basa sólo en evidencias "concluyentes" y "ciertas". Las otras evidencias son no concluyentes y resultan de falta de conocimiento y falencia provisional de datos base. La solución para la falta de evidencias concluyentes se resuelve con más investigación. Este camino implica el registro de datos cuantitativos probabilísticos precisos y solamente se actúa cuando se dispone de este tipo de "certezas" (Craye, 2006).

A lo largo de los años, controversias ambientales y sanitarias han generado cuestionamientos científicos a ese modelo de relación entre ciencia y toma de decisiones, justamente en problemas como el que ahora enfrentamos los ecuatorianos –proximidad a aspersiones con un paquete herbicida que incluye glifosato- y en casos provocados por agresores semejantes, sobre los que existen puntos de incertidumbre (i.e. químicos, disruptores endocrinos, dioxinas, organismos genéticamente modificados, radiaciones, etc.). Se ha hecho evidente que las controversias no se producen esencialmente por la falta de información factual concluyente y que no se resuelven con un poco más de investigación, sino que son el producto de la complejidad del problema, de la existencia de perspectivas o visiones científicas y sociales opuestas; y lo que es muy importante, que se dan en contextos institucionales cruzados por intereses encontrados (los de las empresas causantes y los de la población afectada) (Craye, 2006).

La experiencia europea, en estas dos últimas décadas, nos permite comprender que si queremos desarrollar un modelo científicamente objetivo y éticamente justo tenemos que superar el encuadre que hemos explicado. Un punto central es superar la *falsa noción de incertidumbre*, que supone falta de más investigación, y reconocer que la complejidad de nuestros problemas va de la mano con formas más profundas de incertidumbre, que no se reducen a lo que se expresa en términos probabilísticos. Así, varios científicos han demostrado que existe también *ignorancia* (no sólo no tener bases para estimar probabilidades de daño sino desconocer impactos que puedan darse en un contexto específico) (Funtowicz y Ravetz, 1990); *indeterminación* (por la acción imprevista de sistemas no predecibles) (Wynne, 1992); y *ambigüedad* (no hay acuerdo sobre los significados precisos del tema o son confusos) (Wynne, 2001).

Queda claro entonces, que las evaluaciones científicas sobre los impactos de las aspersiones aéreas deben distanciarse de etse modelo científicamente falente y éticamente irresponsable.

V. EL SISTEMA DE ASPERSIONES AÉREAS Y SU IMPACTO EN LAS CONDICIONES DE VIDA Y SALUD

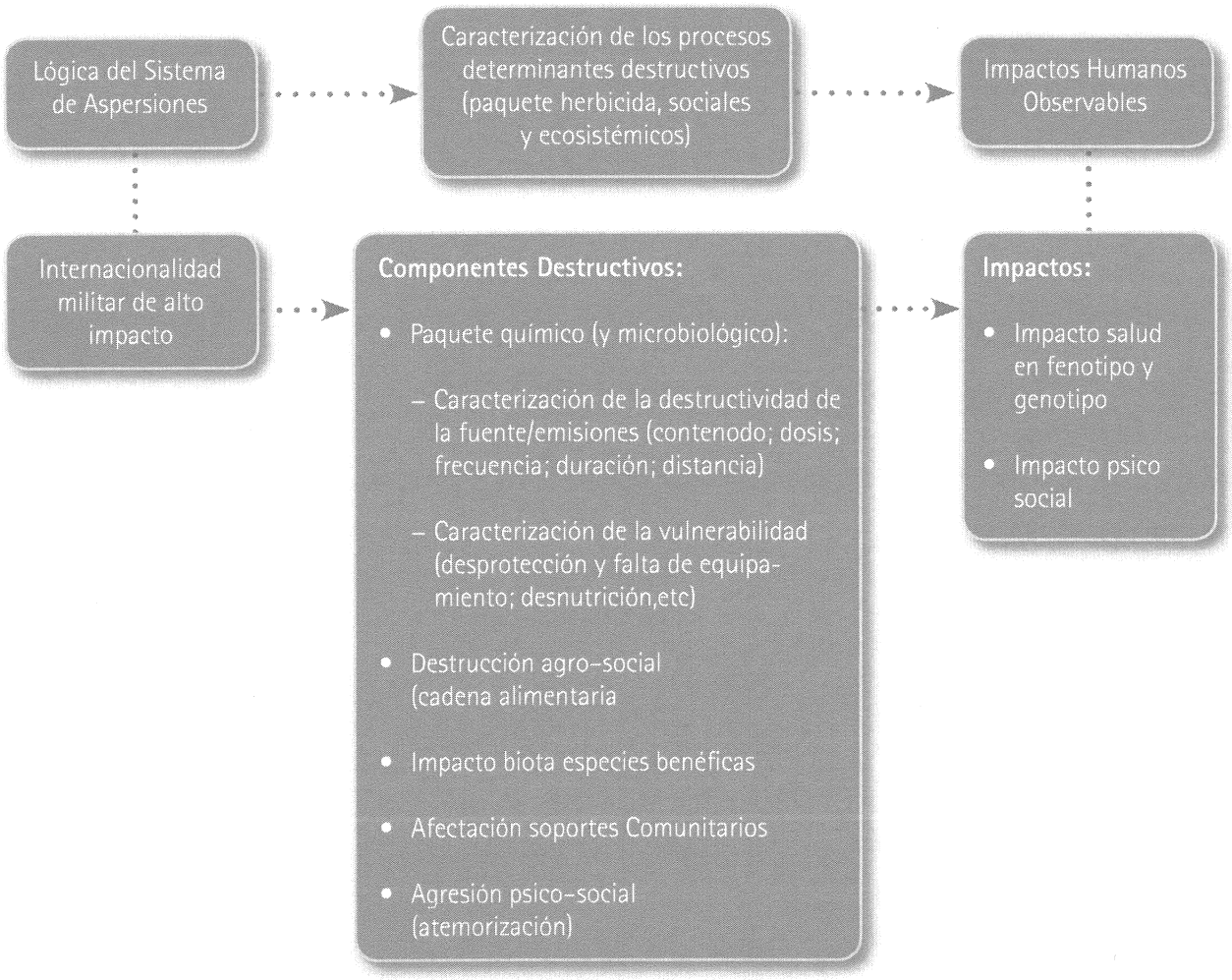
La Noción de Determinantes de La Vida y La Salud como Marco de Estudio

La investigación epidemiológica de un proceso destructivo implica el estudio de un sistema de relaciones -con sus evidencias empíricas-, que explican la conexión que se da entre los elementos que generan una nocividad colectiva, los procesos determinantes de la salud y los diversos impactos generados.

La Organización Mundial de la Salud establece un modelo sobre la determinación de la salud (Commission on Social Determinants on Health, 2005), que debe aplicárselo en la investigación de afectaciones colectivas de la salud, como las que padecen las poblaciones de la franja fronteriza norte del Ecuador, a raíz del inicio del sistema de aspersiones aéreas.

El presente análisis asume entonces la noción de *determinantes de la salud* (Marmot, 2005; Breilh, 2004), como marco lógico para estudiar el sistema de relaciones que permiten comprender los daños operados en la población ecuatoriana de frontera y las vías de determinación de los mismos. (Ver diagrama **siguiente).**

Modelo para Estudiar Impacto del Sistema de Aspersiones Aéreas



El análisis epidemiológico del sistema de aspersiones confirma su diseño de alto impacto y elevada peligrosidad.

* **Lógica del sistema:** no accidental, sino intencional bajo modalidad de alto impacto.
* Destructividad del sistema

Contenido de paquete fuente/emisiones: Glifosato, N-(fosfonometil) glicina herbicida de amplio espectro, no selectivo, que se aplica en paquete con otros componentes peligrosos (como mínimo POEA, Cosmo Flux 411F) y bajo modalidad de aspersión aérea de altura, con efecto múltiple y atemorizante (ya descrito).

"Dosis"/magnitud de las aplicaciones: concentraciones altas que se corroboran por la corta latencia del efecto. En las entrevistas a informante claves de la población de

Mataje[7] se establece lo siguiente sobre la última incursión aérea:

- Flotilla de seis avionetas y cinco helicópteros.
- Número de vuelos observados: la mayoría reconocen 3 y otros 5.
- Demoraron entre 4 y 5 minutos en cada repaso, cubriendo todo el horizonte.
- Distancia: los informantes en la población de Mataje se encontraban entre 700 a 1000 metros de distancia durante la última aspersión.

En el caso de aspersiones del 2002 (Maldonado, 2002), para verificar la distancia de las fumigaciones efectuadas en la frontera, la misión de verificación se adentró en territorio colombiano y, con un equipo de GPS procedió a identificar las zonas fumigadas en Colombia y su distancia del Río San Miguel, dando los siguientes resultados:

Tabla 5
Puntos de GPS y distancia a la frontera desde Colombia

Lugar	Punto	Elevación	18° Norte	UTM	Distancia a Ecuador
La Pedregosa (Col)	7	248 m	0317989	0029601	6m
Nueva Granada (Col)	8	266 m	0318341	0031095	1.412 m
Nueva Granada (Col)	9	275 m	0318295	0031318	1.635 m
La Pedregosa (Col)	10	270 m	0318088	0030359	706 m
Los Cristales (Col)	14	270 m	0333976	0037515	8.285 m
Aguas Blancas (Col)	15	276 m	0332612	0035459	6.981 m
Aguas Blancas (Col)	16	292 m	0332616	0035463	6.986 m

- Altura estimada: alrededor de 100 m; 30 m sobre dosel
- Emisiones: mayoría reconoce que fueron abundantes y de color blanco, para uno fueron muy abundantes y de color verde oscuro.

7. Entrevistas en la población de Mataje (Esmeraldas) el día miércoles 21 de febrero, es decir a los 16 días de la última aspersión aérea por la aviación de Colombia.

En dicho estudio realizado para el área del Putumayo se estableció además lo siguiente: las fumigaciones aéreas, dentro del marco del Plan Colombia, comenzaron oficialmente en el departamento del Putumayo el 22 de diciembre del 2000. Hasta el 28 de enero del 2001 se fumigaron alrededor de 29.000 hectáreas; durante el 2001 se fumigaron 94.000 ha, según la embajada de Estados Unidos en Colombia. La administración norteamericana planeaba ampliar el área de fumigación a 150.000 ha durante el 2002 y a 200.000 ha para el 2003, lo que exacerbaría los impactos socio-ambientales y a la salud humana de las poblaciones de frontera.

La investigación permitió testimoniar y establecer un registro preciso de las operaciones de aspersión ya en el 2002, como lo destaca el estudio antes citado.

TESTIMONIOS DE ASPERSIONES EN EL AÑO 2002

En La Pedregosa (punto 7), a seis metros del río San Miguel, se encontraron signos de cultivos destruidos por las fumigaciones, posiblemente por la deriva aérea.

En el punto 10 se observaron severos impactos, dado que las fumigaciones se hicieron directamente sobre el área y a 706 metros de distancia de la frontera.

En el recinto Nueva Granada (puntos 8 y 9), a 1.600 metros de la frontera, los testimonios de la población informan que, entre el 30 de agosto y el 6 de septiembre, los aviones fumigaron directamente sobre las casas. Como evidencia de ello, se observaron en la cancha de fútbol, situada en el centro del poblado, grandes círculos de clorosis. La profesora de la escuela manifestó que sus 35 alumnos se enfermaron con dolores de cabeza, lagrimeo y fiebre.

En Aguas Blancas (puntos 15 y 16), a una distancia de 7 a 8 km de la frontera, se comprobó la destrucción de todo tipo de cultivos.

En Los Cristales (punto 14), se obtuvieron testimonios acerca de que las avionetas pasaron por encima de las casas y fueron rociados el 1 y 18 de agosto del 2002, sin consideración de que se estaban afectando las viviendas, cultivos alimenticios y fuentes de agua.

En La Playera Oriental y Chone 2 (entre 1 y 1.257m de la rivera del río San Miguel) se observaron evidentes daños derivados de las fumigaciones realizadas el 6 de septiembre del 2002, en el lado colombiano, en las orillas del río San Miguel.

En todos los puntos, se tomo muestras de suelo y vegetación, se obtuvo datos de salud de la población y testimonios sobre los impactos sociales.

Patrón de Exposición

En el caso de Mataje todos los entrevistados se encontraban en la localidad (1 en el patio de guardería, 2 en el río lavando, otro en el exterior frente a la playa del río); varios sintieron los efectos casi inmediatamente en la piel :"una sensación de hormigueo" y luego comenzó la "rasquiña", e irritación de los ojos; otros sintieron comezón luego de estar en el río un rato ese día; todos ingirieron agua del río o fuentes de la zona; todos tuvieron contacto del agua con la piel en ese mismo día y posteriores. Además, reportaron haber registrado en la familia y en familias vecinas casos de diarrea, mareos y a los pocos días algunos niños desarrollaron conjuntivitis purulenta. En familias entrevistadas 2 casos de estados respiratorios agudos. La enfermera de la localidad ha procurado atender esta casuística.

En el caso de aspersiones anteriores, el estudio de Maldonado (2002) estableció el mismo patrón de evidencias que en Mataje. La Asociación de Campesinos "Santa Marianita" (Ordóñez, 2002) de la Parroquia General Farfán, con 27 socios, denuncia que tras las fumigaciones recientes en Colombia sufren "de enfermedades en la piel y los ojos, infecciones respiratorias, fiebres semejantes a las del paludismo, pero con análisis siempre negativos. Los animales hembras mal paren y tenemos una baja en la producción de maíz, cacao, arroz, plátanos, hasta no poder recuperar la inversión". La comunidad Chone 2, Puerto Nuevo y La Playera, en la vía Tetetes, parroquia de Pacayacu, denuncian daños en sus cultivos y en los animales. De igual manera se habla de graves daños y problemas a la salud en la comunidad fronteriza de Cohembí.

Protección y vulnerabilidad de la población

También en el caso de las aspersiones más recientes en Mataje, todos los entrevistados refirieron que fueron sorprendidos; se encontraban con brazos y piernas descubiertos; algunos ingresaron por breve tiempo a sus desprotegidas casas, pero debieron salir y aun ir al río en ese mismo día y posteriores. En los niños afectados de la zona se encuentran signos de desnutrición crónica.

Existe en la frontera de Ecuador con Colombia un mayor nivel de desnutrición en la población escolar que la presentada en una población igual pero a más de 20 km de la frontera. La desnutrición, crónica, aguda y global, son superiores en la población a menos de 10 km de la frontera y que en reiteradas ocasiones han recibido los impactos de las fumigaciones del Plan Colombia. La situación de violencia que se vive en la frontera, se aumenta en este sector de la población ecuatoriana por un componente más: el miedo. Miedo, estrés y desnutrición son una carga demasiado pesada para una población sin ayuda, de la cual ha huido, en los últimos 5 años, el 56% (Maldonado, 2006).

Destrucción Agro–Social y Pérdidas de Recursos Alimentarios

En enero del 2001 la prensa nacional se hizo eco de los impactos en la Provincia de Sucumbíos, por las fumigaciones de diciembre (*El Comercio*, Quito, 12/01/01).

Meses más tarde, 188 campesinos de diferentes comunidades presentaron una denuncia a la Defensoría del Pueblo de Lago Agrio; trámite que pasó a la Defensoría de Quito donde se detuvo su avance. En esta denuncia se recogían las demandas de campesinos de las parroquias de General Farfán, Nueva Loja, Pacayacu, Dureno y Tarapoa. La demanda recogía las siguientes pérdidas:

Tabla 6
Daños a los cultivos y animales en Sucumbíos (Ecuador) 2001

Cultivos	Número hectáreas dañadas	Porcentaje	Animales	Número animales muertos	Porcentaje
Café	1.215	47.4%	Peces	6.355	53.7%
Potrero	785	30.6%	Gallinas	4.681	39.6%
Plátanos	182	7.1%	Chanchos	315	2.7%
Arroz	103	4.0%	Vacas	188	1.6%
Maíz	87	3.4%	Cuyes	117	1.0%
Cacao	79	3.1%	Patos	73	0.6%
Frutales	53	2.0%	Perros	49	0.4%
Yuca	51	2.0%	Caballos	43	0.4%
Total	2.560		Total	11.828	

Impactos semejantes, como se verá inmediatamente, han sido reportados por organizaciones sociales e indígenas de Colombia

Una comisión de verificación (ADUC, 2003) al departamento de Arauca (al norte de Colombia - frontera con Venezuela) en el 2003, reportó importantes pérdidas económicas y efectos en la nutrición de la población:

- *"La fumigación aérea se hace de forma indiscriminada, afectando directamente a sectores que no tienen cultivos ilícitos, por el contrario, los plantíos más afectados son los destinados a*

la subsistencia de los habitantes de la región, así como a los hábitat naturales cercanos a los sectores fumigados (...) No hay una directa erradicación de los cultivos ilícitos, han sido fumigados los cultivos de pancoger, afectando la alimentación y la subsistencia de la región".

Tres años antes se acabó con un proyecto de achiote para la elaboración de tinturas para exportar a países europeos (Puyana, 2007)

En Nariño, la Personería Municipal de Buesaco elaboró un informe (Cabrera, 2003) en que profesionales universitarios, miembros de la Secretaría de Agricultura y Medioambiente de Nariño, el coordinador de la UMATA municipal y profesionales de ese municipio lo recogen así:

- *"Se pudo constatar que los mencionados sectores no tienen presencia de cultivos ilícitos y que los cultivos fumigados corresponden a cultivos lícitos de pancoger (...) las avionetas del gobierno asperjaron sus cultivos de pancoger y destruyeron su único medio de subsistencia".*

Representantes del Pueblo Kankuamo (Rodríguez, 2003), asentados en la Sierra Nevada del departamento de Santa Marta (costa norte atlántica de Colombia) han denunciado como:

- *"Árboles frutales como el aguacate, la naranja, el limón, etc., ya son productos escasos en esta zona, debido a muchas fumigaciones que se han hecho, tenemos enfermedades en plantas medicinales, (...) enfermedades en los animales, estamos sufriendo las mismas consecuencias que el sur de Colombia, la muerte de caballos, burros, vacas, chivos, cerdos,... y de animales silvestres de los cuales nosotros nos mantenemos".*

En agosto del 2000 cultivadores de palmito agrupados en "Agroamazonía" parte del proyecto oficial PLANTE y financiado por USAID en el Putumayo, reportaron las pérdidas de 100 hectáreas de cultivos con destino a la planta procesadora de Puerto Asís y a la cadena de supermercados Carrefur, por valor de 300 millones de pesos. (Puyana, 2007).

La Organización Nacional Indígena de Colombia (ONIC, 2007) ha manifestado que a pesar de que la sentencia SU 383 del 2003 obliga al Estado a la consulta sobre las fumigaciones en territorios indígenas, se sigue fumigando y en los sitios afectados por las fumigaciones aéreas se ha generado que las familias queden desamparadas y sin posibilidades económicas, pues la fumigación de una hectárea de coca deja 10 ha dañadas a su alrededor.

El cabildo Embera (2006) denunció a la Defensoría del Pueblo que las comunidades de San Antonio, La Danta, y San Juan están con hambre, sin cosecha, sin semillas y sin saber qué comer porque hasta el río fue fumigado y los peces murieron.

Todas estas afectaciones son, como hemos dicho, semejantes a las sufridas por los ecuatorianos en la frontera. Las comunidades de Chone 2, Playera

Oriental, Yanamarum, Puerto Nuevo, Chanangué, Santa Marianita, Puerto Mestanza, 5 de agosto, Monterrey, La Frontera, Corazón Orense, El Trampolín, San Francisco 1, San Francisco 2, San Pedro del Cóndor, 10 de Agosto, Nuevo Mundo, Salinas,... son nombres de una larga lista de comunidades que han recibido los impactos de las fumigaciones al interior del Ecuador.

En la zona de Mataje surgen iguales reclamos. Cinco familias que vivían de la pesca se han visto obligadas a dejar esa actividad o la han visto dramáticamente mermada, pues según expresan los entrevistados en 2007, ya no se consigue el camarón de río ni la minchilla, cuya pesca era un renglón alimentario y de supervivencia importante. (Comisión Científica Ecuatoriana, 2007).

La Comisión Científica Ecuatoriana registró otros impactos en la vida cotidiana de los pobladores de Mataje. En la siguiente tabla se sistematiza los testimonios recogidos, en lo referente a los cambios que las aspersiones han significado en su vida cotidiana, especialmente en el uso del tiempo y del espacio.

Tabla 7
Impactos de las aspersiones de glifosato en la frontera colombo ecuatoriana

ACTIVIDAD	PROBLEMA PRODUCIDO POR LAS ASPERSIONES	CAMBIO EN EL USO DEL TIEMPO	CAMBIO EN EL USO DEL ESPACIO	PERJUCIOS A LA POBLACIÓN
Agricultura	Con las aspersiones se han dañado muchos cultivos, especialmente de plátano y yuca. Cuando sobrevuelan los aviones se queman los cultivos. Unas semanas más tarde, cuando se quiere volver a sembrar, los cultivos no prosperan. El suelo pierde su fertilidad. En otros caso se reporta que los cultivos se secan desde la raíz hacia arriba.	Muchas personas han abandonado la agricultura debido a los impactos de las aspersiones en los cultivos.	UDENOR ha entregado a algunos campesinos cacao, pero no están seguros que va a resultar un cultivo rentable o si van a tener mercado. El cacao es sembrado en las tierras dedicadas a cultivos de subsistencia como el plátano (alimento básico), yuca, caña.	Debido a la destrucción de cultivos, los pobladores que antes vendían plátano en San Lorenzo, ahora tienen que comprarlo. Lo mismo sucede con otros cultivos.

Pesca	En las aspersiones del año pasado, el río se llenó de camarones y peces muertos. Las poblaciones naturales del camarón de río no se han recuperado.	Las personas que se dedicaban a la recolección de camarón de río han tenido que dedicarse a otras actividades.	El río ya no es utilizado para la recolección de camarón de río. Las poblaciones de pescado de agua dulce también se han reducido.	La pérdida de las poblaciones naturales de camarón han afectado económicamente a las personas que se dedicaban a esta actividad. Ellos, trabajando 3 días a la semana tenian ganancias de $80 dólares. Los habitantes ya no pueden incluir en su dieta normal al camarón.
Cacería	Las aspersiones han ahuyentado a animales de caza.	Los hombres ya no pueden salir de cacería.		Disminución de fuentes de proteínas.
Actividades domésticas	Contaminación del río. Las mujeres lavan la ropa en el río. UDENOR les ha dotado de agua entubada, pero ésta tiene un costo, por lo que prefieren lavar en el río.	Muchas mujeres dejan de lavar la ropa durante el período de las fumigaciones para que no les afecte su salud. Esto significa un recargo de trabajo cuando el grado de contaminación disminuye.	Otras mujeres han dejado de lavar en el río y usar agua entubada.	Las mujeres tienen que lavar la ropa con agua entubada, dejar de lavar durante el período de fumigaciones, o enfrentar los problemas de salud debido a la contaminación presente en el río
Socialización	Un espacio de socialización es el río. Ahí las mujeres van a recoger agua para múltiples actividades.			Con la contaminación del río, disminuyen los espacios de socialización.
Recreación	Los niños del pueblo juegan en el río. Cuando ellos están en el río durante las aspersiones, entran en contacto directo con los químicos.	Los niños tienen que dejar de jugar durante el período de las aspersiones.	El río deja de ser el espacio de recreación de la niñez.	Esto genera impactos sicológicos en los niños.

Salud	Las aspersiones han afectado a todas las personas que estuvieron expuestas a los químicos y a los que consumieron productos contaminados.	La gente ha tenido que dedicar tiempo para ir al centro médico (donde sólo hay una enfermera y ocasionalmente un médico) y en casos de más gravedad, han ido a San Lorenzo.		Los impactos en la salud han significado un perjuicio económico a los pobladores.
Trabajo remunerado	Pérdida de productividad de los cultivos.	Debido a que la agricultura no produce como antes, muchos hombres han tenido que irse a trabajar a las plantaciones de palma. El trabajo es muy mal remunerado. Les pagan un promedio de $6 al día (0,75 dólares la hora, si trabajan 8 horas diarias).		En términos económicos, ahora perciben ingresos inferiores a los que percibían cuando se dedicaban a otras actividades.

Efectos genéticos en un cultivo agrícola

Para analizar los impactos del glifosato en los cultivos agrícolas, la Dra. Mariana Moyón, Bióloga de la Universidad Central del Ecuador, condujo estudios sobre genotoxicidad en cebolla. Se evaluó el daño que el glifosato solo, por una parte y el glifosato en preparación con sus coadyuvantes, por otra, produce en el material genético de las plantas. A las cebollas se las sometió a concentraciones de glifosato solo y preparado en el porcentaje que recomienda el fabricante (3,3%), y a períodos variables: 4, 24 y 48 horas. Se estudiaron las raicillas obtenidas en la generación en mezclas de glifosato en agua (Astudillo, et al., 2006).

El estudio encontró que existe también un daño del material genético en las plantas, manifestado en células con dos y tres núcleos, fragmentación de los cromosomas, células con núcleos gigantes y anormales y otros daños de la estructura del ADN.

Algunas de las alteraciones presentes en los ensayos de cebolla. Puentes telofásicos A (Fotografía 1), puentes anafásicos B (Fotografía 2) y células con micronúcleos C (Fotografía 3).

Actualmente existe una lista de estudios validados en los medios científicos, que dejan constancia y diluyen las dudas sobre el daño que el glifosato produce sobre diferentes especies.

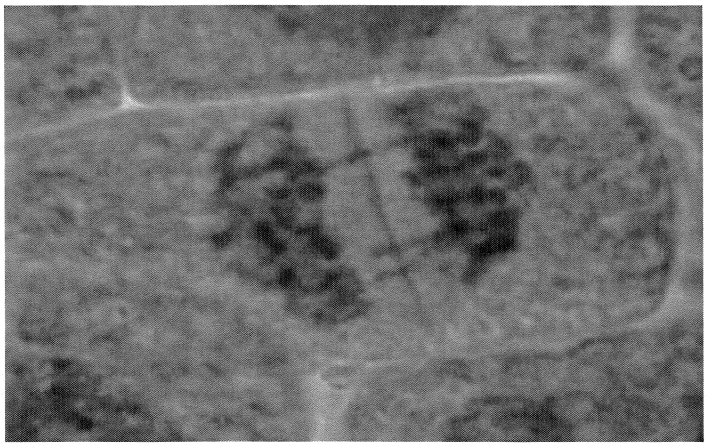
Presencia de glifosato en agua

Existen algunos informes que dan cuenta de la presencia de glifosato y AMPA en cuerpos de agua. Se ha reportado la presencia de glifosato en aguas superficiales y subterráneas en Canadá, Dinamarca, Holanda y el Reino Unido.

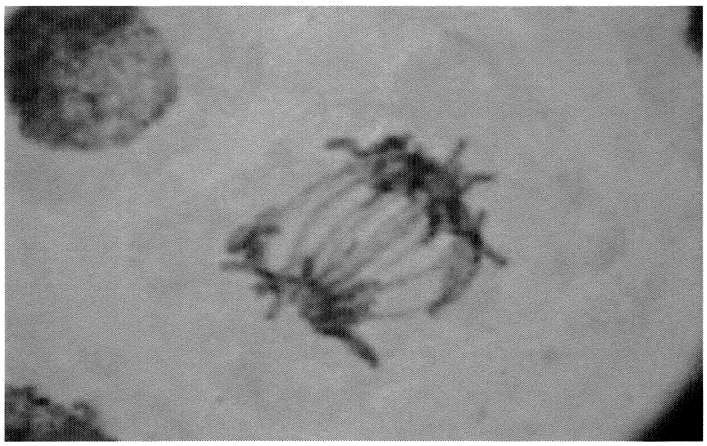
Un informe de la OMS sobre glifosato y AMPA en agua potable, reporta que se han encontrado en Estados Unidos fuentes de agua que contenían entre 90 y 1700 µg de glifosato por litro y de 2 a 35 µg/litro de AMPA. En aguas corrientes se ha reportado contenidos de entre 35 y 1237 µg/litro de glifosato y hasta 10 µg/litro de AMPA (WHO, 2005).

En Canadá se encontraron residuos de glifosato de hasta 5153 µg/litro, después de una aplicación aérea sobre lagos. Su degradación dependió de la vegetación presente (WHO, 2005).

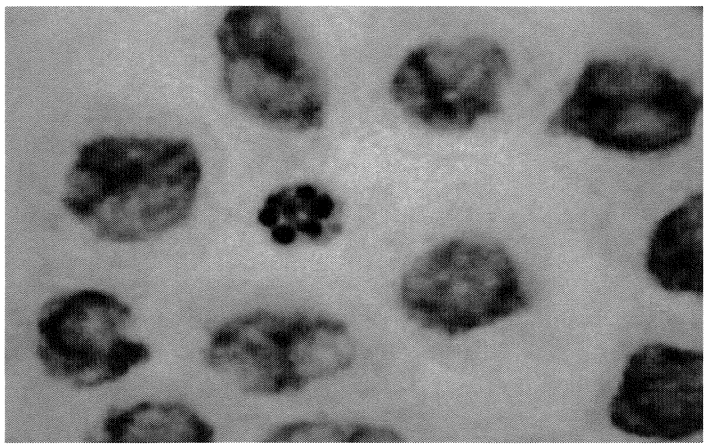
En el 2003, el Ministro de Ambiente de Dinamarca prohibió el uso de glifosato en lugares donde puede haber escorrentía del herbicida, con el fin de evitar la contaminación de agua subterránea, que es la fuente de agua potable en ese país, con inaceptables niveles de glifosato y AMPA (Legarth y Schmidt, 2003; Kjær et al, 2003).



A Fotografía 1



B Fotografía 2



C Fotografía 3

Presencia de glifosato en alimentos

Como lo señalamos ya, con el advenimiento de los cultivos transgénicos tolerantes al glifosato, a partir de 1996, en Estados Unidos y Europa se ha elevado sorpresivamente en más de 200 veces el límite de glifosato residual en soya. Aumento que responde a las solicitudes e influencias de las empresas productoras de glifosato.

Los vestigios de glifosato y sus metabolitos en la soya transgénica están presentes también en alimentos elaborados en base a la leguminosa. Los análisis de residuos de glifosato son complejos y costosos, por eso no son realizados rutinariamente por el gobierno en Estados Unidos. Pero existen investigaciones que demuestran que el glifosato puede ser absorbido por las plantas y concentrarse en las partes que se usan como alimento. Por ejemplo, después de su aplicación, se ha encontrado glifosato en fresas, moras azules, frambuesas, lechugas, zanahoria y cebada. Según la Organización Mundial de la Salud, su uso antes de la cosecha de trigo para secar el grano resulta en "residuos significativos" en el grano; el afrecho contiene residuos en concentraciones 2 a 4 veces mayores que el grano.

Impactos en la Salud Mental

Nuestras apreciaciones acerca de los impactos sobre la salud mental están basadas en:

- las concepciones que guían el pensamiento científico de la salud colectiva latinoamericana,
- las evidencias, opiniones y reacciones recogidas directamente durante dos misiones binacionales de visita a la frontera (Campaña, 2004; Campaña, 2005) y de la misión científica nacional de visita a Mataje, con recuperación de información de primera mano, (2007)[8],
- y la revisión de los estudios disponibles sobre esta materia.

En las tres misiones señaladas hemos dialogado y entrevistado no sólo a los pobladores y nacionalidades directamente afectados por las aspersiones aéreas, sino a miembros de las más variadas instituciones preocupadas por la problemática, como pastorales, organismos de derechos humanos, organismos internacionales, municipios, gobernaciones, ejército, policía, servicios de salud y educación.

8. Comisión Científica Ecuatoriana. Evaluación del impacto de las aspersiones aéreas de febrero del 2007 sobre la salud de los habitantes de Mataje.

El compromiso con la defensa de la salud y la vida de nuestros compatriotas, y con los principios de la ética científica y la adhesión irrenunciable al principio de precaución, nos obligan a tomar atención también de la situación generada sobre los hermanos colombianos del cordón fronterizo por las aspersiones aéreas. Como bien lo afirmara el representante de una organización de derechos de Estados Unidos, se hacen utilizando concentraciones de herbicidas y adherentes que rebasan dramáticamente las cantidades tolerables para la práctica común de la agricultura y la jardinería (Isacson, 2002). Desde el punto de vista científico es, además, completamente válido, tomar referencia de las experiencias vividas y de los impactos acumulados por la población colombiana en su salud mental y física, durante años de sometimiento a este programa de "erradicación de cultivos ilícitos".

Caractericemos entonces, en forma general, la dimensión de las afectaciones en la salud mental cuando, sobre el telón de fondo de la violencia prevaleciente, el impacto de las aspersiones aéreas es más vertical y directo, o sea cuando depende menos de la deriva por el viento, del arrastre de las aguas y de la proximidad excesiva a lugares-objetivos "no planeados":

Sufrimiento por hambre y enfermedad.

Una primera cosa que merece destacarse es que, según la Defensoría del Pueblo de Colombia, en la mayoría de las quejas sobre las fumigaciones (que ya bordean las diez mil) el tema de los graves daños sobre la salud y sobre la disponibilidad de alimentos, es decir el sufrimiento por las enfermedades asociadas y por el hambre, está siempre presente.

Sufrimiento por desplazamiento y búsqueda de refugio.

Otro problema médico social y de salud pública que se percibe a lo largo de las conversaciones con personeros de la regional de ACNUR, en la ciudad de Pasto, es el de la cantidad de desplazados y de refugiados a causa de la violencia interna y de las aspersiones; en Nariño habrían ya registrados por encima de los 25.000 desplazados. Las implicaciones de esto en la salud mental son realmente graves: pérdida de los vínculos colectivos, frecuente ruptura de la unidad familiar, desgaste psicológico -que a veces alcanza nivel de maltrato- que acompaña al proceso de solicitud de reconocimiento de la condición de desplazados. En el 2004 se calculaba que 350 personas colombianas habrían cruzado la frontera entre Chiles y Tufiño y buscado refugio en el lado ecuatoriano; también que unas 47 familias lo habrían hecho desde Mataje a San Lorenzo. Los impactos sociales, económicos, culturales y psicológicos que preceden al desplazamiento físico de las personas son prolongados y muy desgastantes, y las respuestas a sus necesidades específicas de salud, más aún de salud mental, adolecen de grandes limitaciones o simplemente son inexistentes.

Sufrimiento por exposición sorpresiva.

La actitud previsiva declarada por los ejecutores del plan de aspersiones, que dicen anunciar

con antelación las aplicaciones para alertar a la población y apartarla de los lugares-objetivos, es francamente desmentida por los afectados. Expresión común utilizada por éstos es la de "haber sido fumigados". La primera fumigación "nos agarró a las 11 de la mañana un día de octubre; después de los helicópteros vinieron las avionetas e hicieron unas cuatro pasadas; de nada sirvieron los pañuelos blancos de paz que ingenuamente sacamos; la madre comunitaria alcanzó a encerrar a los niños en la casa para que no sean afectados", dicen los comuneros del Corregimiento Martín Pérez de El Rosario. En enero del 2004 recibieron dos fumigaciones masivas con intervalo de ocho días. Como resultado de ello, el 70% de los cultivos murieron, las aguas de la quebrada se contaminaron, la mayoría de personas expuestas presentaron alergias, inflamación e infecciones de la piel, irritación de ojos, nariz, garganta y dificultades para respirar, náusea, vómito, dolores del vientre y diarreas. Incluso se reportó la muerte de un adolescente que no pudo reponerse a estos síntomas.

Sufrimiento por pérdida de cultivos e inseguridad económica.

Aclaran los campesinos que al no estar los cultivos de coca concentrados en un mismo terreno sino dispersos en muchas pequeñas parcelas, las fumigaciones caen indiscriminadamente sobre todos los demás cultivos y al dañarlos les quitan toda posibilidad de sustento alimentario. El estrés generado por el ambiente de guerra que les rodea, como por el sentimiento de ser parte de una actividad ilícita, y también por la inseguridad económica, por la ausencia de planes reales de desarrollo y por la falta de perspectiva futura, influye en la producción de signos y síntomas de malestar psicológico, e incluso de trastornos psiconeuróticos y mentales, que a lo mejor pasen desapercibidos por la ausencia de servicios de salud y de profesionales capacitados para su detección, pero que, de existir la atención y los registros adecuados, revelarían estar bastante por encima de la tasa considerada razonable para una población "normal".

El sufrimiento mental en comunidades indígenas y afrodescendientes.

El miedo, el temor, la inseguridad, la tristeza y la depresión, antes poco conocidos por los nativos, se han constituido ahora en algo habitual. Los médicos nativos señalan que con las fumigaciones aéreas las plantas medicinales se han visto afectadas; hay lugares en que simplemente han desaparecido y si reaparecen, "ya no tienen el mismo espíritu de antes". Al irse perdiendo estos recursos las enfermedades han proliferado. Señalan también que el impacto de las fumigaciones sobre los cultivos –yuca, caña, plátano, etc.- termina alterando la alimentación y que la contaminación de las aguas, contribuye a incrementar el hambre, las enfermedades y la muerte. Los nativos relacionan la muerte de dos niños (uno de diez y otro de trece años) quienes luego de una masiva aspersión, regresaron de tomar su baño habitual en el remanso del río, y en la noche empezaron con dolor de cabeza, vómito y más vómito y murieron en el camino al hospital. Se señala también que otros cuatro niños han sido

hospitalizados en Tumaco, a consecuencia de la sintomatología generada por las fumigaciones.

Desde el ingreso de los primeros alzados en armas a territorio Awá en 1995 y con las aspersiones aéreas desde el 2000, el perfil epidemiológico de los indígenas se habría transformado de manera crítica: la morbimortalidad asociada con el imperio de la violencia habría alcanzado un repunte inusitado; también se habrían incrementado las enfermedades infecciosas especialmente asociadas con mala nutrición y debilitamiento de las capacidades inmunológicas o defensivas del organismo; además habrían aparecido, con la presencia de extraños armados, enfermedades traídas por ellos y a las cuales los nativos se habrían tornado sensibles (v. gr.: enfermedades de transmisión sexual); y se habría añadido un conjunto de padecimientos asociados con el estrés y con la alteración de los patrones culturales de desarrollo y relaciones de la personalidad, que se estarían manifestando en aparatosos trastornos conductuales, tales como comportamientos neuróticos, acentuaciones patológicas del carácter, y en algunos casos hasta francas psicopatías.

Todo un conjunto de problemas de salud humana, directa e indirectamente relacionados con una estructura de relaciones sociales, económicas y políticas imperantes en Colombia, a lo largo del cordón fronterizo con Ecuador. Compartimos ciertamente el punto de vista del gobernador de Nariño, en el 2004, quien decía que en lugar de las costosas fumigaciones se debería promover los cultivos alternativos, la cooperativización y la cultura empresarial, pagar buen precio por los productos y facilitar su comercialización.

Con los antecedentes señalados y dado que nunca se han podido ni se podrán interrumpir los dinamismos e intercambios económico-sociales propios de la estrecha vecindad, que comportan incluso el desplazamiento cotidiano de pobladores del lado ecuatoriano en calidad de jornaleros para labores agrícolas ilícitas pero que pagan mejor jornal, hemos venido siguiendo la pista de sus efectos nocivos sobre territorio ecuatoriano.

Los impactos reales provocados sobre la salud mental de la población ecuatoriana que habita a lo largo de la frontera con Colombia, por las aspersiones aéreas programadas y realizadas por el gobierno de dicho país para el control de cultivos ilícitos desde el año 2000 hasta la fecha, corresponden básicamente a tres causas:

Impactos por el efecto directo de altas dosis de sustancias químicas –glifosato, surfactantes y probablemente otros utilizados pero no declarados– sobre el organismo humano.

El rociado diurno directo sobre el borde mismo de la frontera, la deriva provocada por la conjunción entre el viento y la altura del rociado y los flujos de agua contaminada han sido sistemáticamente reportados por la población ecuatoriana afectada, como los causantes de síntomas y signos inmediatos, generalmente muy traumáticos desde el punto de vista psicológico, puesto que son caracterizados como masivos –irritación de ojos, nariz y garganta, malestar general súbito,

ronchas en todo el cuerpo, marcada dificultad respiratoria, vómito y diarrea, dolor de cabeza, mareo y confusión.

En poblaciones tradicionalmente muy saludables como la de la nacionalidad Awá en el cantón San Lorenzo, la valoración psicológica de tales síntomas se agrava porque se los experimenta como un verdadero presagio de fatalidad.

Algo similar ocurre con la población afroecuatoriana usuaria del río Mataje, anteriormente considerado de aguas puras para el baño y la preparación de alimentos, que ahora acarrea la contaminación química procedente de las quebradas y del río Mira, desde Colombia, y que produce aguda irritación de la piel y malestar general. Es necesario destacar la presencia de casos de manchas blancas (tipo vitiligo o despigmentación de la piel) que aparecen tiempo después del contacto del agua con la piel en niños y jóvenes. Tratándose de población negra resulta más evidente e impacta como doloroso estigma en la autovaloración de la imagen personal.

La cantidad de síntomas neuropsíquicos reportados por quienes se han visto afectados por las aspersiones derivadas desde Colombia, nos permite sospechar que entre las sustancias combinadas para el ataque a los cultivos ilícitos se está utilizando alguna –o algunas- de carácter francamente neurotóxico. Hay que recordar que el surfactante POEA, que lleva el Roundup, es más tóxico que el mismo glifosato y produce daño al sistema nervioso central. La acción neurotóxica del glifosato, una sal de N-fosfonometilglicina, es conocida y resulta de la activación de los receptores N-metil-D-aspartato (NMDA) por la glicina, promotora de la incorporación del calcio en las neuronas que, en concentraciones elevadas causa hiperexcitabilidad y muerte celular (Newell et al., 1997).

Un caso de parkinson por exposición accidental a glifosato ha sido reportado por especialistas de Brasil (Costa, M. D.L. et al., 2003). Se trata de un vigilante, previamente saludable, que a sus cincuenta y dos años de edad, cuando aplicaba glifosato en el jardin de su local de trabajo, sin protección, derramó accidentalmente el herbicida sobre su cuerpo y no procedió a limpiarlo sino después de 30 minutos; seis horas después presentó malestar general y enrojecimiento de las conjuntivas y la piel expuesta. Una semana después desarrolló un cuadro generalizado de parkinson y desde el comienzo de los síntomas presentó déficit de la memoria para hechos recientes. Recibió tratamiento con levodopa con buena respuesta. Dos años después pasó a tratamiento al Ambulatorio de Trastornos del Movimiento, de la Clínica Neurológica del Hospital de la Universidad de Sao Paulo. Al Mini Examen del Estado Mental alcanzó un puntaje de 23 sobre 30 puntos posibles, con dificultades evidentes en las áreas de atención, memoria y cálculo. Las imágenes de Resonancia Magnética en T2 revelaron los daños característicos del mal de parkinson en el globo pálido, sustancia negra, vía nigro-estriada, y en la sustancia gris periacueductal.

A propósito de este caso, viene bien recordar los resultados de la investigación realizada

por un equipo científico encabezado por el Dr. Anthony Seaton de la Universidad de Aberdeen, Escocia, y divulgada en la edición electrónica de la revista *New Scientist*, que evaluó más de tres mil personas, entre ellas 767 portadoras del mal de parkinson, en cinco países europeos: Escocia, Italia, Suecia, Rumania y Malta. Los estudiados tenían más de sesenta años, y una historia de vida y salud bastante semejante, aunque expuestos a pesticidas en frecuencias diferentes. El estudio demostró *"que el uso de pesticidas tiene una influencia importante en términos de riesgo ocupacional de desarrollo de parkinson."* En definitiva, quienes se dedican a la jardinería y se hallan, por eso, expuestos a índices elevados de pesticidas, resultaron ser *hasta 43% más propensos a desarrollar parkinson en comparación con los no expuestos.* En personas que se exponen con una frecuencia menor, este índice es de 9%. Si bien la investigación no estaba orientada a identificar el tipo de sustancias que traerían más riesgos a la salud, se debe recordar que entre ellas cuentan los herbicidas -glifosato incluido- de aplicación controlada, focal y a ras de suelo en las tareas usuales de la jardinería europea.

Ya se ha comentado también, en otra parte de este documento, el caso de la intoxicación y la alerta sanitaria por acrilamida en alimentos (Cummins, 2002). Esta sustancia neurotóxica se suele añadir al glifosato para aumentar su superficie de contacto.

Nada nos impide pensar entonces que, tras las repetidas y masivas aspersiones aéreas que se han venido produciendo desde el 2000 hasta la fecha, tanto por su impacto inmediato directo sobre las personas como por la contaminación que se acumula en el ambiente y en la cadena alimentaria, se ha creado un escenario facilitador de alteraciones de la neurofisiología humana y animal. El ataque repetido o crónico al sistema nervioso puede interferir seriamente el desarrollo neuroevolutivo de los niños -toxicidad neuroevolutiva- y producir deterioro de la capacidad de reacción neurológica y psicológica en jóvenes y adultos -neuropsicotoxicidad.

Impactos por la afectación masiva de las fuentes de subsistencia, por la acción también directa de los químicos sobre la flora y fauna y sobre los cultivos y animales domésticos.

Esta situación, siempre reportada por nuestros hermanos y hermanas de la frontera, la gran mayoría dedicados a actividades agropecuarias y de una u otra manera integrados en relación de amplia dependencia ecosistémica, es con toda seguridad la más devastadora en términos de salud mental. Tómese en cuenta que la mayoría son parte de familias pobres, muchas llegadas a la zona en condición de colonos, pero cargadas desde el inicio de esperanzas y deseos de vivir, resueltas a extremarse en sacrificios y aceptar los desafíos impuestos por el proceso de adaptación a espacios naturales todavía poco trabajados.

La pérdida de los frutos del trabajo agrícola (cosechas) e incluso el debilitamiento o muerte de las plantas (plátanos, yucas, malangas, papayas, etc.), provocados por las aspersiones aéreas de químicos, determinan algo que resulta grave

para el equilibrio psicológico de cualquier ser humano: la carencia de su fuente inmediata de sustento, la sensación de desamparo e inutilidad y, algo peor aún, la inseguridad con respecto al mañana y la pérdida de esperanza en el futuro. Esta es la realidad que están viviendo no menos de tres mil ecuatorianas y ecuatorianos en edad laboral desde el año 2000, cuando las aspersiones empezaron a afectarlos.

Particular atención hay que poner en los impactos de esta situación sobre la población infantil y adolescente. En primer lugar, porque los anhelos de vivir y el espíritu optimista, de mediar condiciones normales, son una característica casi connatural en estas edades y, en segundo, porque en medio de las relaciones sociolaborales de la zona ellos participan, en medida no despreciable, como aprendices y como colaboradores de la actividad agropecuaria. De manera que los devastadores resultados de las aspersiones químicas sobre la actividad económico social de sus familias golpean, en su caso, en forma doblemente traumática: se pierden ingentes recursos materiales y recursos espirituales indispensables para el desarrollo armonioso de la personalidad y se debilitan los estímulos positivos para la adquisición de conocimientos y destrezas asociados con el oficio o vocación laboral más próximo a su realidad. Como bien lo señalan los miembros del grupo de investigación acción comunitaria Martín Baró,

> *Niños y niñas que se encuentran en la ruralidad tienen un vínculo afectivo muy profundo con el medio natural, a diferencia de los adultos el niño y la niña se relaciona con su imaginación a este medio, pero observamos que este medio está siendo destruido también por los enfrentamientos armados o por las fumigaciones y se puede ver cómo se introyectan en el niño /niña para causarle dolores profundos que quiebran esa relación natural, los animales muertos, ensangrentados, flacos, son el reflejo también de cómo está su relación con ellos (Supliguicha et al, 2006).*

Vale decir que la desazón e incertidumbre, la ansiedad y angustia, los temores generados en los padres por la crisis económica, que muchas veces los obligan a dejar transitoriamente las fincas para buscar alguna solución pasajera, terminan produciendo una atmósfera familiar nada propicia para el desarrollo espiritual de sus hijos e hijas. El abandono total o parcial del hogar por alguno de los progenitores, o la búsqueda de refugio en soluciones perniciosas -el alcohol, por ejemplo- ahondan más el problema.

Impactos por la percepción directa de un peligro equiparable a francas acciones de amedrentamiento y de guerra.

Para quien tenga aunque sea un conocimiento básico acerca de las potencialidades de las pruebas proyectivas, utilizadas en psicología para acceder al conocimiento del mundo interior de las personas, no le será difícil encontrar, en los dibujos realizados por escolares de las zonas afectadas, los indicios contundentes de la situación de preocupación, miedo, e incluso terror que han sido interiorizados por los pequeños en razón

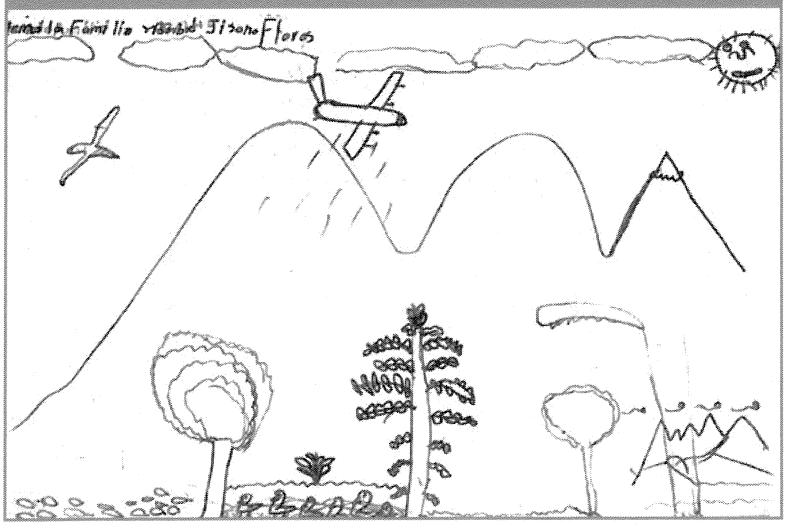
de haber presenciado directamente estos operativos y sus inmediatas y mediatas consecuencias.

Dibujo 1

Los primeros dibujos, luego de las primeras fumigaciones de los años 2000 y 2001 en la frontera con el Putumayo, todos, sin excepción, grafican escenas de dolor, de enfermedad, de muerte; en todos se evoca la presencia de avionetas echando líquido, ríos contaminados, aves, perros, ganado muerto, plantaciones pasmadas, personas enfermas e incluso fallecidas. Para entonces los niños y niñas, a pesar de semejante experiencia, no habían perdido aún los ánimos y plasmaban sus dibujos con mucho detalle y con el uso generoso de colores.

La misma prueba, realizada en el 2006 y manteniendo condiciones de aplicación semejantes, revelan, en los niños y niñas, la presencia de iguales temores, dolores y ansiedades, pero ahora curiosamente pintados con tonos apagados y con elementos adicionales reveladores de quiebre personal, ruptura familiar, ausencia y desamparo.

Dibujo 2

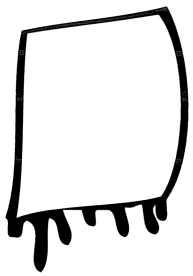


Por lo demás, resulta altamente preocupante que a este niño, al que se ha pedido dibujar una familia, termine pintando el cuadro de las aspersiones, con todo su drama de impacto a la naturaleza y en el que ¡hasta el sol! muestra su amargura. ¿Se podría negar que el dibujo esté proyectando la pérdida de su familia a consecuencia de las atrocidades de las aspersiones? Tienen razón los psicólogos del grupo Martín Baró, cuando ante evidencias como éstas señalan:

Uno de los casos más extremos que podemos observar en los dibujos es el de la eliminación de sí mismo, la eliminación del propio niño /niña, muchas veces la eliminación no es completa sino que más bien puede aparecer muy sutilmente en medio del dibujo o de la conversación sublimado o proyectado, porque es complicado que un niño/a renuncie a su propia existencia, pero lamentablemente en el presente diagnóstico encontramos que efectivamente hay varios niños/as que se eliminan completamente –y eliminan a toda su familia, añadamos nosotros- y que reflejan una depresión bastante grave que se manifiesta en esta ausencia (Supliguicha et al , 2006).

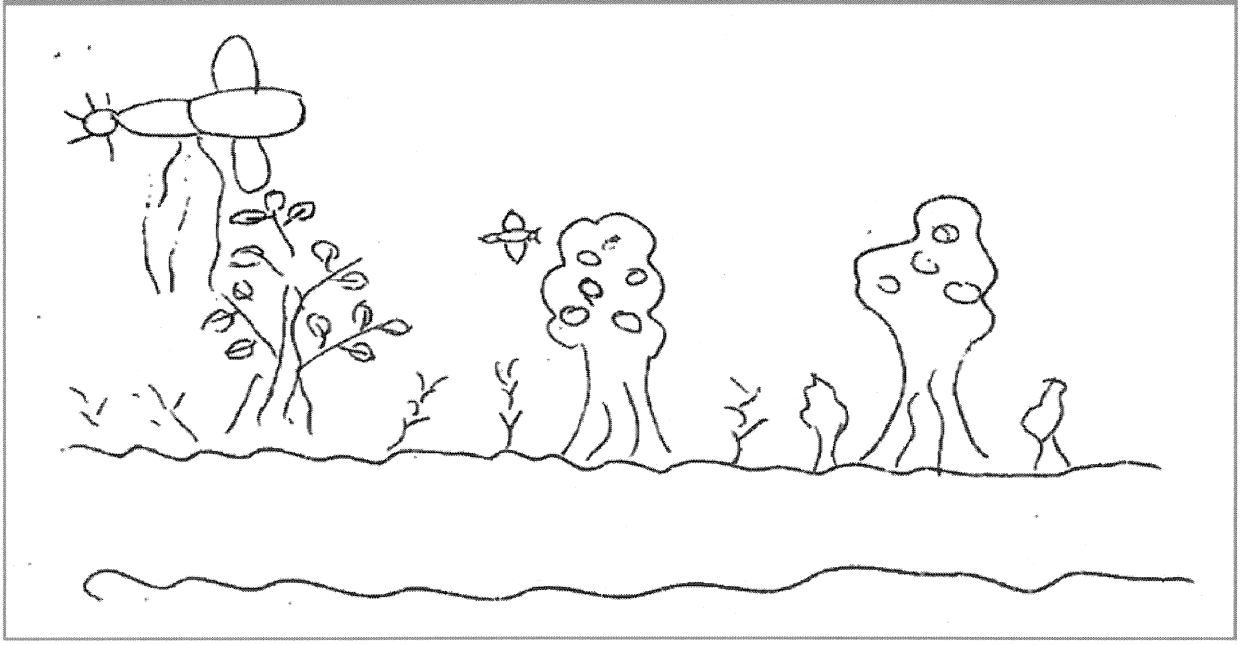
En nuestra visita a Mataje, el 21 de febrero del 2007, a dos semanas de las continuadas aspersiones aéreas directamente visibles desde el lado ecuatoriano, como lo muestran las filmaciones que nos fueran entregadas por la Armada del Ecuador, un niño de siete años, Gabriel, al que solicitáramos dibujar lo visto, nos preguntó si nos referimos "al veneno"; le volvimos a insistir en que dibuje lo visto, y plasmó la siguiente imagen:

Dibujo 3



La expresión "EL VENENO" es, ciertamente, la que surge como asociación mental más inmediata cuando se pide a los pobladores de Mataje referirse a lo experimentado días atrás a propósito de las aspersiones aéreas. Una mujer de 23 años, Landy, casada y madre de dos hijos, realizó el siguiente dibujo:

Dibujo 4



La imagen, en la que se ve sencilla pero hermosamente reflejada la naturaleza y el vínculo personal con la misma, refleja obviamente la cercanía de la avioneta fumigadora, tal cual fue por ella sentida, puesto que se encontraba lavando en el río mientras sus dos hijos nadaban en las proximidades. Cuando le pedimos que nos describiera lo dibujado, nos dijo:

- *El VENENO cae a los árboles y al río, a los animales, que mueren; es tan fuerte que arrastra con todo; y cuando llueve se lava todo y el VENENO baja por las quebradas y viene al río. Los ojos, justo cuando llegó la fumigación me dolían y se pusieron colorados; a mis dos bebés igual. Cuando se lava en el río coge una comezón en la piel y salen ronchas; me estuve echando una crema; era una comezón que no plantaba; debe ser eso -el veneno- porque yo estaba justo lavando en el río, y mis niños estaban bañándose en el río... como a ellos les encanta bañarse, los ojos tenían rojos y empezaban a botar como una materia así amarilla; como llovió fuerte y creció el río todo lo malo salió de las quebradas para afuera. Eso fue hace dos o tres semanas...*

Esta joven madre y esposa, para quien entre los mejores recuerdos de su vida escribe:

- *"Lo mas hermoso que a mí me ha pasado es enamorarme, tener dos lindos hijos y estar siempre unida a ellos; no separarme nunca..."*

Le aflige de tal modo la situación, que cuando se le pide decir lo que más quiere o desea en la vida, escribe:

- *"Lo que yo quiero es que no haya más fumigación, porque eso nos afecta mucho a los pobres que vivimos en la parroquia de Mataje...*

El ejemplo ilustra, de manera concentrada, la forma y las vías en que se impacta directamente la vida y la condición psicológica de las personas de la zona, y nos permite prefigurar los deterioros de la salud mental a futuro, en el tejido familiar y social de la gente de Mataje, en el caso de que persistan y se sigan ahondando estas acciones de violencia.

Una Reflexión Obligada

Entendemos los procesos de salud-enfermedad mental no como algo resultante exclusivamente de condiciones individuales, sino como algo históricamente determinado y mediado a través de las relaciones sociales de las que los individuos son parte activa o pasiva. Por eso concedemos en nuestros análisis un valor clave a conceptos como el de personalidad, entendida como un ensamblaje de actitudes, comportamientos, valores y capacidades adquiridos en medio de relaciones sociales, a través de la vida en familia y en comunidad, a través de actividades humanas como la creatividad, el trabajo y la reposición de energías; el amar y ser amados, el autoafianzarse y sentirse parte de lugares y tiempos concretos.

El fundador del Psicoanálisis, Freud, sostenía que para ser mentalmente saludables se requiere cumplir a cabalidad dos capacidades: trabajar y amar. Son los derechos de la población de frontera: trabajar y amar en paz y en libertad.

Sabemos que las aspersiones aéreas afectan directamente estos dos pilares de la vida mental saludable, e interfieren con los anhelos del actual gobierno ecuatoriano de auspiciar el progreso material y espiritual de la población de la zona.

Impactos en la Salud Orgánica y Genética

Ya se mencionaron anteriormente los preocupantes descubrimientos de un equipo de Francia sobre el impacto de plaguicidas que contienen glifosato en la ruptura de los sistemas de verificación de la disvisión celular y en las fases iniciales de un proceso de daño genético que lleva a la cancerigenicidad (Belle et al., 2004). Y hemos señalado que al degradarse en el organismo y en el ambiente produce sustancias dañinas como el N-Nitroso glifosato y el formaldehído -cancerígenos reconocidos- y ácido aminometil fosfónico que puede producir daño de eritrocitos. También se ha destacado que el glifosato afecta sistemas enzimáticos en animales y humanos; por ejemplo, en ratas, se ha constatado que luego de inyección intrabdominal disminuye la actividad de algunas enzimas detoxificantes: el citocromo P-450, una monooxigenasa y la aril hidrocarbono hidroxilasa (Cox 1991 y 1995).

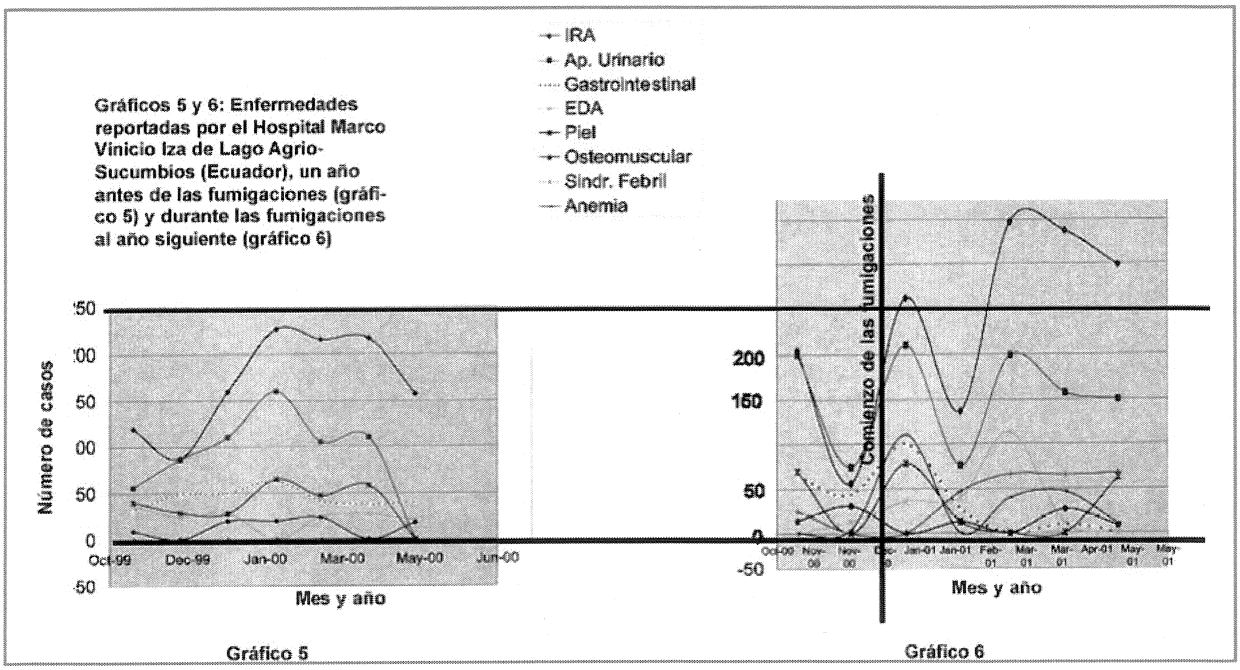
Algunos de los signos y síntomas asociados con el glifosato y sus componentes en la fórmula comercial, se destacan a continuación:

- **Sulfato de amonio:** Irritación ocular, náusea, diarrea, reacciones alérgicas, respiratorias. Daño ocular irreversible en exposición prolongada.
- **Benzisotiazolona:** eczema, irritación dérmica, fotorreacción alérgica en individuos sensibles.
- **3-yodo-2-propinilbutilcarbamato:** Irritación ocular severa, mayor frecuencia de aborto, alergia cutánea.
- **Isobutano:** náusea, depresión del sistema nervioso, disnea.
- **Metil pirrolidinona:** Irritación ocular severa. Aborto y bajo peso al nacer en animales de laboratorio.
- **Acido pelargónico:** Irritación ocular y dérmica severas, irritación del tracto respiratorio.
- **Polioxietileno-amina (POEA):** Ulceración ocular, lesiones cutáneas (eritema, inflamación, exudación, ulceración), náusea, diarrea.
- **Hidróxido de potasio:** Lesiones oculares irreversibles, ulceraciones cutáneas profundas, ulceraciones severas del tracto digestivo, irritación severa del tracto respiratorio.

- **Sulfito sódico:** Irritación ocular y dérmica severas concomitantes con vómitos y diarrea, alergia cutánea, reacciones alérgicas severas.
- **Acido sórbico:** Irritación cutánea, náusea, vómito, neumonitis química, angina, reacciones alérgicas.
- **Isopropilamina:** Sustancia extremadamente cáustica de membranas mucosas y tejidos de tracto respiratorio superior. Lagrimeo, coriza, laringitis, cefalea, náusea.

Por el momento, la investigación puede únicamente poner al descubierto una parte de la morbilidad y muertes causadas, que corresponden a trastornos de corta evolución, puesto que procesos que se incuban en varios años no son detectados aún. La recopilación de datos de salud en la zona asperjada evidenció un cambio en el comportamiento de la salud de la población en la frontera Ecuador-Colombia; las enfermedades eran diferentes antes y después del inicio de las aspersiones con glifosato. Las constataciones de salud realizadas en la zona y luego de las visitas a varios centros de salud, concluyen que 90% de personas de la zona, presentaron cambios importantes de su estado de salud: dermatosis resistentes al tratamiento, irritación ocular, problemas de vías respiratorias altas, astenia, mialgias (Comisión Interministerial, 2001; Maldonado, A. 2002; CIF, 2003). Los gráficos siguientes muestran cómo el cambio de las patologías se produce a partir de las fumigaciones en la zona.

Posteriormente a las aspersiones, en el 2001, una investigación toxicológica clínica realizada en 142 personas de la zona asperjada,



Gráficos 5 y 6: Enfermedades reportadas por el Hospital Marco Vinicio Iza de Lago Agrio-Sucumbios (Ecuador), un año antes de las fumigaciones (gráfico 5) y durante las fumigaciones al año siguiente (gráfico 6)

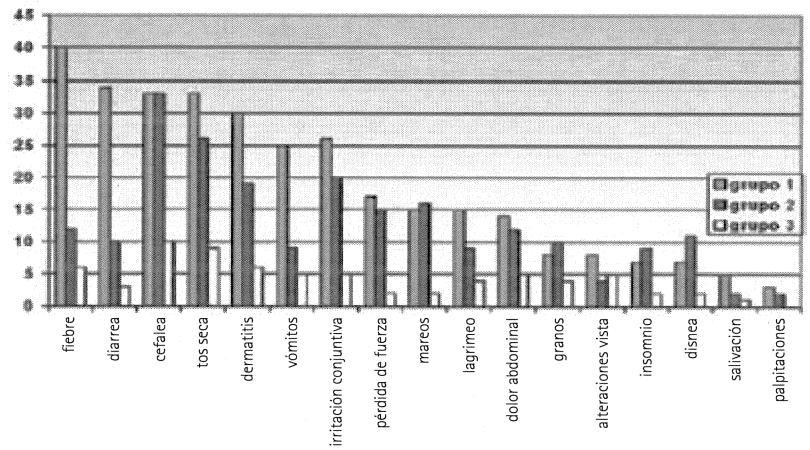
Gráfico 5

Gráfico 6

que evaluó 54 síntomas, informados como nuevos en la población afectada, mostró que entre el 100 al 89% de personas que vivían en la franja de 5 km desde la frontera, presentaron la serie de síntomas descritos (Comisión Interministerial, 2001; CIF, 2003). Se observó que los síntomas disminuían a medida que el análisis se realizaba a 2, 6 y 10 km.

Se reportaron impactos hasta los 10 km de la frontera al interior de Ecuador, y se encontraron casos incluso de personas fallecidas, muertes de animales y pérdidas del 70-90% de las cosechas. Sucesos que coincidieron el mismo tiempo en que se dieron las fumigaciones. (Ver gráficos siguientes). Los habitantes de la zona incrementaron dramáticamente los problemas respiratorios, gastrointestinales, alérgicos, dermatológicos, neurológicos y psicológicos, justamente signos y síntomas que han sido informados en otros estudios (CIF, 2003). Los testimonios (motivos de consulta en medicina) de los pobladores de la zona y las constataciones del daño producido por el glifosato son abundantes, incluso denunciados por organismos de Derechos Humanos, Defensoría del Pueblo, ONGs y otros (CEDHU, 2007; Organizaciones Ecuatorianas, 2007; Plataforma Interamericana de Derechos Humanos, Democracia y Desarrollo, 2007).

Patologías más frecuentes encontradas en la frontera durante las fumigaciones, según la distancia al área fumigada en Colombia. Sucumbíos – Ecuador – junio 2001



Grupo 1: a menos de 2 km.; Grupo 2: entre 2 y 5 kms.; Grupo 3: de 5 a 10 km.

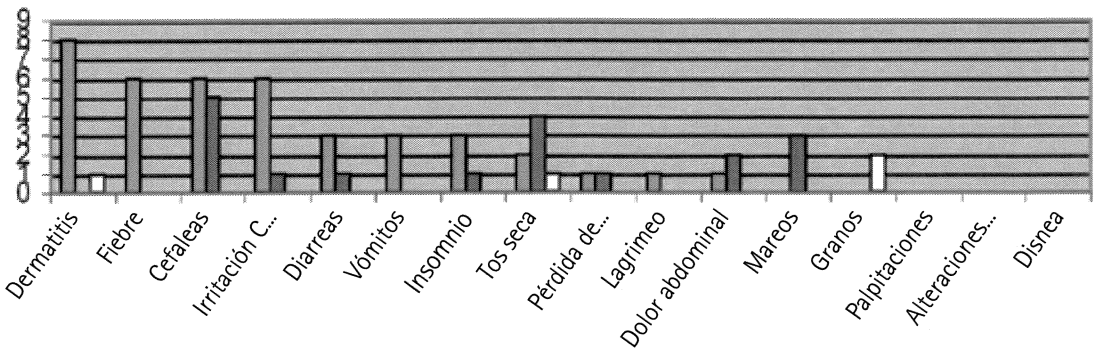
Fuente: Acción Ecológica.

Todos los síntomas fueron más frecuentes en la población cercana a la frontera y disminuían al alejarse de ella. Tres meses después, las enfermedades en la zona habían disminuido cinco veces con respecto al momento de las fumigaciones.

El estudio concretó algunas sistematizaciones básicas para la frontera de Sucumbíos sobre la base de los impactos de las aspersiones del 2001. (Acción Ecológica, 2001). En ellas se demostraba que:

- El 100% de la población en la zona de frontera ha sido impactado con las aspersiones por Roundup Ultra en una franja de 5 km, y el 89% cuando la franja se amplía a 10 km.
- Tres meses después de las fumigaciones la población, hasta los 5 km, mantiene síntomas de intoxicación crónica con señas de afección neurológica, problemas de piel y conjuntivas.
- Existe una relación temporal directa entre las fumigaciones y la aparición de las enfermedades.
- Existe una relación directa entre la distancia donde se fumigó y la sintomatología. Al aumentar la distancia con el foco fumigado, disminuye la sintomatología en la población.
- La posibilidad de nuevas fumigaciones sobre población que ya tiene síntomas de intoxicación crónica, puede causar un impacto de incalculables consecuencias para sus vidas.
- La población, que ha sufrido los impactos de la fumigación, está en zozobra. Sin apoyos económicos, sin indemnizaciones y sin atención adecuada, su salud se ve deteriorada por un programa de fumigaciones que los invisibiliza.
- Los impactos negativos en la salud de la población y en su estado nutricional, pueden incrementarse si no se toman medidas adecuadas para reponer el fracaso de sus cosechas y la muerte de ganado y animales.

Patologías encontradas según la distancia a la fuente de fumigación, 3 meses después de las fumigaciones Sucumbíos – Ecuador – junio 2001



La permanencia del Roundup en el suelo (que se calcula de 45 días a 3 años) somete a la población campesina de estas zonas a la incertidumbre sobre el futuro de sus cultivos.

Debido a la presencia de vientos en esa época, se vieron gravemente afectadas comunidades como San Francisco 1 y 2, Nuevo Mundo, San Miguel, 10 de Agosto, Proyecto San Miguel y Perla del Pacífico, entre otras.

En la zona fronteriza, los estudios sobre vientos del INHAMI muestran que las corrientes provienen del nor-oriente y van hacia el sur-occidente, o sea, desde el territorio colombiano hacia el ecuatoriano. En la estación meteorológica de Nueva Loja, se ha encontrado que a nivel anual existe un claro predominio de vientos del W (oeste) con 28.1%, y del S (sur) con 26.4%. Esta estación cubre el área de influencia de la zona norte de la amazonía ecuatoriana, cercana a las estribaciones de la Cordillera Oriental; la información de viento de esta estación comprende el período 1981 – 2004.

Sin embargo, en algunos meses la máxima frecuencia se registra en la dirección S (sur). En abril, los vientos del Sur tienen un porcentaje de 42% de ocurrencia, seguida de la dirección del W (oeste) con 33%. En mayo, la frecuencia máxima se registra en la dirección S (sur), con un porcentaje del 38% de ocurrencia. En los meses de junio y julio, los vientos del S (sur), tienen un porcentaje del 54% de ocurrencia (el más alto del año) y en agosto con 38%. Esto significa que las aspersiones aéreas son llevadas hacia el territorio ecuatoriano y por lo tanto se produce contaminación de agua, tierra, plantas, animales y personas (INAMHI, 2006).

En un segundo estudio, realizado tras las aspersiones del 2002, se aplicaron encuestas a 17 familias de un universo de 102 (el 16.7% del total), repartidas en cuatro comunidades, con un total de población aproximado de 657 personas. En promedio, el número de afectados alcanza a 85,5%, como se aprecia en el cuadro siguiente:

Tabla 8
Distribución de afectados por comunidad estudiada

Localidad encuestada	Familias encuestadas	Total de familias	Porcentaje	Personas en las familias	Porcentaje afectados
Chone – 2	6	30	20%	39	79%
Playera Oriental	5	18	27.7%	38	63%
Palma Seca	1	18	5.5%	10	100%
Puerto Nuevo	5	35	14.3%	23	100%

Fuente (Maldonado, A. 2001)

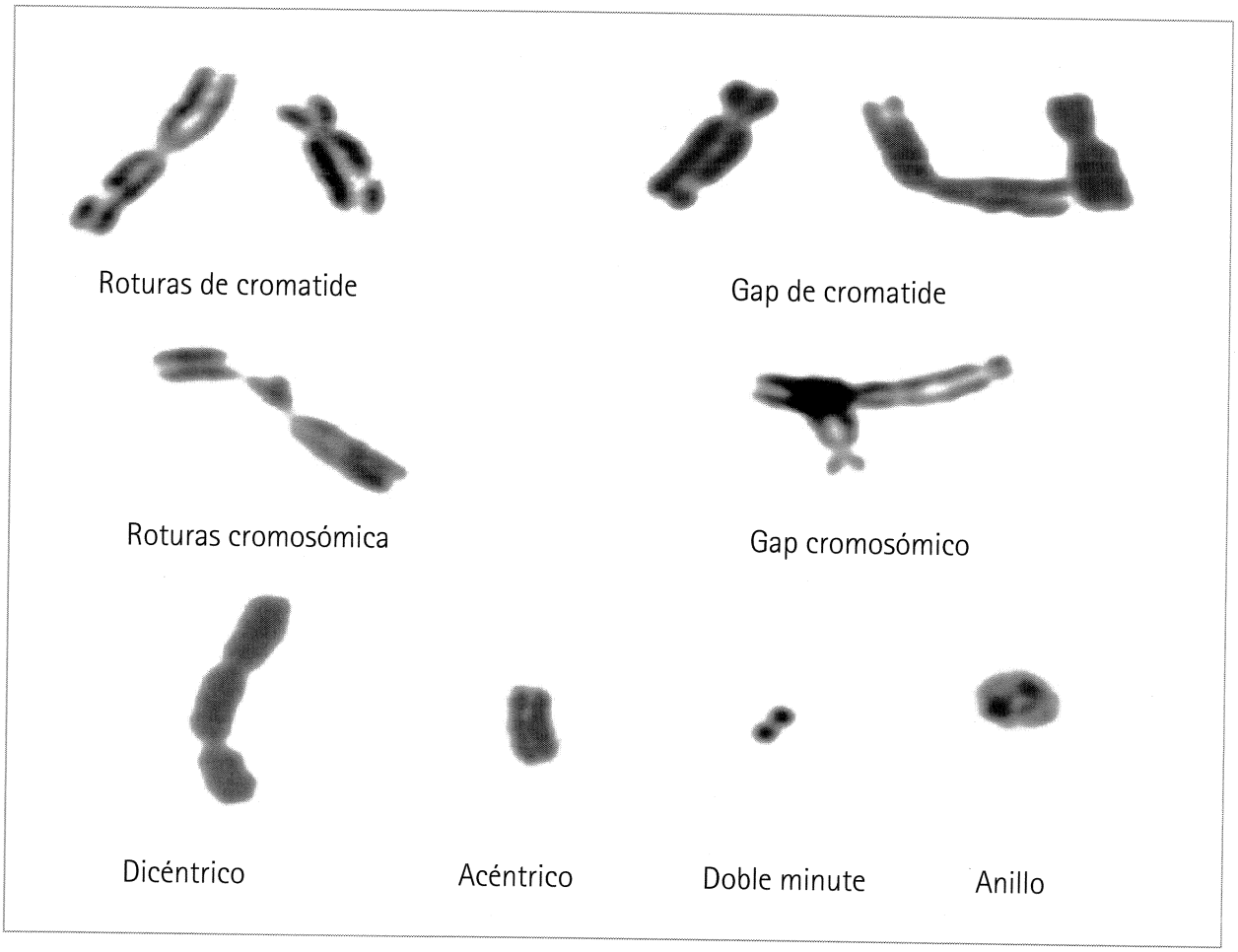
De las historias clínicas analizadas podemos deducir lo siguiente:

- La gran mayoría de la población, después de las fumigaciones manifiesta afectaciones como dolores de cabeza e irritación en ojos y lagrimeo. En las comunidades colombianas que reciben las fumigaciones con mayor intensidad es muy común el cuadro digestivo con mareos, dolores abdominales, vómitos y nauseas, diarrea, cansancio y pérdida de fuerza. La presencia de fiebre en Colombia, se incrementa significativamente con respecto a Ecuador.
- Otro grupo de síntomas aparecen por afectación de la piel. Un gran prurito (comezón) acompaña a diferentes cuadros que van desde la dermatitis (inflamación) hasta la aparición de granos por diferentes causas. El carácter irritante del químico queda de manifiesto con estas sintomatologías que acompaña a la de los ojos, y que del lado ecuatoriano tienen una incidencia mayor que los síntomas digestivos.
- Algunos campesinos manifestaron que hay dos tipos de fumigaciones: una de líquido blanco o transparente y otra de color oscuro, tras la cual comienza una fuerte "comezón".
- El efecto psicológico que las fumigaciones producen en los campesinos de Ecuador es diferente al de Colombia. Mientras en los primeros se presenta una situación de stress que les produce insomnio, en los colombianos hay una situación de depresión, producto de la compleja realidad que enfrenta la población colombiana de esta zona, agudizada por los impactos de las fumigaciones.

Una primera evaluación cromosómica en habitantes de la zona asperjada

A continuación, algunos hallazgos locales sobre impactos atribuibles a las aspersiones aéreas con glifosato en la salud genética de habitantes de la zona asperjada de la frontera.

En septiembre del 2002 se desplazó a la frontera colombo-ecuatoriana una misión de verificación, compuesta por 11 organizaciones, para evaluar los daños que las fumigaciones contra cultivos de coca, realizadas en esas fechas, habían ocasionado sobre la población ecuatoriana, sus cultivos y animales (Maldonado, 2002). En esa ocasión se recolectaron muestras al azar de sangre de 4 personas afectadas por las fumigaciones. Se realizaron cultivos de linfocitos B en medio adecuado estándar (RPMI 1640), estimulado con fitohemaglutinina; a las 72 horas de cultivo se cosechó con la técnica estándar: colchicina, choque hipotónico, extensión y tinción con colorante Giemsa (Paz-y-Miño, et al., 2002b). Evaluados los cromosomas en microscopio óptico a mil aumentos, se encontró que el número de aberraciones cromosómicas era 17 veces más alto que en la población control (2%), que consistió en personas sanas, no expuestas a otros genotóxicos conocidos y de las mismas edades y sexos de los expuestos a aspersiones. Similar estudio al del 2002 se realizó en un muestreo, en febrero del 2007, encontrándose similares resultados; un



Fotografía 4

34% de daño cromosómico en los expuestos de la zona de Mataje, provincia de Esmeraldas, frente a los resultados de población control con 3% de aberraciones.

Algunas de las alteraciones cromosómicas que se pueden observar en individuos expuestos a genotóxicos: tanto roturas como gaps, son las alteraciones más frecuentes observadas en los individuos expuestos a las aspersiones aéreas, así como un número pequeño de células presentaron fragmentos acéntricos y dobleminutes.

Ante esta situación, el año 2002 se decidió hacer un nuevo estudio que permitiera detectar si en el origen de estas lesiones están las aspersiones aéreas, o si son ocasionadas por alguna otra causa.

La hipótesis de partida es que asperjar con un producto de estas características (con esa mezcla) y a esta concentración, al ser los componentes sinérgicos en su efecto, es decir, que unos potencian a los otros, también potencian el efecto secundario sobre las personas.

Estudio del material genético en personas expuestas a aspersiones aéreas

El objetivo del estudio fue verificar, en una muestra seleccionada de habitantes de la frontera, si presentaban o no alteraciones genéticas producto de la exposición a las aspersiones aéreas con el paquete herbicia.

Se hicieron encuestas del estado de salud, a mujeres que refirieron sintomatología posterior a las aspersiones aéreas. Ellas mencionaron haber recibido entre una a dos semanas el impacto de las fumigaciones sobre sus casas y haberse protegido en ellas durante el momento de más intensidad. Se seleccionó también una población similar como grupo control. El criterio de investigar sólo a mujeres fue adoptado porque los agroquímicos en agricultura son usados con menos frecuencia por las mujeres que por los hombres, y por tanto están menos expuestas a genotóxicos. Las personas seleccionadas para el análisis, hasta donde se pudo averiguar, no estaban expuestas a otros genotóxicos conocidos (tabaco, alcohol, fármacos o drogas).

Fueron analizadas y entrevistadas 47 mujeres, repartidas en dos grupos de estudio, de similares características de edad (alrededor de 37 años en promedio) y tiempo de residencia en la zona (alrededor de 16 años en promedio): 1) El grupo expuesto, lo componen 22 mujeres que habían recibido el impacto de las fumigaciones aéreas en al menos una ocasión, y presentaron signos o síntomas de afecciones. 2) El grupo control, incluye a 25 mujeres ubicadas a 80 km de la frontera donde se realizaron las fumigaciones y, hasta donde se pudo averiguar, no estaban expuestas a genotóxico conocido alguno.

El estudio sobre el grupo afectado se centró en la Provincia de Sucumbíos (Ecuador) en comunidades ecuatorianas del cordón fronterizo con Colombia, impactadas por las fumigaciones, y sin indicios de estar afectadas por actividades petroleras, a menos de 3 km de la frontera, pertenecientes a Puerto Nuevo, Palma Seca, Playera Oriental, Santa Marianita y Corazón Orense. En el grupo control eran procedentes de Abdón Calderón, Huamayacu, Morán Valverde, 23 de Julio y Unión Manabita.

Ninguna mujer del grupo expuesto trabaja con pesticidas. El grupo control no estuvo expuesto a genotóxico alguno. Las personas expuestas no son fumadoras ni consumen algún tipo de bebida alcohólica con regularidad. Entre las malformaciones o afectaciones congénitas familiares hay un 10,5% entre las afectadas y un 12% en el grupo control. Los antecedentes de cáncer alcanzan sin embargo 52,63% en el grupo de expuestas, frente al 35% del grupo control (no está separado el período de fumigaciones).

Resultados de genotoxicidad: ensayo cometa

La genotoxicidad es la capacidad que tiene una sustancia para producir cambios en el ADN, estos pueden ser reversibles o no. Los genotóxicos se clasifican en genotóxicos propiamente dichos, mutagénicos, carcinogénicos y teratogénicos.

Los pesticidas están considerados como agrotóxicos, esto es que tienen la capacidad de ser genotóxicos y por esta propiedad pueden actuar como cualquiera de los descritos (Paz-y-Miño *et al*, 2002a). La genotoxicidad se puede evaluar por el porcentaje de fragmentación del ADN, observable en cromosomas o pedazos de ADN, que en condiciones especiales de los ensayos pueden salir del núcleo preparado para observar este efecto. El efecto se ve como un cometa, de ahí su nombre. El cometa tiene un núcleo que debería ser uniforme en caso de normalidad, frente a núcleos con fragmentación ubicada en la periferia a modo de cola del cometa.

Mientras más larga es la cola del cometa, producida por la electroforesis en el ensayo del laboratorio, mayor es el daño. Se evalúa el daño del ADN calculando el porcentaje de núcleos con cola (Paz-y-Miño, *et al.*, 2002c, 2007).

La prueba cometa es muy sensible a cambios o alteraciones de una o las dos cadenas de ADN celulares sobre los que han actuado agentes genotóxicos. Su ventaja es la rapidez con que se obtienen los resultados. En la actualidad se usa en biomedicina para monitoreo humano en exposición a genotóxicos (Paz-y-Miño, *et al*, 2002a, 2002b, 2002c). La prueba consiste en someter las células a un flujo eléctrico. Si no hay daño celular el material genético no se altera y los núcleos celulares se mantienen circulares (normales). Conforme se incrementa el daño del material genético, los núcleos celulares se van deformando y adquiriendo una forma de cometa estelar, de ahí su nombre, que en función del daño tendrá mayor o menor dispersión (ver fotografía 5 y cuadro adjunto –tabla 9- de tipologías de cometa A-F).

Un incremento en la frecuencia de aberraciones cromosómicas (AC) está relacionado con exposición a agentes genotóxicos y se conoce que existe una asociación entre la frecuencia de AC y el riesgo de desarrollar cáncer. Se ha informado de duplicaciones en la incidencia de cáncer en individuos con alta frecuencia de Aberraciones Cromosómicas, por lo que el análisis de AC puede ser utilizado para estimar riesgo genotóxico (Paz-y-Miño, *et al.*, 2000, 2002a, 2002b,

Tabla 9
Tipos de cometa según medida y su porcentaje de presentación

Tipo de cometa	Medidaen nanómetros	% de presentación
A	22,5 – 25	70-90 normal
B	27,5 – 35	10-30 daño bajo
C	37,5 – 75	2 daño medio
D	75 – 110	1 daño alto
E	112,5 – 120	1 daño muy alto
F	120 - +	0 daño máximo

2004, 2005, 2007). Si la población expuesta a las fumigaciones presenta alteraciones significativas en sus cromosomas o fragmentación del ADN evaluada por el ensayo cometa, significará que es una población de alto riesgo mutagénico, cancerigénico y teratogénico (Paz-y-Miño, *et al*, 2002a, 2000b, 2002c).

En la tabla 10 se puede observar cómo el 100% de las mujeres estudiadas en la frontera y que estuvieron en contacto con las fumigaciones presentaron una alta incidencia de daño genético en sus células, en la categoría C de cometa.

El número de células con daño genético (C+D+E) en el grupo expuesto (ver tabla 10) alcanza una media del 36%, es decir, 9 veces más que los datos considerados normales por el laboratorio (4%). En este grupo de mujeres expuestas, los valores extremos de las muestras oscilaron entre 18,7% y 85,3% de células dañadas, es decir, entre 4 y 21 veces más de lo esperado, comparado con la población control.

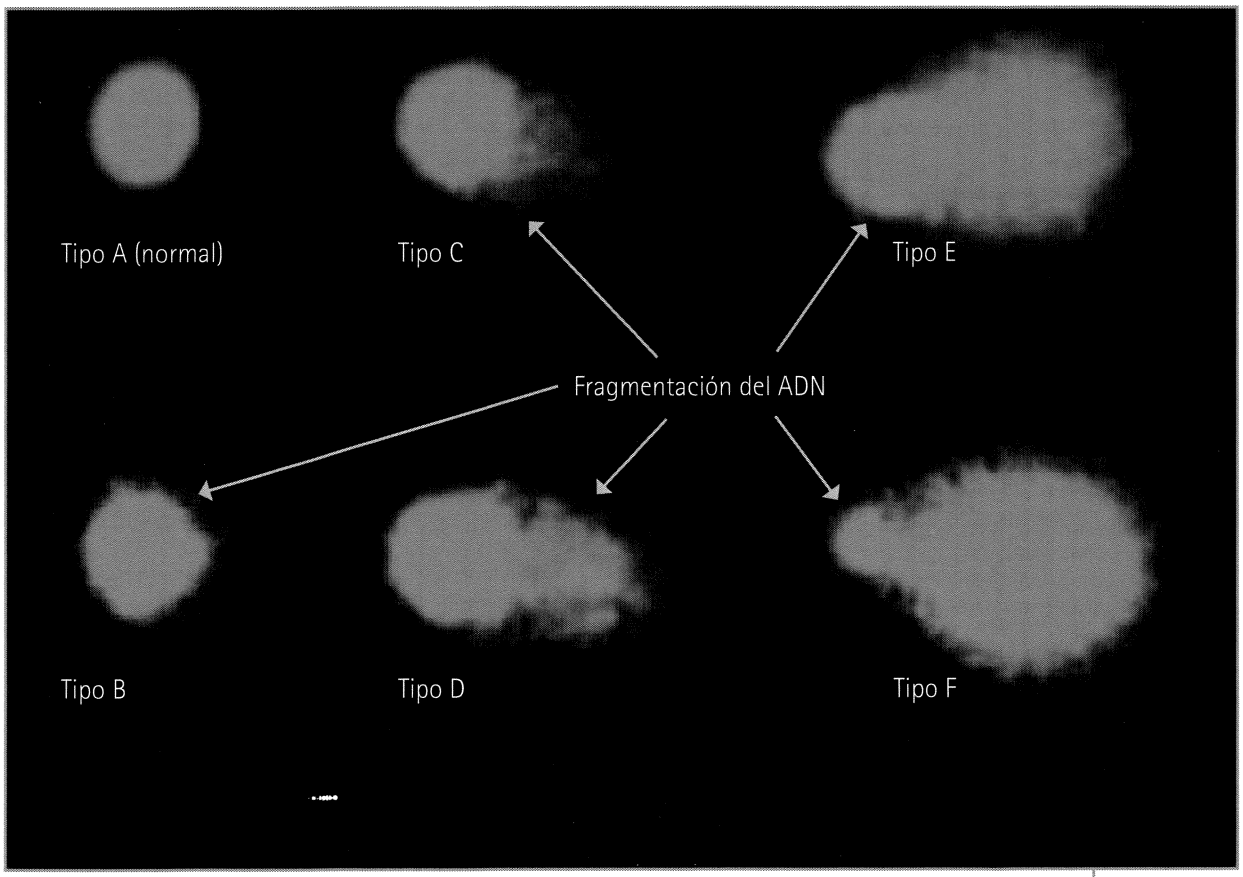


Imagen que muestra la prueba cometa y sus diferentes tipos. A sin daño del ADN, no hay migración en la electroforesis. De B a E el daño es progresivo, existe un aumento del tamaño de la cola, hasta la destrucción de núcleo en F.

Fotografía 5

Tabla 10
Alteraciones celulares en mujeres expuestas a aspersiones aéreas

Mujeres	A	B	C	D	E	Edad
1	0.9	53.7	38	5.55	1.89	53
2	0.9	29.7	28.7	36.1	4.65	40
3	6.93	45.5	40.6	6.93		37
4	7.2	62.2	28.8	1.8		44
5	26	57	15	2		50
6	10.3	65.4	22.4	1.87		38
7	10.3	54.2	33.6	1.87		46
8	10	54	36	0		55
9	12.4	47.6	40	0		50
10	13.2	58.5	28.3	0		22
11	4.8	62.5	29.8	2.88		59
12	18.7	61.7	18.7	0.93		28
13	4.9	47.1	48	0		59
14	17.3	52.9	29.8	0		55
15	29.1	49.5	21.4	0		17
16	3.37	64	32.6	0		34
17	4.67	70.1	23.4	1.87		45
18	5.55	74.1	20.4	0		28
19	0	75.5	23.5	0.98		21
20	0.94	66	33	0		34
21	0	14.7	85.3	0		23
22	0	43.1	55.9	0		34
Media Total Expuestos	8.52	55	33.3	2.85	0.3	

Los valores encontrados muestran: entre 16% y 32% con células dañadas; es decir, entre 4 y 8 veces por encima de lo esperado, estaban el 40% de las mujeres. Con más de 32% y hasta 56% de células dañadas (entre 8 y 14 veces el daño esperado) estaba el 50%, presentándose una mujer (10% de la muestra) con un daño del 69,5%; es decir, 17 veces lo esperado. En todas las mujeres del estudio (100%), están aumentados los porcentajes de células del tipo C; es decir, con daño medio. El porcentaje de daño celular de todas las muestras del grupo de expuestas asciende a un 36,45%, como término medio.

Las muestras 1, 2, y 3 correspondieron a mujeres expuestas en octubre del 2002, cuando la intensidad de las fumigaciones fue mayor. En ellas se destaca que el daño celular comprometió a los tipos D y E, con daño muy grave. Posiblemente por una exposición mayor y constante.

En la siguiente tabla se encuentran los datos del grupo control en la Amazonía: 25 mujeres a 80 km de distancia de la zona asperjada. Las diferencias con respecto al grupo afectado son notables:

El número de células con daño genético (tipo C) en el grupo control de la Amazonía, alcanza una media del 6,9%; es decir, menos del doble de los datos considerados normales (4%). En este grupo los valores extremos de las muestras oscilaron entre la ausencia completa y el 29% de células dañadas; es decir, entre la normalidad y un techo de 7 veces más de lo esperado, según los datos controles.

Tabla 11
Alteraciones celulares en mujeres del grupo control

Edades	A	B	C	D	E	Edad
20	46.1	50	3.92			42
21	43.5	47.8	8.69			40
22	56.6	32.1	11.3			29
23	27.1	57.9	15			32
24	73.5	22.6	3.92			21
25	69.8	23.6	6.6			43
26	80	15	5			53
27	78.9	11.5	9.61			35
28	82.9	17.1				57
29	80.8	12.5	6.73			38
30	89.3	6.79	3.88			22
31	94.1	3.96	1.98			71
32	91.6	5.6	2.8			39
33	87.3	8.82	3.92			25
34	80.2	16.8	2.97			21
35	86.5	9.61	3.84			21
36	92.2	6.79	0.97			50
37	46.6	48.5	4.85			40
38	50	42	8			21
39	63.6	26.2	10.3			38
40	66.3	30.8	2.88			38
41	51.5	35	13.6			43
42	38.3	32.7	29			28
43	55.7	37.7	6.6			50
44	66	27.3	7			41
Promedio	**67.9**	**25.1**	**6.93**	**0**	**0**	

Los valores se repartieron de la siguiente forma: menos del 4% de células dañadas, es decir normalidad, presentaron el 44% de las mujeres. Entre un 4 y 8% de daño celular; es decir, hasta el doble de lo esperado, presentaron un 32% de mujeres. Hasta 4 veces por encima del daño esperado, presentaron el 20% de mujeres y, sólo un 4% de las mujeres presentaron el valor de 29% de células dañadas, equivalente a 7 veces lo esperado.

La evaluación del efecto de las aspersiones aéreas con glifosato en los individuos expuestos en la frontera, mediante la prueba cometa, se ve reforzada por estudios in vivo, realizados en ratones utilizando la misma técnica. Luego de la inyección intravenosa de glifosato al 0,4% de cantidades variables del químico (100, 200 y 400 mg/Kg), se evaluó la clastogenicidad (fragmentación del ADN), producida por este herbicida. El mismo estudio evaluó la producción de micronúcleos (fragmentación de la cromatina). Los resultados muestran que existe un daño progresivo del ADN, siendo a 400 mg/kg cuando más alteración se produce tanto para la prueba cometa, como para el ensayo de micronúcleos. El trabajo muestra el efecto genotóxico del glifosato (Mañas-Torres, F. *et al.*, 2006).

Conclusiones de los estudios genéticos

La totalidad (100%) de mujeres estudiadas habitantes de las zonas asperjadas y que refieren síntomas asociados a este evento, presentan lesiones genéticas en el 36% de sus células.

El daño genético en estas mujeres, es de un 800% por encima del grupo control establecido por el laboratorio y un 500% superior a los daños encontrados en población de similares características en la Región Amazónica, a 80 km de la zona de estudio. La población estudiada que recibió las aspersiones fue expuesta, al menos una vez en los últimos 9 meses, por lo que no se puede determinar si las lesiones producidas son efecto del impacto recibido en las últimas fumigaciones o producto de la acumulación de fumigaciones previas.

Sin embargo, sí se puede afirmar que someter a la población a más fumigaciones puede aumentar el riesgo de daño celular.

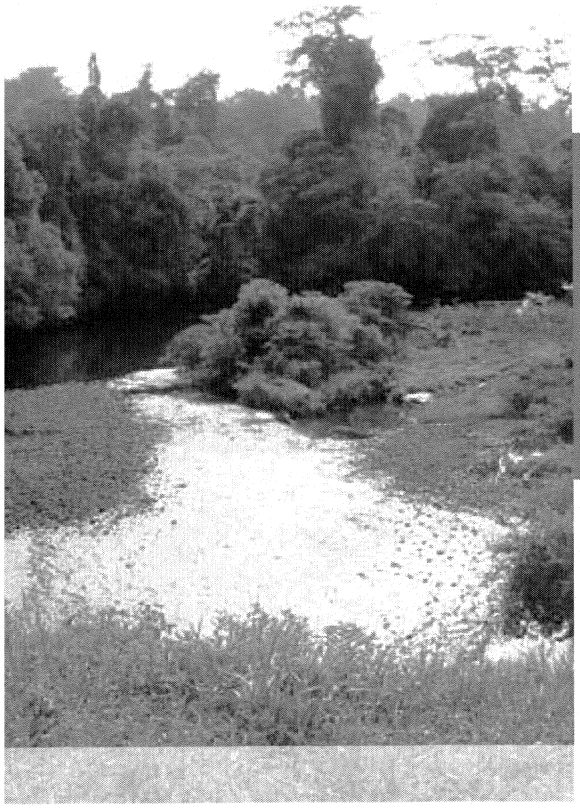
La fragmentación del material genético está relacionada con alteraciones de genes en los sitios en que se rompe el ADN; estos genes pueden inactivarse, perderse o transponerse a otros sitios, determinando mutaciones que están relacionadas directamente con un 30% más de riesgo de desarrollo de cáncer, un 20% más de riesgo de abortos y un 10% más de riesgo de embarazos con malformaciones congénitas.

Incremento elevado, puesto que se trata de contacto continuo con los genotóxicos asperjados.

Tanto abortos como niños con problemas malformativos ya están siendo relatados por la población expuesta; otros, como el cáncer, se deben evaluar periódicamente hasta identificar su inicio.

Casos de alteraciones genéticas han sido informados en estudios de universidades colombianas (Groot, 2005; Lacera-Rua, 2000; Monroy, 2005).

En un estudio reciente, cultivamos linfocitos en presencia de glifosato, aplicando diferentes concentraciones de este herbicida directamente a cultivos de sangre periférica (1, 2, 5 y 10%). Se prepararon placas para observar alteraciones y fragilidad en cromosomas metafísicos y se realizaron cultivos al 5%, con glifosato esterilizado y no. El medio de cultivo se degrada, cambiando sus propiedades (color rojo oscuro, comparado con el rojo brillante del control). El botón celular, luego de la cosecha del cultivo, también varía, mostrando destrucción ya al 5% de glifosato. Igual situación ocurre con el número de células, pues los controles tienen mayor número. Al microscopio, a 5% de concentración del químico, no se observaron metafases; sí se observaron núcleos normales y deformados, siendo mayor la cantidad de deformados. A una concentración de 0.98%, el cultivo también es alterado: se observan núcleos normales y deformes, no metafases. Concluimos que el glifosato es citotóxico y genotóxico en las concentraciones evaluadas. Los resultados están en acuerdo con las observaciones de toxicidad celular informadas en la literatura (Paz-y-Miño, *et al*, 2007).



VI. EL SISTEMA DE ASPERSIONES AÉREAS Y SU IMPACTO EN EL AMBIENTE

El enfoque que se da a esta revisión, acerca de los impactos ecológicos que el programa de erradicación de cultivos ilícitos estaría produciendo en el Ecuador, se basan en la mejor información científica disponible sobre esta problemática.

Sin embargo, el uso de plaguicidas en ambientes tropicales puede no producir impactos de manera inmediata, pero sí efectos acumulativos y sinérgicos a largo plazo, probablemente cuando ya se hayan producido impactos irreversibles y graves.

Existe además, una serie de impactos potenciales que no han sido aún identificados por la ciencia, porque los bosques tropicales son ecosiste mas complejos y poco estudiados.

Generalmente, las evaluaciones de riesgo no toman en cuenta todas estas variables, especialmente cuando se trata de problemas complejos, como es el caso de las aspersiones dentro del

Plan Colombia (exposiciones múltiples, sensibilidad de las poblaciones u otros posibles peligros). Sólo se evalúan los riesgos convencionales.

En caso de contaminantes químicos, se suele analizar químico por químico y organismo por organismo, pero no el conjunto del problema. No se toma en cuenta los problemas ya existentes en el lugar estudiado, ni las reacciones diferenciadas a distintos tipos de ecosistemas, a las comunidades biológicas dentro de esos ecosistemas, a los organismos que conviven en esas comunidades y a las interacciones entre distintos ecosistemas. Tampoco se evalúa el efecto del plaguicida en las redes tróficas del ambiente receptor, ni los efectos de la interacción entre los ecosistemas terrestres y acuáticos.

En muchas evaluaciones se utilizan los esquemas jerárquicos. Se inicia con experimentos simples en unas pocas especies y se avanza a través de una secuencia escalonada de experimentos que aumentan en complejidad, sofisticación, costo, y duración. Dependiendo de los resultados en las pruebas de los niveles más bajos, se inician experimentos en el segundo nivel, únicamente si los resultados en la primera indican potenciales efectos adversos.

En muchos casos, se utilizan especies que no están presentes en el ecosistema en el que se quiere evaluar los impactos del plaguicida o se evalúan especímenes fuera de su contexto natural.

Este es el caso del estudio de Solomon *et al* (2005), comisionado por la CICAD. Este equipo de investigación hizo una evaluación de riesgos sobre los impactos de las formulaciones hechas en los programas de erradicación en el Plan Colombia, usando los siguientes organismos: un alga verde de agua dulce (*Selenastrum capricornutum),* una pulga de agua (*Daphnia sp.),* trucha arcoiris (*Onchorynchus mykiss*) y foxino de cabeza gruesa (*Pimephales promelas*). Nos preguntamos si alguno de estos organismos representan la complejidad de la biodiversidad de la Amazonía colombiana, como para que los investigadores concluyan que el glifosato + cosmoflux no producen impactos en ese medio ambiente.

Estos investigadores consideran que no es importante hacer estudios basados en los organismos presentes en el ecosistema a evaluar. Afirman que:

- *"Una pregunta común al hacer evaluaciones de riesgo en las regiones tropicales y otras regiones que no sean templadas es la escasez de datos de toxicidad de las "especies tropicales". Es cierto que la mayoría de las especies que se usan en las pruebas de laboratorio para toxicidad, especialmente de plaguicidas, son "especies de zona templada", en gran parte por la ubicación de los laboratorios de investigación que tienen la capacidad de realizar pruebas de toxicidad con buenas prácticas de laboratorio. Con la excepción de unas pocas sustancias con mecanismos de acción definidos, no existe ninguna razón para creer que los organismos de las regiones tropicales sean inherentemente más o menos sensibles que los organismos de las zonas templadas".*

En la revisión que presentamos a continuación, trataremos de rebatir esta afirmación, mostrando cómo el glifosato tiene un efecto diferenciado aun en organismos presentes en la misma comunidad biológica.

En esta sección, revisaremos los probables impactos de los programas de erradicación de cultivos ilícitos en el ambiente, sobre la base de la literatura científica existente. Aquí incluimos información generada por científicos de distintas partes del mundo, quienes reportan sus estudios hechos en diferentes ecosistemas y organismos.

Con esta información, analizamos los peligros de las aspersiones aéreas, no sólo desde la perspectiva del impacto en organismos aislados, sino de cómo estos programas impactan en las interacciones ecológicas, las redes tróficas y el equilibrio ecológico en general.

Impactos en el Ecosistema Boscoso

Los programas de erradicación de los cultivos ilícitos en la zona de la frontera de Colombia con el Ecuador, tienen lugar en los bosques húmedos tropicales amazónicos y de El Chocó, ambos considerados como regiones con altísimos índices de biodiversidad y de elevada vulnerabilidad.

La selva amazónica con su enorme superficie y complejidad ecosistémica, es una de las más importantes reservas biológicas existentes en el mundo. Su base natural está conformada por numerosos ecosistemas que interactúan entre sí, que presentan una gran diversidad de flora y fauna y un alto grado de endemismo. Otra dimensión no menos importante es la oferta hídrica de la selva amazónica, que juega un papel importante como reguladora del clima mundial.

El Chocó biogeográfico constituye un mosaico de especies biológicas terrestres y marinas; sus territorios atraviesan la Costa del Pacífico de Colombia y el noroccidente ecuatoriano. Los científicos dan mucha importancia al Chocó pues, además de poseer una extraordinaria biodiversidad, mantiene la única selva lluviosa tropical continua del Pacífico Sudamericano. El Chocó posee una gran cantidad de formas de vida, gracias a sus múltiples ecosistemas. Es importante señalar que en esta región existe un importante número de especies endémicas, en peligro de extinción (Boada, 2006).

Ecuador y Colombia son considerados como megadiversos: poseen el 10% de la biodiversidad mundial con menos del 1% de la superficie terrestre. Esta considerable biodiversidad es resultado de procesos geológicos, geo-morfológicos, condiciones climáticas y de la intervención de las culturas indígenas que han habitado la región por miles de años.

Las aspersiones aéreas con un paquete químico que incluye glifosato, pone en riesgo esta biodiversidad.

Un estudio sobre la base de imágenes Landsat Enhanced Thematic Mapper Plus (ETM+) llevado a cabo por un equipo de la Universidad del Estado de Michigan en la región de Putumayo de Colombia, donde se ha aplicado aspersiones con agentes defoliantes para erradicar las plantaciones de coca (Messina y Delamater, 2006), encontró que este programa ha impactado no solamente en los cultivos ilícitos, sino también en fincas sembradas con cultivos alimenticios y bosques nativos. Se habían afectado 106.178 ha, a pesar de que el United Nations Drug Control Program reportó que se había erradicado apenas 71.891 ha. Hay pues una diferencia de 34.287 ha, que según los autores, corresponden a cultivos lícitos, potreros, frutales, cultivos de ciclo corto y bosques naturales, en una proporción de defoliación de 2 ha de cultivos ilícitos por una de lícitos o bosques.

Es importante señalar además que, a pesar de los programas de erradicación desde el año 2000, la superficie total plantada con coca ha aumentado en un 18% en Nariño, y en un 5% en Putumayo, los dos Departamentos fronterizos con el Ecuador, tal como se resume en la siguiente tabla:

Tabla 12
Evolución de las plantaciones de coca en Departamentos fronterizos con Ecuador

Año	Nariño	Putumayo
2000	9.343	66.022
2001	7.494	47.120
2002	15.131	13.725
2003	17.154	7.559
2004	14.154	4.386
% total 2004	18%	5%

Fuente: UNODC; Gobierno de Colombia, 2005

El Efecto de Borde

Los impactos del paquete de herbicidas con glifosato, en el ecosistema boscoso, no se limitan al área directamente afectada, sino que es mucho mayor debido al efecto de borde.

Este efecto se refiere a la alteración en la composición de comunidades vegetales cerca del borde, ocasionado por los herbicidas. Allí, las especies típicas de una comunidad clímax son desplazadas por especies pioneras. El efecto de borde afecta además la eco-fisiología de las plantas, por ejemplo su tolerancia a las variaciones de temperatura y humedad así como su potencial hídrico (Kapos, Wandelli, Camargo y Ganade, 1997).

Puesto que el efecto de borde produce también cambios en el micro clima, que está fuertemente determinado por las comunidades vegetales presentes, este fenómeno también afecta a las comunidades microbiológicas (Stephen, Turton y Freiburge, 1997). Los efectos microclimáticos debido al borde han sido detectados hasta 30 metros dentro del bosque, a partir de la zona deforestada.

El efecto de borde altera también a los microorganismos de la filosfera que quedan más expuestos a las variaciones térmicas, a las fluctuaciones de humedad y del potencial hídrico en el borde, que bajo la sombra.

En estudios en invertebrados del suelo, se ha encontrado que las poblaciones de Coleópteros se afectan por el efecto de borde en áreas de entre 100 y 210 metros, en bosques que han sido perturbados (Didhám, 2007).

Impactos en las Redes Tróficas, Sucesión Ecológica, Fenología

El impacto del glifosato en las redes tróficas se demostró en un estudio hecho en Australia, donde se encontró que especímenes de 5 especies de pinzones nativos murieron luego de estar expuestos a semillas tratadas con glifosato (Evans y Batty, 1986).

Otros estudios han demostrado que las aves pueden afectarse por alteraciones de sus sitios de alimentación, de anidación, por cambios en la sucesión natural de los ecosistemas, o por disminución de sus fuentes alimenticias. Esto hace que la densidad de poblaciones de aves disminuya, que se seleccionen algunas especies más tolerantes a ecosistemas alterados, desfavoreciendo a especies con requerimientos ecológicos más reducidos (MacKinnon y Freedman, 1993).

Resultados similares han sido encontrados en poblaciones de pequeños mamíferos. Estas poblaciones se han impactado negativamente luego del uso de glifosato para clarear el bosque. Estas especies perdieron sus fuentes alimenticias, especialmente plantas y artrópodos (Santillo *et al*, 1989; D Anieri *et al*, 1987; Richie *et al*, 1987).

Santillo y colaboradores (1989) en su estudio en el Estado de Maine, encontraron que luego de la aplicación de glifosato, la composición vegetal se hacía menos diversa.

El impacto del glifosato en la sucesión ecológica boscosa fue estudiado por Bell y colaboradores (1997), que hicieron una investigación en el noroeste de Ontario – Canadá, en bosques deciduos temperados. Ellos encontraron que el uso de este herbicida disminuía la cobertura vegetal de árboles deciduos, arbustos y helechos. En el caso de bosques de coníferas, encontraron que el glifosato reducía la vegetación leñosa y herbácea. Es decir, ejercía un impacto en la composición y estructura de estos bosques.

Se ha registrado además, cambios en la fenología de plantas debido al efecto del glifosato. Un grupo de investigación del Reino Unido, estudió los impactos del glifosato y otros herbicidas en la vegetación de bosques marginales, barreras arbustivas y campos marginales que habían sido expuestos a estos plaguicidas en los últimos tres años, una vez por año (Marrs, Williams, Frost y Plant, 1989). Analizaron los efectos de dosis subletales en la productividad de las especies, los patrones de floración, producción de semillas, variabilidad de semillas y la invasión de nuevas especies en estos espacios. Encontraron que todas las especies estudiadas habían sido impactadas negativamente por la deriva provocada durante las aplicaciones hechas con herbicidas. Pero, el comportamiento de cada especie fue distinto, dependiendo de la estructura de la comunidad vegetal en la que se encontraban. Este estudio nos muestra que es extremadamente difícil extrapolar resultados toxicológicos entre una comunidad vegetal y otra.

Sin embargo, es necesario resaltar que los cambios en la fenología en comunidades vegetales en bosques tropicales son un factor crítico para el equilibrio ecológico. Varios estudios se han hecho sobre la co-evolución entre plantas y animales; y la relación entre la floración o fructificación de ciertas especies vegetales con la ecología reproductiva de determinadas especies polinizadoras, responsables de la dispersión de los frutos, etc. (Bawa y Hadley, 1990) .

Cambios en la fenología de comunidades vegetales generados por efectos del glifosato, pueden interferir en estos procesos.

Las plantas necesitan defenderse de los ataques biológicos y del estrés ambiental, pero su falta de movilidad y la falta de sistema inmunológico como el que poseen los animales, han hecho que desarrollen mecanismos de defensa en que cada célula posee capacidad de defensa inducida y preformada. Sin embargo, estos mecanismos pueden ser influenciados por el uso de herbicidas. Algunos incrementan la severidad de

ciertas enfermedades induciendo o inhibiendo la formación de fitoalexinas. Así como los herbicidas del grupo de los difenileteres favorecen la producción de formas activas de oxígeno, aplicaciones de subdosis de glifosato provocan efecto contrario, disminuyendo la formación de estos elementos y aumentando la severidad de enfermedades, según lo señalado por Rizzardi *et. al.*, (2003).

Efectos en las Interacciones Ecológicas

Los efectos ecológicos del programa de erradicación de cultivos ilícitos en los ecosistemas boscosos, no pueden ser evaluados analizando únicamente las zonas deforestadas. Los cambios que producen en la estructura y funciones del bosque, afectan la interacción entre las comunidades biológicas, la sucesión ecológica y las redes tróficas, y la disponibilidad de nichos ecológicos, alterando el equilibrio ecológico.

La alteración de determinadas poblaciones, afecta negativamente a otras poblaciones de una misma comunidad biológica, produciéndose un fenómeno que se llama "efecto cascada".

Por ejemplo, algunas poblaciones vegetales especialmente vulnerables al glifosato o sus coadyuvantes, cuando son alimento de algunas especies de insectos, éstos se afectarán y a su vez afectarán a pájaros o anfibios que se alimentan de ellos. Si hay otros animales que dependen de esos pájaros para su alimentación, también serán afectados, produciéndose impactos en toda la red trófica.

Estas mismas plantas, al mantener relaciones simbióticas con otras especies como epífitas, saprofititas, parásitas, con micro-organismos fijadores de nitrógeno o micorrizas serán impactados, lo que significa la desaparición de nichos ecológicos y desequilibrio en las interrelaciones biológicas existentes.

A nivel del suelo también habrá efectos negativos, porque posiblemente las plantas originales permitirán que se desarrolle en el suelo un determinado tipo de comunidades micro-biológicas, las mismas que desaparecerán y el proceso de descomposición y el ciclo de nutrientes se alterará.

Por otro lado, dado que hay especies que son más susceptibles al herbicida que otras, habrá una selección de las especies más resistentes a la contaminación, alterándose la estructura ecológica del ecosistema. Ya veremos esto con más detalle al hablar del surgimiento de supermalezas.

Impactos en el ciclo de nutrientes

Varios estudios demuestran el impacto que tiene el glifosato en comunidades de micro-organismos que juegan importantes roles en el ciclo de nutrientes.

Como es bien conocido, en los bosques tropicales el ciclo de los nutrientes es acelerado, almacenándose la mayor parte de ellos en la parte viva del sistema. Por eso, la mayor parte de la producción primaria neta se utiliza en la producción de hojas y frutos. Este hecho está relacionado con la baja disponibilidad de nutrientes minerales en el suelo.

Por esa baja disponibilidad de nutrientes, en los bosques tropicales se desarrollan asociaciones entre las raíces de los árboles con ciertos hongos, formándose las micorrizas fúngicas. Éstas transfieren a las raíces nutrientes que provienen de la descomposición de la materia orgánica existente en el suelo. El proceso permite que la escorrentía produzca pequeñas pérdidas de minerales, y determina la rápida circulación de éstos.

También en el suelo se encuentran poblaciones de bacterias y cianobacterias, muy importantes en el mantenimiento de los altos valores de biomasa, puesto que son fijadoras de nitrógeno. Determinadas cianobacterias además, forman parte de líquenes que igualmente intervienen en el ciclo del nitrógeno.

Dada la baja fertilidad de los suelos tropicales, un adecuado equilibrio en el ciclo de nutrientes y de los microorganismos involucrados en cada uno de ellos, es vital.

Bacterias nitrificantes

Existen varios estudios que demuestran la interferencia del glifosato en los procesos de fijación de nitrógeno, tanto en bacterias de vida libre como en bacterias que establecen relaciones simbióticas con plantas.

En estudios hechos con soya transgénica con resistencia al glifosato, Zablotowicz y Reddy (2004) encontraron que la bacteria nitrificante *Bradyrhizobium japonicum*, que fija nitrógeno en las raíces de la soya, posee una enzima sensible al glifosato y que cuando está expuesta a este herbicida, acumula ácido chiquímico y ácidos hidroxibenzoicos, lo que produce la inhibición del crecimiento y hasta la muerte de la bacteria en gran cantidad. Se encontró además que el glifosato se acumula en los nódulos de las raíces de la soya. Esto repercute en el crecimiento de todas las plantas leguminosas (que establecen relaciones simbióticas con bacterias nitrificantes) y en la salud del suelo en general. Este herbicida afecta pues al ciclo del nitrógeno en agroecosistemas. Este fenómeno también es reportado por Hutchinson, (1995), Forlani *et al.*, (1995).

Un estudio hecho en la India con suelos degradados provenientes de plantaciones de té tratados con glifosato, redujo colonias de bacterias fijadoras de nitrógeno (Bezbaruah *et al*, 1995).

Se ha reportado también una inhibición en la nodulación en raíces de trébol en suelos con niveles de entre 2 y 2000 mg/kg de glifosato. El efecto persistió 120 días después del tratamiento (Eberbach, et al, 1983).

Se han hecho también estudios con bacterias nitrificantes de vida libre. Santos y Flores (1995)

estudiaron los efectos del glifosato en la fijación de nitrógeno en bacterias heterotróficas de vida libre. Estos autores encontraron que dosis de glifosato superiores a 4 kg/ha inhibían la fijación de nitrógeno. El herbicida afectaba también la respiración y causaba una reducción en el tamaño celular.

Dada la baja fertilidad de los suelos tropicales, la fijación biológica del nitrógeno es vital para mantener el equilibrio de nutrientes en el suelo.

El glifosato es uno de los pocos herbicidas con carga eléctrica positiva, cosa que le proporciona la particularidad de que al entrar en contacto con el suelo, cargado negativamente, sea rápidamente inmobilizado e indisponible para la absorción vía radicular. Sin embargo, existen elementos minerales que compiten por estos sitios con otros elementos y con el propio glifosato, como es el caso de Ca, Fe y P, pudiendo formar sales con metales como Al y Fe. De hecho, de acuerdo a divesos estudios, altos niveles de fósforo favorecen la precipitación de Fe y Al en el suelo, disminuyendo la adsorción de glifosato, lo que aumenta la absorción por las plantas, con el consecuente riesgo de daño (Souza, 1982).

Hongos Micorrizas

La interacción entre microorganismos, sustratos y constituyentes del suelo puede alterar la biodegradación de los herbicidas, pudiendo ser mayor o menor dependiendo de la capacidad de adsorción del suelo. La adsorción puede reducir la cantidad de herbicida en la solución del suelo.

La presencia de glifosato en suelos de bosques puede favorecer a la micro biota que consigue degradar la molécula y, por otro lado, suprimir otros microorganismos, incluyendo los benéficos, con la consecuente alteración del equilibrio de la micro fauna de estos ambientes.

La relación entre hongos micorrizas con las raíces de algunas plantas y árboles es esencial para la adsorción de fósforo.

Junior y Zambolin, (1994), reportaron que el glifosato reduce la colonización de las raíces del eucalipto por micorrizas. De acuerdo a Dodd y Jeffries (1989) citados por Tuffi Santos *et. al.*, (2005), es muy posible que el uso frecuente de herbicidas en una determinada área provoque disminución selectiva de hongos micorrizicos en el campo.

Un estudio hecho sobre los efectos del glifosato en cultivos de soya en Brasil, reveló que el glifosato inhibe el crecimiento del tubo germinativo de micorrizas arbusculares vesiculares simbiontes de la soya (Dos Santos Malty *et al.*).

En una investigación hecha por un equipo canadiense dirigido por el científico Wan y colaboradores (1991), se identificó el efecto nocivo del glifosato en el hongo micorriza arbuscular vesicular *Glomus intraradices,* en raíces de zanahoria. Dado que muchas plantas no pueden crecer sin esta relación micorrizal, este es un efecto posible de las fumigaciones con glifosato a considerar. Posteriormente, Wan *et. al* (1998) realizaron otro estudio para evaluar la toxicidad subletal del

glifosato en las relaciones entre hongos micorrizas, nutrientes y plantas.

La interferencia de glifosato en las relaciones entre hongos micorrizas, nutrientes y plantas fue publicado por Wan *et. al* (1998). La relación entre hongos micorrizas con las raíces de algunas plantas y árboles es esencial para la absorción de fósforo.

En los suelos tropicales, varias especies de importancia comercial se asocian con micorrizas arbusculares vesiculares que juegan un papel fundamental en la adsorción de fósforo, nutriente que es muy escaso en este tipo de suelos. Se ha reportado también que las micorrizas arbusculares vesiculares influyen en la nodulación en leguminosas para la fijación de nitrógeno (Panus, 1980).

Procesos de descomposición de materia orgánica

Los micro-organismos del suelo son los responsables de la descomposición de materia orgánica en nutrientes. Dado que el ciclo metabólico del ácido chiquímico está también presente en micro-organismos, el glifosato les afecta adversamente y, por lo mismo, interfiere en los procesos de descomposición de la materia orgánica.

Un equipo de investigación egipcio estudió los impactos del Roudup en hongos del suelo y en la descomposición de materia orgánica. Ellos encontraron que el herbicida aumentaba la presencia de ciertas especies de hongos y disminuía otras. Se registró también disminución en la tasa de respiración y de descomposición de la materia orgánica (Abdel-Mallek *et al*, 1994).

En Argentina, la utilización de grandes cantidades de glifosato asociada al cultivo de soya transgénica ya está afectando el equilibrio natural y la vida microbiana del suelo, originando problemas en la descomposición de la materia orgánica y amenazando la biodiversidad y el futuro productivo de extensas comarcas (Joensen y Semino, 2004).

En Canadá se ha comprobado que el cultivo de colza resistente a herbicidas afecta a la biodiversidad y actividad microbiana en los suelos (Dunfield y Germida, 2001).

El glifosato tiene efectos negativos en nemátodos y otras lombrices e invertebrados (Dewar, Haylock, May, Beane, Perry, 2000). Una investigación en Nueva Zelanda mostró que el glifosato tenía efectos significativos en el crecimiento y sobrevivencia de lombrices comunes del suelo. Aplicaciones cada 15 días en dosis bajas (1/20 de la dosis normal), redujeron el crecimiento e incrementaron el tiempo de madurez y la mortalidad (Springett, Gray 1992; Cox, 1995).

Aumento de organismos patógenos

El glifosato aumenta el crecimiento de hongos patogénicos, según muchas investigaciones publicadas en la literatura científica. Como resultado, estos hongos predominan en un área para liberar sus propias toxinas (micotoxinas), que son perjudiciales para muchas de las otras formas de vida cercanas, incluso mamíferos.

Uno de los géneros que tiende a aumentarse en presencia de glifosato es el género *Fusarium*. En Estados Unidos se ha observado que la utilización cada vez mayor de glifosato en la soya transgénica, incrementa los problemas de colonización de las raíces por *Fusarium spp*, un hongo que produce grandes daños en los cultivos y cuya presencia en los alimentos puede tener efectos nocivos para la salud humana, llegando a ser mortal en concentraciones elevadas (Kremer y Donald, 2003; Sanogo, Yang, Scherm, 2000; Wan et al, 1989, Delcalzo, Punja, Levesque y Rahe, 1996; Johal y Rahe, 1984; Levesque, Rahe y Eaves, 1992; Levesque, Rahe y Eaves, 1993, Levesque, Beckenbach y Rahe 1993; Rahe, Levesque y Johal, 1997; Wan, Rahe, y Watts, 1998).

La literatura científica asocia a otros agentes patógenos con el uso de glifosato. Un estudio hecho por la Comisión Forestal del Reino Unido, encontró que el 19% de barreras arbustivas de fresno, mostraban síntomas de *dieback*, una enfermedad del fresno que puede ser producida por una serie de agentes, pero que la Comisión Forestal la atribuyó, entre otras causas, al uso de glifosato (Forestry Commission, 1991).

Se ha reportado, además, que el uso de glifosato incrementa la patogenicidad y la sobrevivencia de *Gaemannomyces gramminis*, agente causal del pietín del trigo. Se observó también que por efecto del herbicida, disminuyeron los hongos del suelo que son antagonistas del patógeno y podrían reducir significativamente la incidencia de esta enfermedad. Además, se sabe que el glifosato incrementa la susceptibilidad del fréjol a la antracnosis (cuyo agente causal es el hongo *Colletotrichum lindemuthianum*) y la incidencia de *Rhizoctonia* en la pudrición de la raíz de cebada (Johal y Rahe, 1984; Smiley, 1992; Mekwatanakarn y Silvassithamparam, 1987).

Una misión de verificación, hecha a la zona afectada por las aspersiones dentro del programa de erradicación de cultivos ilícitos en la frontera Ecuador – Colombia en la Provincia de Sucumbíos, encontró la presencia de *Fusarium sp.* en todas las muestras evaluadas (Maldonado *et al.*, 2002). Otros hongos patógenos aislados fueron *Rhizoctonia, Cylindrocarpon y Helminthosporium.* Las muestras fueron hechas en pasto, maíz, maní, arroz y suelos. A continuación en la se resumen los resultados (TABLA 13).

La proliferación de *Fusarium* es de especial importancia en el contexto del Plan Colombia, pues hasta septiembre del 2002, *Fusarium oxysporum var. erythroxyli* iba a ser utilizado por recomendación del Gobierno de los Estados Unidos como un micoherbicida en Colombia con el fin de erradicar la coca, propuesta que fue rechazada por el Comité Andino de Autoridades Ambientales (CAAAM). Aunque nuevamente hay presiones para que se utilice.

Especies del género *Fusarium* han sido responsables en todo el mundo de daños serios a muchos cultivos, suelos envenenados, defectos de nacimientos en seres humanos, y en un caso documentado, la muerte de miles de personas causada por sus micotoxinas cuando éstas se alimentaron de cereales contaminados durante

Tabla 13
Hongos patógenos aislados en muestras de plantas en zonas afectadas

Muestras de cultivos y presencia de hongos					
Lugar	Cultivo	Muestra	Resultados		
Playera Oriental	Maíz	Raíz	Fusarium sp	Rhizoctomía sp	Cylindrocarpon
Playera Oriental	Maíz	Hojas	Helminthosporium	Rhizopus sp.	Mucor sp.
Pedregosa	Pasto	Raíz	Fusarium sp.	Rhizoctomía sp	
Pedregosa	Pasto	Hojas	Fusarium sp.	Rhizoctomía sp	
Chone-2	Maní	Raíz	Fusarium sp.	Rhizoctomía sp	
Chone-2	Mani	Hojas	Fusarium sp.	Alternaria sp.	
		Suelo	Fusarium sp.	Rhizoctomía sp	Cylindrocarpon
Chone-2	Arroz	Raíz	Fusarium sp.	Rhizoctomía sp	Rhizopus sp.
Chone-2	Arroz	Hojas	Fusarium sp.	Rhizoctomía sp	Rhizopus sp.
Playera Oriental	Pasto	Raíz	Fusarium sp.	Rhizoctomía sp	

Fuente: Maldonado *et al* (2002)

los últimos años de la Segunda Guerra Mundial (Marassas, Nelson y Tousson, 1984).

El equipo del CIF encontró además, que los niveles de proteínas fueron muy pobres en las plantas. Los análisis de nutrientes de las plantas, realizados por el Laboratorio de Suelos, Aguas y Plantas en la ciudad de Coca (Labsu), encontraron que

- *"el vegetal no absorbe este nutriente debido a una posible influencia externa, la cual se vio claramente durante la extracción del material de estudio. Este vegetal se observó seco en sus partes aéreas y con putrefacción a la altura de las raíces y tallos. El pasto Dallis presenta niveles altos en cuanto a fósforo total, casi el doble de lo reportado como normal en la bibliografía (760mg/Kg). Consideramos que este es un dato anormal, lo que señala que la planta no ha absorbido el exceso del suelo, ya que el suelo donde se extrajo ese material presenta cantidades adecuadas y no excesivas de este elemento. Posiblemente este exceso pueda provenir de una influencia externa que se aplicó directamente sobre las hojas del vegetal"* (Pazmiño, 2003).

Surgimiento de Supermalezas

El amplio uso del glifosato en áreas de cultivo de transgénicos con resistencia a este herbicida, ha permitido el desarrollo de biotipos de malezas también resistentes, dificultando y encareciendo su combate, pues existe la necesidad de recurrir a herbicidas aun más fuertes, para controlarlas.

Aunque el herbicida glifosato se considere como no selectivo, varias especies de malezas de los géneros *Commelina, Ipomoea y Richardia*, presentan cierto grado de tolerancia a las dosis recomendadas, sobre todo en áreas donde se usa extensivamente este producto. Al evaluar la dinámica de las semillas de estos géneros y de otros susceptibles, se determinó que las poblaciones de las especies de los géneros mencionados como tolerantes, aumentaron de manera significativa, principalmente cuando se aplicaron dosis menores, por lo que se considera que el uso de este herbicida de manera intensiva puede ocasionar un cambio en el área, aumentando la frecuencia de la presencia de estas especies a lo largo de los años (Monquiero y Christoffoleti, 2003).

Efectos Sobre los Sistemas Acuáticos y sus Comunidades Biológicas

El glifosato puede contaminar cuerpos de agua superficial, ya sea por aspersión directa, por efecto de la deriva, o porque este pesticida es lixiviado a los acuíferos.

Estudios realizados por la Comisión Ecuatoriana de Energía Atómica en suelos y agua de la zona de Sucumbíos, con la metodología de análisis EPA 547 basada en cromatografía líquida, muestran que existen trazas de glifosato menores a 100ug/kg en suelo, en muestras de Estero Tapi y La Balastrera, y trazas en agua, menores al 10ug/L, en muestras de Azul Chiquito y Río San Miguel. Los análisis se realizaron a una distancia entre 200 a 500 metros de la frontera ecuatoriano-colombiana. (CEEA, 2005).

La persistencia del glifosato en el agua es más corta que en el suelo. Por su capacidad de adsorción a partículas en suspensión, materia orgánica y minerales, su persistencia en sedimentos es más prolongada.

Debido a los altos valores de precipitación existente en las zonas donde tienen lugar los programas de erradicación de la coca, el glifosato es rápidamente transportado por la escorrentía desde los suelos a aguas subterráneas.

La posibilidad de que el glifosato y sus coayuvantes contaminen los cuerpos de agua superficial y subterránea en las regiones tropicales fronterizas del Ecuador, donde tienen lugar los

programas de erradicación de coca, constituye una amenaza seria para el equilibrio ecológico de las regiones afectadas, donde hay una gran cantidad de cuerpos de agua de los que dependen todas las comunidades biológicas, no sólo de los ecosistemas acuáticos, sino también de los ecosistemas terrestres aledaños, pues existe una interacción entre ambos (Victoria *et al*, 2004, Sedell *et al*, 1989).

La región amazónica es considerada como una de las mayores fuentes de agua dulce del planeta, y las cuencas de sus ríos como las que albergan la mayor biodiversidad de peces en el mundo. La cuenca del Tiputini en la Amazonía ecuatoriana, posee el mayor número de peces de agua dulce a nivel mundial. (Barriga, 2001).

Toxicidad en organismos acuáticos

El glifosato altera desde el primer eslabón de la cadena trófica de los ecosistemas acuáticos. Por ejemplo, en un estudio hecho sobre el impacto de 23 plaguicidas en plantas acuáticas, se encontró que las diatomeas y una especie de cianobacteria fueron vulnerables al glifosato. Una de las conclusiones del estudio es que el grado de vulnerabilidad frente al glifosato varía mucho de una especie a otra y que existe un factor de incertidumbre cuando se evalúan estos productos en ecosistemas acuáticos (Peterson *et al*, 1994).

Otro estudio encontró que el glifosato puede estimular la eutrofización en ecosistemas acuáticos, ya que algunos productores primarios, como las diatomeas, utilizan este herbicida como fuente de fósforo. Una de las preocupaciones generadas por los resultados de esta investigación es que la presencia de glifosato, por debajo de los niveles detectables, induce la eutroficación en canales, charcas y otros cuerpos de aguas de superficies pequeñas, lo que afecta el hábitat de poblaciones de peces (Austin *et al*, 1991).

Aunque se afirma que el glifosato no se bioacumula en las cadenas tróficas, el hecho de que altere la ecología de los productores primarios, está alterando el equilibrio ecológico de toda la comunidad. Este es un problema grave para los ecosistemas tropicales (donde tienen lugar los programas de erradicación de la coca), pues en estas regiones existen abundantes cuerpos de agua.

Uno de los problemas más serios de las formulaciones de glifosato utilizadas para la erradicación de la coca, es que algunos de los ingredientes son más tóxicos para la vida acuática que el mismo glifosato. Además, en la combinación que se utiliza, la suma de éstos tienen un efecto aditivo de toxicidad (Bidwell y Gorrie, 1995; Cox, 1995, Abdelghani,1997).

Los impactos en la biodiversidad piscícola amazónica tienen repercusiones importantes a nivel económico y cultural, pues muchas comunidades dependen de la pesca para su sobrevivencia. Este el caso de un importante agroindustrial de la frontera (Mestanza, 2002), quien denunció cómo tras las tres aspersiones del 2001 y 2002 perdió más de 170.000 peces de las 18 piscinas construídas para su producción

comercial, pérdidas que se sumaron a la muerte de más de 400 patos, 150 gallinas, 20 cerdos, 3 yeguas, 30 hectáreas de orito, 8 de caña, 10 de café, 6 de cacao y toda la producción de mandarina, sangre de drago, laurel y manzano colorado. Pérdidas que fueron ratificadas por el entonces gobernador de Sucumbíos (Velasco, 2002) y que en el 2006 mencionó haber dejado secuelas en su producción.

Hay un estudio comparativo sobre el impacto de herbicidas y surfactantes hecho por Abdelghani (1997), en especies acuáticas, quien estableció la toxicidad aguda de tres herbicidas solos o como mezclas (2,4-D, Garlon-3A y Roundup) y un aditivo químico (el surfactante Syndets) en tres especies de agua dulce: el bagre, ojón o chopa criolla (*Lepomis macrochirus)* y un cangrejo de río. De los tres herbicidas, el Roundup fue más tóxico para el bagre y el ojón "bluegill" que el Garlon-3A y el 2,4-D. Los resultados encontrados para el cangrejo del río fueron exactamente los contrarios a los que se encontró en los peces.

El surfactante "Syndets", fue mucho más tóxico que los tres herbicidas para los tres organismos.

Un grupo de investigadores encontró que el glifosato es nocivo en concentraciones sub letales para la carpa *Cyprinus carpio* (Neskovic *et al* 1996). Entre los efectos reportaron cambios en la actividad enzimática a nivel de plasma, hígado, riñones. Encontraron además, alteraciones morfológicas en las branquias, hígado y riñones.

Los estudios realizados en Francia sobre la reproducción celular en erizos de mar demuestran que los plaguicidas que incorporan glifosato alteran el clico universal de división celular en su fase G2/M, mediante defosforilación de la reguladora de ciclo conocida como "CDK1-ciclina", alterando los "checkpoint" celulares que determinan el funcionamiento normal del ADN celular (Marc, Bellé et al., 2004). De acuerdo al Dr. Bellé, si bien sus estudios no han mostrado el proceso de cancerigenización completo que toma muchos años, en cambio han logrado mostrar las primeras etapas del proceso de daño e inestabilidad genética que devienen en cáncer con el tiempo (Bellé, 2007).

Otros estudios revelan que el glifosato es nocivo también para otros organismos acuáticos. Se ha reportado, por ejemplo, cambios en el desarrollo y la reproducción del caracol acuático *Pseudosuccinea columella*, cuando fue expuesto a concentraciones subletales (Tate *et al*, 1997). Los investigadores encontraron además, que cuando el caracol fue expuesto a distintas concentraciones de glifosato, se producía un estímulo en su crecimiento y desarrollo; había un incremento en el número de huevos que tenían más de un embrión. Esto significa que la población de caracoles de esa especie podía incrementarse. Por otra parte, esta especie de caracol es uno de los huéspedes de un parásito del hígado de las ovejas. El estudio concluye que la presencia de glifosato a niveles bajos, puede promover el incremento de este parásito.

Distintas especies de peces tienen distintos grados de vulnerabilidad al glifosato (Wan, 1989). Otros

factores que determinan la toxicidad del herbicida incluyen la cantidad de minerales disueltos en el agua (Hartman y Martin, 1984) y la temperatura del agua (Folmar, *et al.*, 1979).

Impacto del glifosato en anfibios

La contaminación de las aguas por este herbicida es extraordinariamente letal para los anfibios, según un trabajo de investigación que ha revelado una disminución de la diversidad de anfibios del 70% y una reducción del número total de renacuajos del 86% en charcas contaminadas por Roundup (Relyea, 2005).

En investigaciones conducidas en Australia, la formulación Roundup ha demostrado una seria toxicidad en anfibios. En un estudio comisionado en 1995 por el Western Australian Department of Environmental Protection (DEP) y dirigido por el Dr. Joseph Bidwell del Curtin Exotoxicology Program, concluyó que Roundup 360 (otra formulación de Roundup que contiene glifosato y surfactantes) puede ser agudamente tóxico para ranas adultas y renacuajos, en las tasas de aplicación recomendadas (1.8 to 5.4kg/ha) (Mann y Bidwell, 2004).

El herbicida Roundup 360 fue más tóxico a ranas y renacuajos que el grado técnico de glifosato solo. Se asumió que fue el surfactante usado en la formulación del Roundup, y no el glifosato en sí, el responsable en el incremento en toxicidad (Bidwell et. al. 1995). Hay que notar que es precisamente el mismo surfactante (POEA) que se encuentra en el Roundup utilizado en Colombia.

Resultados similares se han encontrado en Canadá, donde el glifosato provocó parálisis y hasta la muerte de especies nativas de anfibios (Bruce, 1996).

Dados los impactos registrados del glifosato en los anfibios, el Congreso de los Estados Unidos exigió al Departamento de Estado (DoS, por sus siglas en inglés) hacer una evaluación sobre el riesgo en los anfibios, provocado por el programa de fumigación aérea que los Estados Unidos financia en Colombia. Como respuesta al requerimiento del Congreso, el DoS contrató a la CICAD para realizar el trabajo científico (AIDA, 2006).

Los anfibios son un componente importante de la biodiversidad de esta región amazónica, donde se han registrado los índices más altos de biodiversidad de anfibios por unidad de área en el mundo. Se ha registrado además una alta tasa de extinción de varias especies de anfibios en el Ecuador (Coloma, 2005) y se cree que por efecto de las aspersiones con glifosato este problema se puede agudizar.

Efectos en organismos no objetivo

Uno de los principales problemas con el uso de pesticidas en general, es que estos afectan a otros organismos distintos a los que se quiere combatir.

En cuanto al glifosato, se afirma que por interferir en la ruta metabólica del ácido chiquímico, que está ausente en animales, éste no los afecta. Sin embargo, existe abundante bibliografía que

demuestra lo contrario. Los impactos pueden producirse por una afectación directa en los individuos expuestos al plaguicida, o por una destrucción de la base de sobrevivencia de la especie. Se han informado cambios a nivel hormonal.

Impactos Sobre Otras Especies Animales

Efectos sobre insectos

Evaluando el impacto del glifosato sobre los organismos vivos, se trabajó con la mosca de la fruta, como modelo genético para estudio de mutagénesis. Se prepararon medios de cultivo en los cuales se colocó moscas para fecundación y reproducción. Se varió las concentraciones de glifosato en el medio entre 3, 6, 12, 24 y 40%. En tres repeticiones de los cruces 3% y 12%, no se obtuvo larvas de tercer estadio, por lo tanto no se observaron cromosomas politénicos ni metafásicos. Sólo en un cruce de 3% se obtuvo una pupa, a los 17 días (normal pupación a los 6 días), la cual adquirió una coloración café y murió. Observamos que el glifosato altera el número de huevos puestos por la moscas, disminuyendo el número de éstos al aumentar la concentración, es decir, retarda el ciclo de vida de *Drosophila*. En el grupo control de moscas (medio sin glifosato) se completa el ciclo a los 13-16 días ciclo. En las concentraciones 6%, 24% y 40% no se completó el ciclo, porque los adultos mueren. Concluimos que el glifosato impide el desarrollo normal de la mosca y larvas (Paz-y-Miño, *et al.*, 2007).

El uso de glifosato en ambientes agrícolas ha desencadenado el brote de algunas plagas agrícolas, y esto se ha relacionado con la disminución de las poblaciones de especies predatorias de dichas plagas, que actúan como agentes de control biológico natural. Este es el caso del brote violento del áfido del cereal que tuvo lugar en Estados Unidos, al inicio de la década de 1970 (Potts y Vickerman, 1994).

Una evaluación hecha por la Organización Internacional de Control Biológico sobre los impactos de los plaguicidas en especies benéficas, reportó que el 80% de una población de escarabajos predadores de plagas vegetales murieron cuando fueron expuestos a glifosato. Por otro lado, el 50% de la población de avispas parasitoides, mariquitas, crisopos y ácaros predadores también murieron luego de la exposición a glifosato (Hassan et al 1988).

Productos como glifosato, simazine+ametrine, 2,4-D, acetoclor y oxifluorfen reducen de manera significativa el crecimiento vegetativo y esporulación del aislado de *Beauveris bassiana* (UEL 114), entomopatógeno controlador de la

cochinilla de la raíz (Dysmicoccus texensis Tinsley) del café (Andaló *et al.*, 2004).

Las formulaciones de glifosato también pueden afectar el comportamiento de otros organismos controladores de plagas, sobre todo en su capacidad de parasitismo, como es el himenóptero *Trichogramma pretiosum* (Giolo *et al.*, 2005).

En un estudio hecho en Carolina del Norte, Estados Unidos se registró una baja poblacional de escarabajos carabus tratados con glifosato. La población no se recuperó después de 28 días (Brust, 1990). Resultados similares se encontraron en un estudio hecho en el Reino Unido, en pastos marginales tratados con Roundup, donde se encontró una reducción en las poblaciones del escarabajo carabus (Asteraki *et al.*, 1992).

Hay bibliografía científica que da cuenta de la afectación de poblaciones de insectos benéficos debido a cambios en su hábitat. Es el caso de un estudio hecho durante tres años consecutivos en Estados Unidos, en un área forestal que 4-5 años antes había sido clareada con Roundup, y luego plantada con plántulas de abeto. Los investigadores encontraron que poblaciones de insectos herbívoros y de invertebrados del suelo habían disminuido significativamente y no se recuperaron durante el período del estudio. Los autores concluyeron que la caída poblacional se debió fundamentalmente al cambio del hábitat de estos organismos (Santillo *et al*, 1989).

Asteraki *et al*, (1992) reportan una disminución en el número de arañas en pastos marginales tratados con Roundup, posiblemente porque se habían destruido las plantas donde ellas hacían sus telas.

Se ha registrado también alteraciones en los patrones reproductivos en algunas poblaciones de artrópodos benéficos. Chiverton *et a.,l* (1991) llevaron a cabo un estudio comparativo entre poblaciones de artrópodos rociados y no rociados con herbicidas, en campos de trigo de primavera, en el Reino Unido. Encontraron que escarabajos carabus hembras, que no habían sido tratadas con glifosato, ponían más huevos que aquellas que habían estado expuestas al glifosato. Es posible que la reducción de las especies que les servían como presa al escarabajo carabus, produjeran una baja en la fertilidad de la especie, lo que significó una reducción en la capacidad de depredación de las plagas agrícolas.

Muchas sustancias son utilizadas para el combate de plagas, enfermedades y malezas, pero éstas, en su mayoría, son tóxicas para el hombre y los animales, y además pueden reducir el nivel de control de depredadores, parasitoides y entomopatógenos. Algunos agroquímicos pueden actuar negativamente y reducir el efecto biocontrolador de estos organismos.

Las formulaciones de glifosato también pueden afectar el comportamiento de otros organismos controladores de plagas como es el caso de *Trichogramma pretiosum* (Hymenoptera: Trichogrammatidae), sobre todo en su capacidad de parasitismo, siendo aquellas a base de sal isopropilamina, moderadamente nocivas (Giolo *et. al.*, 2005).

Otro grupo de insectos benéficos afectados por el glifosato incluye las especies polinizadoras.

El profesor Joe Cummins, de la Universidad de Western Notario, hace una revisión sobre la alarmante disminución de las poblaciones de abejas a nivel mundial. Él la atribuye, entre otros efectos, al creciente uso de plaguicidas. Señala que las abejas son especialmente susceptibles a los herbicidas, pues éstos afectan a su desarrollo, longevidad, cambios en el comportamiento (navegación, hábitos alimenticios y aprendizaje), en el sistema inmunológico, oviposición. La toxicidad subletal puede producir cambios fatales en las colmenas (Cummins, 2007).

Una de las quejas que se presentaron con respeto al programa de fumigación con Roundup (más surfactantes), que el gobierno de los Estados Unidos llevó a cabo para eliminar cultivos de amapola en Guatemala, fue que se había destruido la apicultura en las zonas cercanas a las aspersiones.

> *"Aunque el programa de fumigación tuvo un efecto mínimo en los cultivos de amapola, según los campesinos locales, se destruyó la base tradicional de la producción en la región, en particular tomates y abejas."* (Freed, 1989).

De acuerdo a estudios realizados por Nemoto *et al.*, (2002), la presencia de glifosato redujo fuertemente el crecimiento micelial de *Bipolaris euphorbiae*, afectando también la germinación de los conidias.

Como resultado de las presiones de ambientalistas, este Programa de Fumigación fue suspendido y ahora el cultivo de amapola en Guatemala está controlado, gracias a la erradicación manual.

Efecto del Glifosato en Mamíferos

En estudios de campo, poblaciones de pequeños mamíferos se han visto afectadas a causa del glifosato, por muerte de vegetación que ellos o sus presas utilizan para alimentarse o protegerse.

En el caso de animales herbívoros, la ingestión de vegetación contaminada con glifosato también puede generar efectos negativos. Adicionalmente, los animales pueden entrar en contacto con este herbicida en un ecosistema que ha sido fumigado a través de contacto por la piel, los ojos o por inhalación.

La aplicación de glifosato en ecosistemas boscosos puede alterar las tasas reproductivas de algunas especies, privilegiando a aquellas que se adaptan a hábitats intervenidos, como pastizales, y desplazando a especies que viven en bosques menos intervenidos. Santillo y sus colaboradores (1989) encontraron una menor presencia de pequeños mamíferos en la zona norte-central de Maine, en terrenos "tratados" con glifosato.

Richard y colaboradores (2005) concluyeron que el glifosato actúa como un disrruptor de la actividad de la citocromo P450 aromatasa en mamíferos, a concentraciones 100 veces más bajas que las que se recomiendan para su uso agrícola. El

citocromo juega un papel importante en el metabolismo de sustancias ajenas al organismo, como son fármacos, plaguicidas, etc., muchos de los cuales pueden tener efectos cancerígenos.

Encontraron además, que en concentraciones menores a las recomendadas para uso agrícola, el Roundup puede inducir a problemas reproductivos.

Estudios hechos en espermatozoides de conejo (Yousef, *et al.*, 1995) encontraron que el tratamiento con el herbicida glifosato redujo el peso corporal, la libido, el volumen de la eyaculación, la concentración y volumen del esperma; se registró además un alto porcentaje de espermatozoides anormales y muertos. Los efectos nocivos continuaron en el período de la recuperación.

Efecto del glifosato en reptiles

Aunque se han hecho pocos estudios de los impactos de los plaguicidas en reptiles, Sparling *et al.*, (2006), encontraron efectos adversos en embriones de la tortuga *Trachemys scripta elegans* cuando éstos fueron expuestos al glifosato y sus surfactantes en distintas concentraciones.

En la Amazonía ecuatoriana, las tortugas charapas constituyen una importante fuente de proteínas para las comunidades indígenas, incluyendo aquellas que viven cerca de la frontera con Colombia. Sería importante conocer si las aspersiones con glifosato y sus coadyuvantes están produciendo algún impacto en estos organismos.

Efecto del glifosato en aves

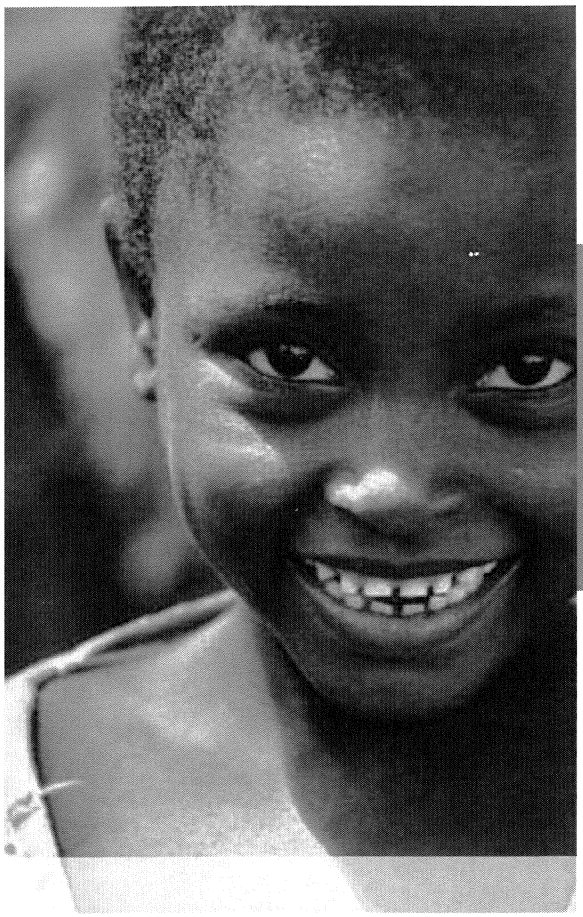
Estudios hechos sobre los impactos del glifosato en aves, han encontrado que este herbicida es moderadamente tóxico. Pero se ha identificado además, efectos indirectos en las comunidades de aves, porque el glifosato afecta a las plantas o insectos de los que estos organismos dependen para su sobrevivencia; por tanto puede causar cambios dramáticos en la estructura de la comunidad de plantas, afectando las poblaciones de aves, pues ellas dependen de las plantas para alimentarse, protegerse y anidar. Esto ha sido documentado en estudios de poblaciones de aves expuestas al glifosato, en la costa norte de Estados Unidos.

En suma

Existen suficientes evidencias en la literatura científica, sobre los impactos ambientales del glifosato y sus coaduvantes.

El herbicida afecta de manera directa a ecosistemas, poblaciones e individuos; y en otros casos, destruye los nichos ecológicos, sitios de anidación, alimentación, etc., de poblaciones biológicas.

Estos impactos podrían ser aun mayores que los reportados en la literatura científica, en el caso de la erradicación de los cultivos ilícitos dentro del Plan Colombia, por las altas concentraciones del compuesto activo, la presencia de coadyuvantes que no han sido evaluados en el medio ambiente en el que van a actuar y por la fragilidad propia de los ecosistemas tropicales.



VII. EL PRINCIPIO DE PRECAUCIÓN COMO EJE CIENTÍFICO, ÉTICO Y JURÍDICO.

La validez de las denuncias sobre impactos, levantadas por los pueblos afectados en la frontera norte (CEDHU, 2007; Plataforma Interamericana de Derechos Humanos, Democracia y Desarrollo, 2007), se establece desde la perspectiva rigurosa de un conjunto de preceptos científicos, éticos y jurídicos, que permiten calificar la evidencia acumulada en la bibliografía científica existente y la suficiencia básica de las pruebas locales, para sustentar el pedido de aplicación inmediata del Principio de Precaución, como elemento irrenunciable y no negociable.

Preceptos científicos

La Comisión Científica Ecuatoriana asume primeramente, junto con la vanguardia del pensamiento científico mundial, un modelo interpretativo integral que reconoce la complejidad multidimensional de la determinación de la salud y la vida (variante del modelo OMS); en segundo lugar, asume una noción integral de la propia evaluación, sin reducirla al análisis

cuantitativo de la incertidumbre y valorando además los testimonios y datos aportados por las colectividades; y, en tercer lugar, replantea el peso que debe otorgarse a la incertidumbre, al menos para que no opere como encubrimiento de conocimientos efectivamente existentes, como pretexto de inacción o como recurso para demandar una interminable búsqueda de certezas, las cuales nunca llegan, o lo hacen cuando ya es muy tarde para impedir un daño masivo.

El papel de la ciencia, en un escenario de amenaza a la vida, es operar en dirección a una alerta temprana y medidas inmediatas de precaución, basadas en el conocimiento disponible y no esperar la acumulación interminable de respuestas absolutas y "certezas" estadísticas, para controlar el sufrimiento y el daño consumados. El papel de la ciencia es aportar conocimientos para la formulación coherente de términos de precaución y de dimensiones de las demandas de protección y remediación. El papel de la ciencia, en un escenario donde existen elementos de incertidumbre, es incorporarlos como alimento de un perfeccionamiento creciente pero no como freno del precepto ético de la precaución.

La ciencia es un sistema de conceptos para interpretar la naturaleza y obtener el conocimiento confiable que nos permita vivir de manera sustentable. Por tal motivo, la ciencia no puede abstraerse de los valores morales. Es por eso que Elsa Nivia, coordinadora de la Red de Acción de los Plaguicidas y sus Alternativas en América Latina, ha dicho que hay que evaluar las fumigaciones que se hacen en su país para erradicar la coca y la amapola, con ciencia, conciencia y corazón (Nivia, 2002).

La acumulación de evidencias científicas contra la supuesta inocuidad de productos de franja segura, como se califica al glifosato, determinó que comunidades científicas nacionales como la de Brasil, luego de profundo debate académico y político demanden a los Estados el cambio de nombre de "plaguicidas", que reproduce la falsa noción de especificidad contra plagas, por "agrotóxicos", que destaca su plena y múltiple peligrosidad (Ley Federal Nº 7802, de 11 de Julio de 1989). Esa medida jurídica reconoce la validez del precepto de Paracelso (Siglo XVI): *"Todo es veneno, nada es veneno, la sola dosis hace el veneno"*. Como se ha explicado antes, hay evidencias suficientes sobre la peligrosidad del glifosato y, más aún del paquete químico completo de las formulaciones usadas y del impacto del sistema de aspersión aérea.

Preceptos éticos

la vida y los derechos humanos son primordiales a los intereses estratégicos de cualquier empresa pública o privada, civil o militar; y las evidencias acumuladas en la zona y el mundo exigen la inmediata aplicación de las normas del principio de precaución.

En el mundo actual, la ciencia ha producido una gran cantidad de productos y tecnologías que entrañan un alto grado de incertidumbre y que constituyen una amenaza para la salud y el ambiente. Sus impactos pueden ser irreversibles.

Esto significa que la ciencia y las decisiones sobre la ciencia no pueden estar sólo en manos de los científicos. Ahora bien, la ciencia no genera datos irrefutables, sino opiniones que pueden ser rebatidas. Y en muchos casos los avances científicos crean nuevas fuentes de amenazas. Por lo tanto, la ciencia no puede permanecer alejada de la sociedad; se requiere de la participación y opinión de todos aquellos afectados por un tema en concreto.

Esta es una ruptura con la concepción de la ciencia como infalible, aquella donde no hay lugar para la duda, donde hay una solución para todos los problemas y donde es inconcebible plantearse que haya varias respuestas para una misma pregunta.

En este contexto surge la propuesta de la ciencia post-normal, desarrollada por Funtowicz y Ravetz (1994), que proponen una metodología de investigación que sea apropiada para investigaciones científicas en que se dan factores de incertidumbre, valores sociales en disputa y altos riesgos ambientales o a la salud humana. La metodología de la ciencia post-normal debe ser utilizada cuando se trata con incertidumbres que pueden generar errores costosos o incluso letales. Se propone una ciencia en la que participa la sociedad. Los avances científicos ya no son avalados únicamente por una comunidad de científicos que hacen *peer reviews*, sino por una comunidad de ciudadanos preocupados por la incertidumbre que los avances científicos pueden ejercer en su vida (Funtowicz y Ravetz, 2000).

Esta metodología es aun más urgente, cuando poco a poco vemos cómo la industria empieza a dominar la investigación científica. En torno a algunas universidades ligadas con marcas y compañías se han formando parques industriales de investigación como Silicon Valley, Route 128, Research Triangle (universidades de Duke, de North Carolina y la estatal de North Carolina), Princeton Corridor, Silicon Hills Texas, la Medical Mile (Penn y Temple University), Optics Valley (Universidad de Arizona) y el Golden Triangle (Universidad de California en San Diego). Lentamente esto hace que los académicos o investigadores se conviertan en empleados o jefes corporativos y que las universidades dejen de investigar para el interés público y se involucren cada vez más en proyectos que sirven a los intereses de sus clientes corporativos. De esta manera, empieza a anularse la posibilidad del beneficio público a través de la investigación, y en cambio servir al beneficio corporativo.

También se va perdiendo la posibilidad de contar con una investigación independiente.

En este escenario, ¿qué ocurre cuando el producto de una de estas empresas que financian la investigación científica en universidades y otros centros de investigación levanta controversia porque su uso puede generar impactos negativos en la salud y el ambiente? Pues ¡se construyen evidencias a pedido de las empresas contratantes! Por eso la ciencia tiene que ser analizada éticamente. La ciencia producida bajo el auspicio de la industria sostiene que no puede ser analizada desde una perspectiva ética y que la cuestión del riesgo no tiene nada que ver con ella.

Se trata entonces de una ciencia de mala calidad, que defiende su "neutralidad" y está divorciada de valores morales. Esta ciencia ignora con frecuencia las evidencias científicas; ha sido cooptada por quienes la auspician, que cada vez más son las empresas transnacionales y sus científicos, que hacen "ciencia por contrato". Semejante ciencia puede hacerle daño a nuestra salud y producir impactos negativos al ambiente.

Esto no sucede solamente a nivel de las empresas. Hay denuncias recientes que señalan que el Gobierno de Estados Unidos ha interferido en resultados científicos que van en contra de sus políticas.

La revista "Democracy Now" (2006) reporta que el *New York Times* informó que:

- "*Líderes sindicales que representan a miles de científicos de la Agencia de Protección Ambiental (EPA) están acusando a los directores del organismo de ceder ante la presión política y permitir el uso de químicos perjudiciales en los pesticidas agrícolas. El llamado tiene lugar antes del vencimiento del plazo este jueves para que el Congreso apruebe miles de químicos que los científicos dicen que plantean graves riesgos para los fetos, las mujeres embarazadas, los niños y los ancianos*". El artículo añade que "*En algunos casos la EPA habría ignorado los estudios científicos independientes que contradicen los (estudios) patrocinados por la industria de los pesticidas*" (Janofsky, 2006).

Veamos, a manera de ilustración, la forma cómo Solomon, científico al servicio del CICAD, atendiendo a unos pretendidos principios de rigurosidad científica, quiere desvirtuar los aportes de Cox. En el informe de la CICAD comisionado a Solomon *et al* (2005), para analizar los impactos del programa de erradicación de cultivos ilícitos en Colombia, aparece el siguiente pie de página:

- *"Debemos anotar que han aparecido en la literatura varias publicaciones sobre el glifosato enfocadas en los efectos adversos del glifosato. Un panfleto/folleto por Cox (1999) fue producido a nombre de una organización activista. El panfleto era muy breve y no fue revisado por pares. Además, un artículo que pretendía hacerse pasar por una revisión científica se publicó en 1998 (Cox, 1998) en el Journal of Pesticide Reform. Se debe recalcar que el Journal of Pesticide Reform no publica artículos originales, no es revisado por pares, es producido por un grupo de activistas y que el editor es a menudo el autor de los artículos. Debido a esto, estos artículos no se utilizaron en este informe".*

Ante estas afirmaciones, hay que preguntar si se debe descalificar toda publicación hecha por parte de organizaciones de la sociedad civil, cuyo objetivo es defender el bienestar público. El *Journal of Pesticides Reform* es publicado por la Northwest Coalición for Alternatives to Pesticides, cuya misión es "proteger a la gente y al ambiente por medio de encontrar soluciones saludables para el problema de las pestes".

Como esta coalición, existen muchas organizaciones de la sociedad civil como la Red de Acción de Plaguicidas y sus Alternativas, Pesticides Action Network, y otras que cuentan con científicos especializados que tienen como objetivo trabajar por el bienestar colectivo. ¿Deben ser descalificados los trabajos generados por estas organizaciones?

Contrastemos esto con las referencias utilizadas en el informe de Solomon *et al*, (2005).

Buena parte de las citas bibliográficas que él utiliza sobre la inocuidad del glifosato, un producto de Monsanto, toma Solomon de investigaciones amparadas por Monsanto y hechas por el profesor Gary Williams (Monsanto, 2005). De acuerdo a la información de Monsanto, el profesor Williams es Director de Patología Ambiental y Jefe del Programa de Medicina, Alimentos y Seguridad Química en el New York Medical Collegue. Este centro de investigación ((NYMC, 2007), cuenta con una División de Desarrollo Tecnológico e Investigación financiada por la industria; negocia y maneja relaciones con la industria y lleva a cabo transferencia de resultados para su aplicación comercial.

El protocolo para los estudios epidemiológicos sobre la salud humana en Colombia y el cuestionario para evaluar la fertilidad/fecundidad fueron aprobados por el Comité de Ética de la Fundación Santa Fe de Bogotá (Solomon *et al*, 2005). La Fundación Santa Fe de Bogotá tiene como benefactores corporativos a: Dupont de Colombia, Dow Química de Colombia, Cyanamid de Colombia, Johnson & Johnson, Laboratorios Abbot, Laboratorios Merck Sharp & Dhome, Pepsicola, Phillips Morris de Colombia, S.A., Occidental de Colombia Inc., Compañía Colombiana de Tabaco, Colgate-Palmolive, entre otros (Fundación Santa Fe, 2007).

¿Dónde está la imparcialidad de la Fundación que aprobó los protocolos?

En este contexto, las declaraciones juramentadas del Dr. Camilo Uribe, también miembro de la Comisión Científica Colombiana en el año 2003, son sorprendentes. Sus palabras, recogidas por Pinzón (2003), y a quien éste presenta como "*Director del Centro Científico más importante en Colombia en materia de toxicología*", mencionan que:

- "*Por vía oral (...) se ha calculado una dosis tóxica letal [para ratas], es decir, capaz de producir la muerte, de 5.500 mg/kg. de peso, esto quiere decir que un ser humano adulto promedio en Colombia, con un peso de 60 kilos debería ingerir una cantidad aproximada de 15 a 18 litros del producto formulado para producirse una toxicidad aguda severa, en el caso del niño hablaríamos de menores de 12 años...la ingesta oscilaría entre 6-8 litros...(p.71).*

Aparte de violar el Código de Conducta de la FAO sobre distribución y uso de plaguicidas, que recomienda en su artículo 11, sobre la publicidad, que se eviten palabras que despierten la confianza en los tóxicos (CONAIE, 2001), afirmaciones como

estas, aunque juramentadas, parten de premisas incorrectas, y por tanto las conclusiones que de ellas derivan son inconsistentes.

El primer error es atribuir a las personas el mismo nivel de letalidad que se observa en ratas, principio falso de partida. Pero incluso, siguiendo la línea de pensamiento del Dr. Uribe, el CIF (2003) demuestra la gravedad del error. Según Monsanto el Roundup contiene 480gramos/litro de glifosato como ingrediente activo. Si siguieramos el razonamiento del Dr Uribe, de que se necesitan 5.500mgr/kg para producir la muerte en las personas como en las ratas, un ser humano adulto promedio en Colombia, con un peso de 60 kilos, debería ingerir una cantidad aproximada de 330.000 mg o 330 gr del producto formulado, es decir 0,68 litros o 687ml de glifosato. Si, según algunos estudios en animales, la absorción intestinal es de un 30% (y se tarda 7 días en eliminar el 99%), significa que de esos 687ml se van a absorber 206, por lo que "para que se produzca la muerte, o se esté al borde de ella", se necesitaría que 687ml sean el 30% absorbido por el intestino. Por tanto el 100% de lo ingerido tendría que ser 1.668ml., o sea 1,6 litros, y no los 16 litros que menciona el Dr. Uribe.

El CIF (2003) además describe cómo, si aceptamos que efectivamente la literatura recoge que el glifosato + POEA es 22 veces más tóxico (y no hay estudios con la suma del Cosmoflux, que incrementa su absorción), bastarían, según las cifras que estamos manejando (1.668ml / 22 veces), 76 centímetros cúbicos (aproximadamente el tercio de un vaso) para que se produjera la muerte o intoxicación aguda grave.

Esta cantidad coincide con la de los casos registrados en Japón, donde se ha descrito la muerte de personas tras la ingesta. En una revisión de intoxicaciones, Nivia (2001b) calculó que la cantidad de Roundup concentrado, intencionalmente ingerido en casos de suicidio, fue de 184 centímetros cúbicos (rango de 85 a 200), aunque se anota que la ingestión de cantidades mayores en otros casos resultó sólo en síntomas leves a moderados. Otros estudios reportan que la ingestión promedio de 104 a 120 centímetros cúbicos no ha llegado a ser fatal, mientras que la de 206 a 263 centímetros cúbicos produce la muerte. En Brasil, el Centro de Control de Intoxicaciones de Unicamp (2001), informa que una dosis de 25 centímetros cúbicos puede causar fuerte lesión gastroesofágica, la ingestión de 5ml intoxicación leve, la de 20ml moderada, y por encima de 85ml grave. El lavado gástrico está indicado hasta 4 horas después, a partir de la ingesta de 0,5ml/kg que ya es dosis tóxica. La entubación endotraqueal está indicada en algunos casos para prevenir las aspiraciones y evitar la neumonía química. Se recomienda realizar monitoreo cardiovascular, respiratorio y renal a las personas intoxicadas.

En un ambiente como el fronterizo entre Ecuador y Colombia, donde las parasitosis intestinales son importantes, la desnutrición escolar es de alrededor de 30%, y las enfermedades tropicales tienen alta incidencia, cantidades menores pueden, sin embargo, ser más tóxicas. Con 5ml/Kg se produce irritación de la mucosa gastrointestinal y puede aparecer hipotensión, acidosis metabólica, insuficiencia pulmonar y oliguria, como refiere Unicamp, a diferencia de lo sostenido por el Dr.

Uribe en CIESPAL, en Quito. Consta en su declaración juramentada, aunque no escrita ni difundida en documento público, pues no soportaría, es obvio, el debate científico.

Preceptos jurídicos

existe una normativa o marco legal nacional e internacional que sustenta el derecho inalienable a la salud y ordena su garantía y protección por parte de los Estados cuya población se vea afectada.

La República del Ecuador considera que para abordar adecuadamente el tema de las aspersiones aéreas, deben considerarse dos aspectos de vital importancia que tienen concretos sustentos jurídicos: la centralidad de la persona humana y el deber de protección del Estado; y la vigencia del principio de precaución.

NORMATIVA ECUATORIANA LEGAL RELACIONADA CON EL DERECHO A LA SALUD

*La Constitución Política (Art. 42) como garantía del derecho a la salud, su promoción y protección.
*El Código de Salud (J. M. Velasco Ibarra, 1971) y sus sucesivas reformas.
*La Ley Orgánica del Sistema Nacional de Salud (2002) y su Reglamento (2003); Obligaciones del Sistema Nacional de Salud, Art. 3 Objetivos (con sus numerales 2 y 3: 2. Proteger integralmente a las personas de los riesgos y daños a la salud; al medio ambiente de su deterioro o alteración. 3. Generar entornos, estilos y condiciones de vida saludables.; 5 Mecanismos de implementación (numeral 2):
2. Acciones de prevención y control de los riesgos y daños a la salud colectiva, especialmente relacionados con el ambiente natural y social. Obligaciones establecidas por el Código de Salud; Normas del Saneamiento Ambiental (disposiciones generales Capítulo 1, Art. 7,8,11,12). Art. 7.- El saneamiento ambiental está sujeto a la política general de salud, a las normas y a los reglamentos que proponga la Dirección Nacional de Salud, estableciendo las atribuciones propias de las municipalidades y de otras instituciones de orden público o privado. Art. 8.- La Dirección Nacional de Salud podrá asumir, transitoriamente, las funciones propias de otras Instituciones, cuando haya necesidad de proteger la salud pública. Art. 11.- Cuando una persona, natural o jurídica, obligada a realizar obras sanitarias o higiénicas, las demorare o las ejecutare en otra forma que la ordenada, la autoridad de salud podrá llevarla a ejecución por cuenta de dicha persona, y se cobrará el costo de ella por vía coactiva más el diez por ciento por gastos de administración. Art. 12.- Ninguna persona podrá eliminar hacia el aire, el suelo o las aguas, los residuos sólidos, líquidos o gaseosos, sin previo tratamiento que los conviertan en inofensivos para la salud.
Los reglamentos y disposiciones sobre molestias públicas, tales como, ruidos, olores desagradables, humos, gases tóxicos, polvo atmosférico, emanaciones y otras, serán establecidos por la autoridad de salud.
Del abastecimiento de agua potable (Capítulo 2, Art 16,17).

Art. 16.- Toda persona está obligada a proteger las fuentes y cuencas hidrográficas que sirven para el abastecimiento de agua, sujetándose a las disposiciones de este Código, leyes especiales y sus reglamentos.
Art. 17.- Nadie podrá descargar, directa o indirectamente, sustancias nocivas o indeseables en forma tal, que puedan contaminar o afectar la calidad sanitaria del agua y obstruir, total o parcialmente, las vías de suministros. De los Plaguicidas (Título VIII)). Art. 149.- Las empresas que elaboran o comercializan plaguicidas, y las que se dedican a la desinfección, desratización, fumigación de los domicilios, ambientes colectivos y áreas rurales, deben contar con permiso previo para su funcionamiento, y estarán sometidas al control periódico de sus operaciones. Art. 150.- No podrán almacenarse, transportarse o venderse plaguicidas, sin el empleo de envase adecuado que lleve la advertencia de su peligro.

La centralidad de la persona humana y el deber de protección del estado ecuatoriano.

Varios pronunciamientos de órganos jurisdiccionales internacionales han puesto de relieve la responsabilidad estatal de proteger los atributos básicos de la persona humana a través de la protección de los derechos humanos y, si fuera el caso, de la restricción de la acción del poder público. Por ejemplo, según la Corte Interamericana de Derechos Humanos:

- *"... la protección a los derechos humanos (...) parte de la afirmación de la existencia de ciertos atributos inviolables de la persona humana que no pueden ser legítimamente menoscabados por el ejercicio del poder público. Se trata de esferas individuales que el Estado no puede vulnerar o en los que sólo puede penetrar limitadamente. Así, en la protección de los derechos humanos, está necesariamente comprendida la noción de la restricción al ejercicio del poder estatal"*

La obligación de hacer respetar o garantizar los derechos humanos, por su lado, según la misma Corte:

- *"(...) implica el deber de los Estados Partes de organizar todo el aparato gubernamental y, en general, todas las estructuras a través de las cuales se manifiesta el ejercicio del poder público, de manera tal que sean capaces de asegurar jurídicamente el libre y pleno ejercicio de los derechos humanos. Como consecuencia de esta obligación los Estados deben prevenir, investigar y sancionar toda violación de los derechos reconocidos por la Convención y procurar, además, el restablecimiento, si es posible, del derecho conculcado y, en su caso, la reparación de los daños producidos por la violación de los derechos humanos."*

La normativa internacional, la Constitución de la República y los pronunciamientos jurisdiccionales internacionales determinan que la

República del Ecuador tiene la obligación de actuar para proteger y prevenir el menoscabo de los derechos humanos de personas bajo su jurisdicción, como es el caso de los ciudadanos ecuatorianos afectados en sus derechos por las aspersiones aéreas que lleva a cabo el Gobierno de la República de Colombia en su territorio y cuyos efectos alcanzan al territorio ecuatoriano.

Sobre el principio de precaución

El Estado ecuatoriano, a través de diversas instancias administrativas y judiciales, ha recibido múltiples informes y testimonios de habitantes en territorio ecuatoriano que han afirmado haber sufrido daños por las fumigaciones producidas en territorio colombiano. Ecuador cuenta con un amplio catálogo de tales indicios, tanto de estudios científicos como de testimonios de pobladores, así como de pronunciamientos internacionales de expertos de las Naciones Unidas y otras instancias independientes.

Reportes sobre los riesgos para la salud y el medio ambiente del Programa colombiano constan en pronunciamientos tales como el Informe del Comité de los Derechos del Niño de la ONU de 2006, que expresa su preocupación por

- *"los problemas de salud ambiental que crea el uso de la sustancia glifosato en las campañas de fumigación aérea contra las plantaciones de coca (que forman parte del Plan Colombia), ya que esa práctica afecta la salud de grupos vulnerables, entre ellos niños".*

EL PRINCIPIO DE PRECAUCIÓN COMO OBLIGACIÓN IRRENUNCIABLE Y CONDICIÓN DE OBJETIVIDAD SE APLICA CUANDO

(1) Hay una razonable sospecha del proceso destructivo, y
(2) Hay una incertidumbre científica; entonces
(3) Hay un deber de tomar acción para prevenir, mediante
(4) La transferencia del peso de la prueba desde la comunidad que sufre el problema hacia aquellos cuyas actividades provocaron la sospecha de daño en primer lugar, y evaluando las alternativas disponibles para encontrar aquella que ofrezca el menor daño posible, usando un proceso de toma de decisiones transparente, informado y democrático, que incluya a los afectados.

El Comité también recomienda a Colombia

- *"que lleve a cabo evaluaciones independientes y basadas en derechos de los efectos ambientales y sociales de las fumigaciones en diferentes regiones del país y vele por que, si éstas afectan a comunidades indígenas, se consulte con éstas previamente y se tomen todas las precauciones necesarias para evitar efectos dañinos en la salud de la infancia".*

Asimismo, en un informe sobre su misión a Colombia misión a Colombia, el Relator Especial sobre los Pueblos Indígenas de la ONU (Stavenhagen, 2005) señaló a la Comisión de Derechos Humanos que

- *"la expansión del cultivo y tráfico de estupefacientes y su combate, especialmente a través de las fumigaciones aéreas de los plantíos, han incidido en forma negativa sobre el medio ambiente, la economía, la vida social y la cultura de los pueblos indígenas"*, y recomienda que *"al menos que lo pida expresamente una comunidad indígena con previo conocimiento completo de sus implicaciones, no deberán practicarse fumigaciones aéreas en plantíos de cultivos ilícitos cercanas a poblados indígenas o zonas de abastecimientos de estos poblados".*

El mismo Relator Especial (Stavenhagen, 2006) en su informe al Consejo de Derechos Humanos sobre su misión al Ecuador ha manifestado:

- *"85. Se recomienda a los gobiernos del Ecuador y Colombia que nombren una comisión internacional independiente para estudiar los efectos de las fumigaciones aéreas sobre las poblaciones indígenas fronterizas y recomiende las medidas correspondientes vinculantes para estos gobiernos para resarcir los daños.*
  86. Se recomienda al Gobierno de Colombia que suspenda definitivamente las fumigaciones aéreas de los cultivos ilícitos en la región fronteriza con el Ecuador.
  87. Se recomienda al Gobierno del Ecuador que diseñe y aplique un plan de emergencia (en consulta con los pueblos indígenas de la región) para hacer frente a la crítica situación de las comunidades indígenas fronterizas (especialmente del pueblo Awá) como resultado del impacto que ha tenido el conflicto interno en Colombia, las actividades ilícitas de cultivo y tráfico de estupefacientes, el deterioro del medio ambiente, el influjo de refugiados indígenas del vecino país, la situación de inseguridad y violencia en la zona. Deben ser revisadas las concesiones que se han dado a las diversas empresas petroleras y mineras. El Estado debe generar políticas públicas encaminadas a proteger a los distintos sectores, pueblos y comunidades que viven en la zona de la frontera norte, con plena participación de estos pueblos, incluyendo el ejercicio de la consulta previa libre e informada."

El Tribunal Constitucional de la República del Ecuador ha considerado que los impactos de

las fumigaciones en el territorio ecuatoriano han provocado *"gravísimos problemas"* que el Gobierno del Ecuador no puede dejar de atender desde sus competencias. Ante una demanda al Ministerio de Relaciones Exteriores para que realice todas las gestiones diplomáticas a su alcance para procurar que no se efectúen fumigaciones en una franja de diez kilómetros, medidos desde la línea de frontera hacia el interior de la República de Colombia, la sentencia dictada por el más alto tribunal de control de constitucionalidad resolvió que:

- *"se adopten de inmediato, las medidas conducentes a remediar los daños irrogados e impedir que sigan causándose, con cuyo propósito los Ministerios demandados y organismos competentes de la Función Ejecutiva, en sus respectivas órbitas de acción, ejecutarán las providencias tutelares y de reparación necesarias, porque las acciones que hasta aquí se han tomado, no han podido solucionar, hasta hoy, de manera definitiva, los gravísimos problemas denunciados."*

Esta resolución del Tribunal Constitucional que, entre otros principios y derechos, invocó el principio de precaución, no es la única. Existen fallos en otros tribunales internaciones en los que, incluso sin que exista evidencia científica, se ha impedido ejecutar acciones que podrían tener riesgo para la salud.

LA INCLUSIÓN DEL PRINCIPIO DE PRECAUCIÓN EN DERECHO INTERNACIONAL

En el derecho ambiental internacional, existe abundante legislación relacionada con el principio de precaución. De igual modo, se pueden apreciar regulaciones y hasta prohibiciones en relación al uso del glifosato, lo que pone de manifiesto la relevancia de la aplicación del principio de precaución. A continuación se hace una sistematización de los cuerpos legales más importantes:

* Capítulo Mundial de la Naturaleza, 1982
  Aquellas actividades que pueden entrañar riesgos a la naturaleza, deben ser precedidas de una evaluación extensiva. Sus proponentes deben demostrar que los beneficios esperados sobrepasan los potenciales daños a la naturaleza y cuando los potenciales impactos no son totalmente entendidos, no se deben llevar a cabo las actividades (Principio 11.b).

* Protocolo de Montreal sobre Erosión de la capa de Ozono
  Las Partes de este Protocolo... determinan proteger la capa de ozono, por medio de tomar medidas precautelatorias para controlar las emisiones... que lo erosionan, con el objetivo último de su eliminación, en base al desarrollo del conocimiento científico, tomando en cuenta consideraciones técnicas y económicas.

* Declaración Económica, Cumbre Económica de Naciones Industrializadas, 1990
  Acordamos que, frente a amenazas irreversibles de daños ambientales, la falta de certidumbre científica, no es una excusa para posponer acciones que justifiquen su propio derecho.

* Recomendaciones de La Haya sobre Derecho Internacional, 1991
  En el desarrollo de políticas ambientales a nivel nacional o internacional, los estados deben aplicar entre otros: principios que tomen acciones de precaución. (Principio I.3d).

* Agenda 21, 1992
  Ante amenazas de daños ambientales irreversibles, la falta de conocimientos científicos no deben ser excusa para postergar la adopción de medidas que se justifiquen de por sí. El enfoque basado en el principio de la precaución, podría suministrar una base científica sólida para la formulación de políticas relativas a sistemas complejos que aún no se comprenden plenamente y cuyas consecuencias no se pueden predecir todavía (Parágrafo 35.3).

* Convenio sobre Diversidad Biológica, 1992
  Observando que cuando exista una amenaza de reducción o pérdida sustancial de la diversidad biológica, no debe alegarse la falta de pruebas científicas inequívocas como razón para aplazar las medidas encaminadas a evitar o reducir al mínimo esa amenaza (Preámbulo).

* Declaración de Río de Janeiro sobre Ambiente y Desarrollo, 1992
  Con el fin de proteger el medio ambiente, los Estados deberán aplicar ampliamente el criterio de precaución a sus capacidades. Cuando haya peligro de daño grave o irreversible, la falta de certeza científica absoluta no deberá utilizarse como razón para postergar la adopción de medidas eficaces en función de los costos para impedir la degradación ambiental. (Principio 15).

* Convenio Marco sobre Cambio Climático, 1992
  Las Partes tomarán medidas precautelatorias para anticipar, prevenir o minimizar las causas del Cambio Climático y mitigar sus impactos adversos. Cuando haya amenazas de daños graves o irreparables, la falta de certidumbre científica no debe ser usada para posponer esas medidas, tomando en cuenta que las políticas y medidas para tratar con el Cambio Climático, deben ser efectivas para asegurar los beneficios globales y al menor costo posible (Artículo 3.3).

* Protocolo de Cartagena sobre Bioseguridad
  La falta de certidumbre científica debido a la falta de información y conocimientos científicos relevantes relacionados con la extensión de efectos adversos potenciales de los organismos vivos modificados, para la conservación y uso sustentable de la diversidad biológica en las partes de importación, tomando en cuenta los riesgos a la salud humana, no debe prevenir a una Parte de importación, tomar acciones para prevenir o minimizar dichos efectos adversos potenciales.

El Convenio sobre Diversidad Biológica

El Convenio sobre Diversidad Biológica establece que es obligación de los Estados asegurar que las actividades que se llevan a cabo dentro de su jurisdicción o bajo su control, no perjudiquen al medio de otros Estados o de zonas situadas fuera de toda jurisdicción nacional (Artículo 3).

Tanto Colombia como Ecuador son Partes de este convenio internacional.

Reacciones oficiales en Colombia

Son numerosas las manifestaciones de autoridades colombianas que hablan de la amplitud del impacto de las aspersiones aéreas en ese país:

En febrero del 2007, el Sr. Alejandro Vélez, director encargado de la DNE reconoció que en Colombia se habían producido casi 7.000 quejas por las aspersiones aéreas, que se había iniciado procedimiento en 772 (11%) y que se había fallado a favor de 33 (0,47%), aunque ni una sola por problemas a la salud (el procedimiento fue creado para daño en bienes lícitos, no para salud) (CIF, 2007).

La Defensoría del Pueblo de Colombia (DPC, 2002) ha concluido que

- *"la ejecución del Programa de Erradicación Aérea de los Cultivos Ilícitos no se ajusta a los mandatos de la Constitución Política (...) no es adecuada para el fin propuesto y que la afectación que ésta genera sobre los derechos fundamentales de los colombianos supera con creces los pretendidos beneficios que ella generaría".*

Ese mismo año en la resolución Nº 26, la Defensoría del Pueblo de Colombia (DPC, 2002) sentenció:

- *3.9.1. Los daños en los cultivos de pancoger de los campesinos e indígenas ponen en riesgo su seguridad alimentaria, puesto que, con la destrucción de sus cultivos de yuca, plátano, maíz y árboles frutales, no se asegura a la población el suministro de alimentos que cubran sus necesidades nutricionales.*

En la Resolución Defensorial Nº 28 (DPC, 2003), reconoció que *"las fumigaciones, además de no haber demostrado su efectividad en la lucha contra las drogas ilegales, han privilegiado el objetivo de luchar contra la delincuencia, sin armonizar sus consecuencias con otros preceptos constitucionales"*, con ese antecedente afirmó en su estudio sobre el eje cafetalero que:

- *107. La aplicación del PECIG (Programa de Erradicación de Cultivos Ilícitos con Glifosato) ahondaría las vulneraciones al derecho a la alimentación y a la seguridad alimentaria. Ello como consecuencia de los siguientes efectos del citado programa:*
  - *a. la destrucción de cultivos lícitos por el uso del Glifosato.*
  - *b. la contaminación de las fuentes de agua y, con ello, la afectación de los recursos hídricos.*
  - *c. los impactos sobre proyectos producti-*

vos, *bien sean los dirigidos a asegurar el autoabastecimiento de alimentos (cultivos de pancoger[9], cría de animales y estanques piscícolas, entre otros) o los orientados a generación de nuevos ingresos (cultivos de larga duración y de diversificación, tales como la siembra de frutas).*

d. la posible pérdida de credibilidad en el mercado internacional sobre la calidad del café colombiano.

La Contraloría General de la República (CGR, 2001) en un informe especial sobre la política de aspersiones concluyó:

- *"Tras la verificación de las evidencias y de acuerdo con un criterio de equidad y responsabilidad observamos que es necesario y urgente un cambio en la estrategia de erradicación química de cultivos de uso no lícito que contemple: suspender la fumigación con herbicidas y la implementación de una estrategia alternativa integral y coordinada cuyos criterios deben ser, entre otros: voluntaria, manual, concertada y gradual (...) Debido a los altos costos ambientales, sociales y económicos de la actual estrategia, la CGR sugiere la conformación de una veeduría internacional para que realmente verifique y evalúe permanentemente la ejecución de estas políticas, como lo sugiere la Resolución Defensorial No. 04 de febrero de 2001."*

El Contralor General de la República de Colombia manifestó (Ossa, 2003):

- *"El costo de disminuir los cultivos de coca, amapola y marihuana es altísimo en términos de la dignidad de las personas que viven en esas zonas, del atropello que se comete contra ellas y, naturalmente, un costo económico considerable, escandaloso (...) la fumigación tiene efectos colaterales dañinos para el medio ambiente y para los campesinos, de lo contrario no tendría por qué haber un plan de manejo ambiental (...) Aquí se fumiga por encima de cualquier consideración, atropellando los derechos de las personas, atropellando impunemente el medio ambiente."*

La Contraloría General de la República (CGR, 2005) reconoce en el informe del 2005 que:

- "las aspersiones con glifosato se han desarrollado sin licencia ni plan de manejo ambiental durante 16 años (...) han asperjado en promedio, 22% más de las hectáreas de coca sembradas y existentes en el país (...) estos aspectos son de mucha importancia al considerar que hay zonas en el país que son sometidas a doble residualidad y repercusión a costa del herbicida sin que se tenga certeza del bajo nivel de residualidad en los suelos a cuenta del herbicida, pues el país no cuenta con laboratorios que puedan desarrollar estos análisis."

Un informe de la policía (Pabón, 2001) del Valle de Guamués (departamento del Putumayo al sur de Colombia, frontera con Ecuador) en el 2001, reconoció que tras las fumigaciones de enero

y febrero de ese año, sobre 29.000 hectáreas de coca, se produjeron afectaciones de más de 4.430 hectáreas de otros cultivos (un 15,27% extra sobre lo programado para cultivos de coca, en cultivos de sobrevivencia) y se presentaron denuncias de 1.791 personas afectadas y pérdidas contabilizadas de 96.222 animales muertos o muy enfermos.

En el año 2005, el Senador Carlos Moreno Caro planteó al Senado la iniciativa de utilización de la mariposa "come coca", como alternativa natural en la erradicación de los cultivos ilícitos. El Proyecto, que finalmente fuera negado y archivado, buscaba ciertamente conseguir la prohibición legal de la erradicación de cultivos ilícitos con glifosato. En efecto, el Art. 1° disponía que la erradicación de cultivos ilícitos se realice *"mediante la utilización de métodos naturales alternativos que no conlleven efectos nocivos para la salud de la población y velen por la preservación y equilibrio del ecosistema del país."*

Al margen de lo discutible que resultaría, desde el punto de vista ambiental, el uso de este género de polilla para el control biológico de cultivos ilícitos, de la exposición de motivos del proyecto queda claro el reconocimiento que el Senador Moreno Caro hace de que la aspersión aérea con glifosato tendría efectos nocivos para la salud de la población y para el ecosistema, mientras que la mariposa 'come coca' supuestamente no los tendría; presunción bajo la cual *el autor pretende* –así lo destacan los encargados de su evaluación– *eliminar mediante una ley de la República la erradicación de cultivos ilícitos a través de aspersión aérea con glifosato.*

Los ponentes encargados del análisis del Proyecto, los senadores Rafael Pardo Rueda y María Isabel Cruz Velasco, apelando al estudio *preparado para la Comisión Interamericana para el Control del Abuso de Drogas (CICAD,)* argumentan que la aspersión aérea no pone en riesgo ni la salud de la población ni el ecosistema. Y añaden, en forma perspicaz, que si *la iniciativa entiende por métodos naturales alternativos "aquellos que no contemplen la utilización de químicos que pongan en riesgo la salud y el ecosistema" (parágrafo del artículo 1º), por lo tanto, los métodos naturales alternativos podrían incluso tener químicos pero que no "pongan en riesgo la salud y el ecosistema". Así las cosas* –concluyen–, *no sería pertinente prohibir legalmente la aspersión aérea de cultivos ilícitos con glifosato.*

Reacciones de Organizaciones Internacionales

Numerosos organismos internacionales han manifestado su preocupación por los impactos:

La Federación Internacional de Derechos Humanos (FIDH, 2003)) con sede en París ha exhortado al Gobierno de Colombia en función al Principio de Precaución, que suspenda las fumigaciones aéreas en todo el territorio nacional y utilice otros medios para luchar contra los cultivos de coca, dados los efectos devastadores de las aspersiones (con fondos norteamericanos) sobre las personas y el medio ambiente, y a lo ineficaz de sus resultados.

La Asociación Médica Americana (AMA, 2004) emitió una resolución en la cual se pedía que:

- *"Considerando que, las fumigaciones con el herbicida glifosato, proporcionado por la compañía de EEUU Monsanto, se ha reportado ser inadecuado e inexacto y causante de enfermedades generalizadas, destruyendo pastos, destruyendo cosechas de alimento, envenenando ganado, desplazando a millares de pequeños granjeros, y matando pájaros, mamíferos, la vida acuática y plantas naturales (...) SE RESUELVE, que nuestra Asociación Médica Americana emita una declaración pública que solicite el cese inmediato de aspersiones aéreas de herbicida en el país sudamericano de Colombia y sus países vecinos, hasta que los efectos a la salud en las poblaciones locales sean estudiados apropiadamente..."*

Profesores de la Universidad de Massachussets (Massey et col, 2003) manifestaron que el programa de fumigaciones en Colombia presenta riesgos claros a la salud humana y al medio ambiente y que la incertidumbre es sobre la magnitud y el carácter específico de los mismos, recomendando la suspensión de las aspersiones.

El Center for Internacional Policy (Isacson, 2003) ha manifestado que la falta de seguridad en las zonas donde se usan las aspersiones no debe ser un obstáculo para que, ante el gran número de quejas, no se las suspenda atendiendo al principio de precaución y a los reconocidos efectos dañinos que produce la fórmula comercial del Roundup y que la misma empresa suscribe en las etiquetas.

VIII. CONCLUSIONES GENERALES

1. Las aspersiones aéreas, con el paquete herbicida utilizado por el Gobierno de Colombia desde el año 2000, han venido provocando una serie de problemas: ambientales, agro-ecológicos, de salud y socioeconómicos, en la zona de frontera norte del Ecuador.

2. El paquete herbicida de amplio espectro, utilizado en las aspersiones aéreas en la frontera Ecuador-Colombia, tiene varios compuestos químicos (glifosato, POEA, Cosmoflux, etc.), que solos o en conjunto, son los responsables de una parte de los efectos nocivos sobre la zona asperjada.

3. El paquete herbicida forma parte de un sistema nocivo que, a más de los impactos químicos, desencadena procesos de atemorización, migración y ruptura de los soportes comunitarios, destrucción de fuentes de alimentación y sustento económico, impacto en la biota y especies benéficas.

4. La interpretación y el análisis que sobre el problema de las aspersiones aéreas se han dado por parte del gobierno de Colombia y sus técnicos, parten de criterios científicos cuestionables desde la perspectiva epistemológica actual. Se privilegia la argumentación fundamentada en evidencias y pruebas fácticas cuantificables, reduciendo el espectro de observación al elemento glifosato y su deriva, mientras se descartan otros elementos empíricos comprobatorios, como los argumentos y testimonios de las comunidades, y aun se desconocen los estudios nacionales (de las propias instituciones académicas colombianas) e internacionales, que cuestionan el sistema de aspersión aérea con el paquete herbicida de amplio espectro (que incluye el glifosato), por ser de alta destructividad humano-ambiental.

5. Existen evidencias científico-técnicas y metodológicas que ponen en duda el informe de CICAD, usado como sustento para justificar o prolongar las aspersiones aéreas con el paquete herbicida.

6. Existen suficientes estudios internacionales que prueban el efecto nocivo del sistema de aspersiones aéreas del tipo implementado, y del propio glifosato y sus coadyuvantes, que además demuestran los daños ecológicos en diferentes niveles: ecosistemas y sus interacciones, plantas, animales, microorganismos, células, hormonas, genes y cromosomas.

7. Los estudios científicos realizados en Ecuador, sobre el impacto de las aspersiones aéreas con el paquete herbicida, comprueban el daño que provocan estas aspersiones en nuestro territorio. Las evidencias de este daño están verificadas por varias instituciones gubernamentales y académicas ecuatorianas y apuntan a la nocividad en cultivos, daño en animales, afectación de la biodiversidad y especies benéficas, la contaminación de suelos, e impacto en la salud humana física y mental. Muchos de los daños han sido verificados inmediatamente por comisiones oficiales, pero algunos de los daños, partiendo del efecto a largo plazo (cánceres, problemas de fertilidad, problemas malformativos, destrucción del ecosistema, cambios ambientales irreversibles, entre otros) sólo podrán ser evidenciados en el futuro y apenas se insinúan en la actualidad.

8. La problemática de las aspersiones aéreas ha conllevado a fenómenos aledaños como migración, inseguridad, disminución de la calidad de vida, desventajas en la obtención de alimento y vivienda, daño en la salud mental de los individuos expuestos y problemas sociales derivados de estos fenómenos.

9. Las evidencias científico-técnicas, sobre la nocividad de las aspersiones aéreas con el paquete herbicida, afirman la posición ecuatoriana sobre el no uso de esta metodología por las afectaciones que produce, porque contradicen toda norma de respeto a los derechos humanos, contrarían toda norma ética y de convivencia pacífica, e incumplen el Principio de Precaución reconocido por los más altos organismos multinacionales: Naciones Unidas, Organización Mundial de la Salud, Organismo Internacional de Derechos Humanos, Convenio sobre Diversidad Biológica.

10. Por todos estos argumentos expuestos, la Comisión Científico-Técnica Ecuatoriana, cuestiona y objeta el uso del sistema de aspersión aérea con el paquete herbicida asperjado, que llega a territorio ecuatoriano provocando los efectos nocivos descritos, y recomienda la inmediata petición de cese del mismo.

11. La Comisión Científica Ecuatoriana ha sistematizado innumerables testimonios sobre los diversos impactos, que han sido recogidos en las zonas afectadas, y que exigen demandar compensaciones por los daños causados.

Con todo lo expuesto queda claro que la erradicación aérea afecta a la población, en su salud física y psicológica y en su economía de cultivos lícitos, así como a los ecosistemas. Si a pesar de ello, el Gobierno de Colombia persiste en su política de aspersiones aéreas sobre su pueblo, se le reitera el pedido que, como medida de precaución, el Gobierno de Ecuador ha solicitado desde julio del 2001: que para precautelar la salud y la economía de los pobladores ecuatorianos de frontera, establezca una franja de amortiguamiento de por lo menos 10 km desde la frontera con Ecuador hacia el interior de Colombia en los cuales la erradicación de cultivos de uso ilícito no se haga de forma aérea, sino mediante otros método de erradicación.

BIBLIOGRAFÍA

1. Abdel- Malle, A.Y., *et al.* (1994). Effect of glyphosate on fangal population, respiration and the decay of some organic matter in Egyptian soil. Microbiological Research 149: 69 – 73

2. Abdelghani, A.A. (1997). Toxicity evaluation of single and chemical mixtures of Roundup, Garlon-3A, 2,4-D, and Syndets surfactant to channel catfish (*Ictalurus punctatus),* bluegill sunfish (*Lepomis michochirus*), and crawfish (*Procambarus spp.*). Environmental toxicology and water quality. 12(3): 237-243

3. Acción Ecológica, (2001). "Reporte de la investigación de los impactos por las fumigaciones en la frontera ecuatoriana". Quito, Junio 2001.

4. ADUC (2003). Asociación Departamental de Usuarios Campesinos) et col. 2003. Informe de la Comisión de Verificación de las fumigaciones en el departamento de ARAUCA. Bogotá.

5. AIDA (2006). Programa de fumigación aérea del Plan Colombia – Análisis y crítica del informe del Departamento de Estado al Congreso de EE.UU. sobre el riesgo para los anfibios y especies amenazadas.

6. AMA, Resolución 420 (A-04). 30 de abril del 2004.

7. Andalo, V., *et al.* (2004). Compatibilidade de *Beauveria bassiana* com agrotóxicos visando o controle da cochonilha-da- raiz-do-cafeeiro *Dismicoccus texensis* Tinsley (Hemíptera: Pseudococcidae). Neutropical Entomology. 33(4): 463-467

8. Ashraf Haidari, M. (2007). Prohibition of Use of Fumigation (Glyphosate or Roundup) in Afghanistan. Washington: Official Memorandum of the Embassy of Afghanistan in the USA.

9. Asteraki, E. J., *et al.* (1992). The imoact of chemical removal of the hedge-base flora on the community structure of carabid beetles (COL., Carabidae) and spiders (Araneae) of the field and hedge bottom. Journal of Applied Entomology. 113: 398 – 406.

10. Astudillo, Y. *et al.* (2006). Análisis del daño al ADN por exposición a Glifosato. Libro de Resúmenes. XXX Jornadas de Biología, Quito. Genet: 04.

11. Austin, A. P. *et al.* (1991). Impact of an organophosphate herbicide (glyphosate) on periphyton communities developed in experimental streams. Bulletin of Environmental Contamination and Toxicology 47: 29-35

12. Barriga, R. (2001). Peces del Parque Nacional Yasuní. Pp. 139-142. En JP Jorgenson and M Coello Rodriguez (Eds.). Conservación y desarrollo sostenible del Parque Nacional Yasuní y su área de influencia. Memorias del Seminario-Taller 2001. Ministerio del Ambiente/UNESCO/Wildlife Conservation Society. Editorial SIMBIOE: Quito, Ecuador.

13. Bawa, K.S. y Hadley M. (1990). Reproductive Ecology of Tropical Forest. Plants Man and Biosphere Series. Volumen 7. UNESCO.

14. Bell, F. W. *et al.* (1997). Motor-manual, mechanical, and herbicide release affect early successional vegetation in northwestern Ontario. Forestry Chronicle 73.

15. Bellé, R. (2007). El Glifosato Formulado es el que Provoca las Primeras Etapas del Cáncer. Red de Acción en Plaguicidas en América Latina. http://webs.chasque.net/~rapaluy1/glifosato/Glifosato_cancer.html

16. Bezbaruah, B., *et al.* (1995). Effect of pesticides on most probable number of soil microbes from tea (*Camellia sinensis*) plantations and uncultivated land enumerated in enrichment media. India J. of Agric. Sciences 65(8): 578 – 583.

17. Bidwell, J.R. y Gorrie, J.R. (1995). Western Australia. Dept. of Environmental Protection. Acute toxicity of a herbicide to selected frog species. Final

report. Technical Series: 79 (9) Western Australian Dept. of Environmental Protection.

18. Bigwood, J. (2002). Breve Resumen de la Literatura Científica con Respecto a los Efectos Nocivos de Formulaciones Que Contienen Glifosato en Biotas Acuáticas y Suelos. Consultoría para el Ministerio del Ambiente, 6 de marzo. Quito.

19. Boada, C. (2006). El Ecuador biogeográfico. Ecuador Tierra Incógnita. No. 40.

20. Bode, R., *et al.* (1986). Comparative studies on the enzymological basis for growth inhibition by glyphosate in some yeast species. Biochemie Und Physiologie Der Pflanzer 181: 39-46

21. Breilh, J. (2004). Epidemiología Crítica. Editorial FIOCRUZ. Buenos Aires.

22. Bruce, P. (1996) Environmental Contaminants and Amphibians in Canada. Pesticides and Behaviour in Tadpoles. FROGLOG 16.

23. Brust, B.E. (1990). Direct and indirect effects of four herbicides on the activity of carabid beetles (Coleoptera: Carabidae). Pestic. Sci. 30: 309-320.

24. Cabrera, M.L. (2003). Informe a la Personería Municipal de Buesaco. Nariño.

25. Campaña, A.(2004). Misión de observación a los efectos del Plan Colombia en el Departamento de Nariño. Efectos sobre la Salud.

26. Campaña, A. (2005). Misión de observación a los efectos del Plan Colombia en el Cantón San Lorenzo. Efectos sobre la salud.

27. Castro, J. F., (2000). "Los cultivos ilícitos, política mundial y realidad en Colombia". Defensoría del Pueblo de Colombia. Bogota.

28. CCME (1989). Canadian water quality guidelines, Ottawa, Ontario. *Environment Canada.* Canadian Council of Ministers of the Environment.

29. CEDHU (2007). Reseña de los materiales que ha producido el Comité Interinstitucional contra las fumigaciones. http://www.cedhu.org/html/modules.php?name=Content&pa=showpage&pid=95

30. CEEA (2004). Comisión Ecuatoriana de Energía Atómica. Reporte de análisis de glifosato en agua. CEEA. Ecotoxicología. Quito.

31. CEEA (2004). Comisión Ecuatoriana de Energía Atómica (2004). Reporte de análisis de glifosato en sedimentos. CEEA. Ecotoxicología. Quito.

32. CGR (2001). Auditoría especial a la política de erradicación de cultivos ilícitos. Contraloría General de la República – Contraloría Delegada para el Medio Ambiente. Julio de 2001

33. CGR (2005). Plan Colombia: quinto informe de Evaluación. CGR. Bogotá

34. Chaim, A. (2004). Tecnologia de Aplicação de Agrotóxicos: Fatores que Afetam a Eficiência e o Impacto Ambiental. In: Silva CMMS e Fay EF. Agrotóxicos & Ambiente. Brasília. Embrapa, 289-317.

35. Chiverton P. A. and Sotherton N.W. (1991). The effects on beneficial arthropods of the exclusion of herbicides from cereal crop edges. Journal of Applied Ecology 28: 1027 – 1039.

36. CIF (2003). Amicus Curiae: Impactos en Ecuador de las fumigaciones a cultivos ilícitos en Colombia. CIF (Comité Interinstitucional sobre Fumigaciones). Quito.

37. CIF (2007). Entrevista realizada el 21 de febrero del 2007 en la DNE de Bogotá con el Sr. Alejandro Vélez (Director Encargado de la DNE y Elena Hani Jalam, Subdirectora de Asuntos Regionales y Erradicación de la DNE.

38. Claro, J. y Paganella, F. (2000). Roundup ou Glifosato: Agrotóxicos Que Asfetam a Vida. Sobradinho: Cámara Técnica para Atividades Agrossilvipastorais.

39. Comisión Científica Ecuatoriana. (2007). Evaluación del impacto de las aspersiones aéreas de febrero del 2007 sobre los habitantes de Mataje.

40. Comisión Interministerial. (2001). Informe Conjunto de la Comisión Interministerial a Lago Agrio. Ministerio de Salud, Ministerio de Ambiente, Ministerio de Defensa, OPS. Quito.

41. Coloma, L. (2005). Ecuador, Tierra de Sapos y Ranas. Ecuador Tierra Incognita No. 33.

42. Coloma, L. (1991). Anfibios del Ecuador: Lista de especies, ubicación altitudinal y referencias bibliográficas. Reportes Técnicos de EcoCiencia. Quito.

43. Comisión Científica Ecuatoriana (2007). Evaluación del impacto de las aspersiones aéreas de febrero del 2007 sobre la salud y el ambiente de los habitantes de Mataje. Febrero.

44. Commission on Social Determinants of Health (2005) Towards a Conceptual Framework for Analysis and Action on the Social Determinants of Health. Geneve: Discussion Paper for the Commission on Social Determinants of Health, May 2005

45. CONAIE, (2001) Informe Tecnico de la Comisión Internacional sobre los Impactos en Territorio Ecuatoriano de las Fumigaciones Aéreas en Colombia y Recomendaciones de las Organizaciones Indígenas, Campesinas y Sociales. CONAIE, Confeunasscc, FENOCIN, 19-22 de Julio del 2001

46. Constitución Política de la República de Colombia, Art. 80.

47. Constitución Política del Ecuador. 1998. (Art. 42).

48. Consejo de Europa, 98/256/CE: Decisión del Consejo de 16 de marzo de 1998 relativa a medidas de emergencia en materia de protección contra la encefalopatía espongiforme bovina y por la que se modifica la Decisión 94/474/CE.

49. Consejo de Europa 96/239/CE: Decisión del Consejo de 5 de mayo de 1998. Ver sentencia "Reino Unido/Comisión, pág. I-2265

50. Convenio sobre Diversidad Biológica (1992). Artículo 3.

51. Corte Interamericana de Derechos Humanos, La expresión "leyes" en el artículo 30 de la Convención Americana sobre Derechos Humanos, Opinión Consultiva OC-6/86 del 9 de mayo de 1986. Serie A No. 6, párr. 21.

52. Corte Interamericana de Derechos Humanos, Caso Velásquez Rodríguez Vs. Honduras, Sentencia de 29 de julio de 1988, Serie C No. 4, párr. 166.

53. Cosmoagro. (2004). Cosmo-Flux 411F, Coadyuvante de la aplicación de Agroquímicos. Lic. ICA 05.4-2186 – Colombia. Hoja Técnica 313.03. Mayo 30/94. Palmira.

54. Cox, C. (1991). Glyphosate Fact Sheet. Journal of Pesticide Reform 11(2).

55. Cox, C. (1995). Glyphosate, Part 2: Human Exposure and Ecological Effects. Journal of Pesticide Reform 15(4): 14-20.

56. Craye, Matthieu (2006). Reflexively Dealing with Uncertainty and Complexity in Policiy Related Knowledge. En: Interfaces Between Science and Society. Guimaraes, Guedes and Tognetti, Editores. Sheffield: Greenleaf Publishing, p. 54-63

57. Cummins, J. (2002). Acrylamide In Cooked Foods: The Glyphosate Connection, 1 August 2002. ISIS Report. http://www.i-sis.org.uk/acrylamide.php.

58. Cummins, J. (2007). The Mysterious Disappearance of Honey Bees. The Permaculture Archives. http://lists.ibiblio.org/pipermail/permaculture/2007-March/026349.html

59. D`Anieri, P., *et al.* (1987). Small mammals in glyphosate treated clearcuts in Northern Maine. Can Field Nat. 101 (4): 547 – 550.

60. Defensoría del Pueblo de Colombia DPC (2002). Las fumigaciones y los derechos humanos. Amicus Curiae. Defensoría del Pueblo. Bogota.

61. Defensoría del Pueblo de Colombia DPC, (2002). Derechos Humanos y Derecho Internacional Humanitario en el marco del conflicto armado y de las fumigaciones de los cultivos de coca en el departamento del Putumayo. Resolución Defensorial Nacional Nº 26. 9 de octubre. Bogotá. p. 25.

62. Defensoría del Pueblo de Colombia DPC, (2003). La crisis cafetera y las fumigaciones en el departamento de Caldas. Resolución Defensorial Nacional Nº 28. Caldas. p.22-23. 21 de mayo.

63. Dewar A.M., *et al.* (2000) Glyphosate applied to genetically modified herbicide-tolerant sugar beet and 'volunteer' potatoes reduces populations of potato cyst nematodes and the number and size daughter tubers. Ann. Appl-Biol. 136(3): 179-187.

64. Democracy Now (2006). Científicos de la EPA: El organismo aprueba pesticidas perjudiciales ante presión de la industria. 2 agosto de 2006.

65. Descalzo, R.C. *et al.* (1996). Identification and role of Pythium species as glyphosate synergists on bean (*Phaseolus vulgaris*) grown in different soils. Mycol Res. 100 (8): 971-978

66. Didhám, R.K. (2007). La Influencia de los Efectos del Borde y de la Fragmentación de Bosques en los Invertebrados de la Hojarasca en Amazonia Central. In Tropical Forest Remnants: Ecology, Management, and Conservation of Tropical Forest Remnants: Ecology, Management, and Conservation of Fragmented Communities. Editado por William F. Laurance y Richárd O. Bierregaard, Jr.

67. Dinham, B. (1999). "Life sciences" take over. En: Pesticides News 44: 7. The Pesticides Trust. PAN-Europe. London, UK.

68. Dirección Nacional de Estupefacientes (2007). Carta dirigida el 17 de enero del 2007 al Colectivo de Abogados José Alvear Restrepo con el nº 085 y

firmada por el Brigadier General Jorge Alirio Barón Leguizamon como Director Antinarcóticos.

69. Dood, J. C. y Jeffries, P. (1989) Effects of herbicides on tree vesicular-arbuscular fungi associated with winter wheat (*Triticum sativum* L). Biol. Fertl. Soils 7:113-119

70. Dos Santos M., J., *et col.* (2006). Efeitos do glifosato sobre microrganismos simbiotróficos de soja, em meio de cultura e casa de vegetação. Pesq. Agropc.bras. 41(2): 285 – 291.

71. Dunfield, K.E. y Germida, J., (2001). Diversity of bacterial communities in the rhizosphere and root interior of field-grown genetically modified *Brasica napus*. Microbiology Ecology 38: 1-9.

72. Eberbach, P.L. y Douglas, L.A. (1983). Persistente of glyphosate in sandy loam. Soil Biol. Biochem. 15(4).

73. Embera-Katío (2006)- Denuncia pública presentada por el Cabildo Embera del Alto San Jorge frente a la problemática ambiental generada por las fumigaciones de la policía antinarcóticos a las comunidades de Dochama (San Antonio y La Danta) en el alto Uré y Nejondó (San Juan Medio).

74. Environmental Protection Agency (1993). Glyphosate (CASRN 1071-83-6) Integrated Risk Information System. http://www.epa.gov/iris/subst/0057.htm

75. Environmental Protection Agency (1999). Technical Fact Sheets on: Glyphosate. National Primary Drinking Water Regulations.

76. Evans, D.D. y Batty, M.J. (1986). Effects of high dietary concentrations of glyphosate (Roundup) on a species of bird, marsupial and rodent indigenous to Australia. Environmental Toxicology and Chemistry 5: 399-401

77. Farm Chemicals Handbook, (1990). Meister Publishing Co. Willoughby, USA

78. FIDH (2003). Comunicado de prensa: la FIDH a favor de la suspensión de las fumigaciones

79. Folmar, L.C. *et al.* (1979). Toxicity of the Herbicide Glyphosate and several of its formulations on fish and aquatic invertebrates. Arch. Environ. Contam. Toxicol. 8: 269-278

80. Forestry Commission (1991). Ash dieback. Bulletin 93. HMSO. London. Reportado en ENDS Report: 193, 1991.

81. Forlani G. *et al.* (1995). Differential sensitivity of plant-associated bacteria to sulfonylurea and imidazonline herbicides. *Plant and Soil.* 176: 243-253.

82. Freed, K. (1989) "Anti-drug Effort Sows Bad Blood; Guatemala: Farmers Complain That Legitimate Crops Are Being Damaged by a U.S. Spraying Program Designed to Cut into Heroin Production." Los Angeles Times, October 15, 1989, Sunday, Home Edition

83. Fundación Santa Fe de Bogotá. Sitio web.Visitado el 11 de marzo del 2007. www.fsfb.org.co/cms/

84. Funtowicz, S. y Ravetz, J.R. (1994). The worth of a songbird - ecological economics as a post-normal science. Ecological Economics 10: 197-207

85. Funtowicz, S. y Ravetz, J. (1990). Uncertainty and Quality in Science for Policy. Dordrecht: Kluwer Academic Publishers.

86. Funtowicz, S. y Ravetz, J.R. (2000) Ciencia con la gente. La ciencia posnormal, Editorial Icaria, Barcelona.

87. Guimaraes, A., Guedes, S. y Tognetti, S. (2006). Interfaces Between Science and Society. Sheffield: Greenleaf Publishing.

88. Giolo, F.P. *et al.* (2005). Selectividade de formulações de ghyphosate a *Trichogramma pretiosum* (Hymenoptera: Trichogrammatidae). Planta Daninha, 23(3): 457-462.

89. Griffith, G., *et al.* (1993). Autecology and Evolution of the Witches' Broom Pathogen (*Crinipellis perniciosa*) of Cocoa. In: Ecology of Plant Pathogens.

90. Groot, H. *et al.* (2005). Glifosato: Riesgo Humano? Hipótesis. Apuntes Científicos Uniandinos, Diciembre No 6.

91. Gerritse, Beltrán y Hernández, (1996). Adsorption of atrazine, simazine, and glyphosate in soils of the Gnangara Mound, Western Australia. Aust. J. Soil Res. 34: 599-607.

92. Haney, R.L. *et al.* (1999). Effect of glyphosate on soil microbial activity. Proc-S-Weed-Sci-Soc. 52: 215.

93. Hartman, W.A. y Martin, D.B. (1984). Effect of suspended bentonite clay on the acute toxicity of glyphosate to *Daphnia pulex* and *Lemna minor*. Bull. Environ. Contam. Toxicol. 33: 355-361

94. Hassan, S. A. *et al.* (1988). Results of the Fourth Joint Pesticida Testing Programme carried out by the Internacional Organization for Biological Control / WPRS - Working Group "Pesticides and Beneficial Organisms". Journal of Applied Entomology 105: 321 - 329

95. Hotakainen, R. (2000) "Colombian Police Spray Herbicide on Coca, Wellstone," Minneapolis STAR TRIBUNE December 1, 2000. Available at http://webserv5.startribune.com/stOnLine/cgi-bin/article?thisSlug=WELL01&tdate=01-Dec-2000&tword=hotakainen

96. Hutchinson, G.I. (1995). Nitrogen Cycle Interactions with Global Change Processes. In Niertenberg, W.I. Encyclopedia of Environmental Biology. San Diego, Academic Press. Volume 2: 583-587.

97. INAMHI (2006). Comportamiento Del Viento En La Zona Fronteriza Ecuador - Colombia. Instituto Nacional De Meteorologia E Hidrologia, Direccion Gestión Meteorologica, Estudios E Investigaciones Meteorologicas. 19 de diciembre.

98. Instituto Nacional de Investigaciones Agropecuarias, (2007). Manejo integrado de malezas en cultivo de arroz. En: Manual de arroz. INIAP

99. Isacson, A. (2002). Cumplimiento con las Condiciones de Fumigación en la Iniciativa Antidrogas Andina. Center for International Policy.

100. Isacson, A. (2003) Carta al Consejo de Estado de Colombia por Acción Popular Fumigaciones del Plan Colombia. Suscrita por 9 de septiembre del 2003.

101. Jave, O. (2001). *Fusarium oxysporum.* La micosis emergente. En: El uso de armas biológicas en la guerra contra las drogas. Memorias de la conferencia. Ed. Gallardo, L., *et al.* Quito.

102. Janofsky. (2006). Unions Say E.P.A. Bends to Political Pressure, New York Times, 2 de agosto de 2006.

103. Joensen, L. y Semino, S. (2004). OMGs en Argentina ¿a qué precio?. Estudio de Caso del Impacto de la Soja Modificada Genéticamente del Grupo de Reflexión Rural de Argentina. Informe publicado por Econexus y The GAIA Foundation. Londres.

104. Johal, G.S., *et al.* (1984). Effect of soilborne plant-pathogenic fungi on the herbicidal action of glyphosate on bean seedlings. Phytopathology 74(8): 950-955

105. Junior, P.T. Z. y Zambolin, L. (1994). Efeito de fungicidas e de herbicidas sobre a microrrrización de *Eucaplytus grandis* por *Glomus etunicatum.* Fitopatol. Bras. (19) 2: 173-177.

106. Kaczewer, J. (2002). Toxicología del Glifosato: Riesgos para la salud humana, 15 enero del 2007: http://www.mamacoca.org/FSMT_sept_2003/es/doc/kaczewer_toxicologia_del_glifosato_es.htm

107. Kapos, V., *et col.* (1997). Cambios Relacionados al Efecto del Borde en el Ambiente y en las Respuestas de Plantas, como consecuencia de la Frag-

mentación del Bosque en la Amazonia Central. En: Tropical Forest Remnants: Ecology, Management, and Conservation of Tropical Forest Remnants: Ecology, Management, and Conservation of Fragmented Communities. Editado por William F. Laurance y Richard O. Bierregaard, Jr.

108. Kjær, J. *et al.* (2003). The Danish Pesticide Leaching Assessment Programme (PLAP). Monitoring results May 1999 - June 2002. Third report.

109. Kremer, R.J. and Donald, P. (2003) Herbicide impact on *Fusarium spp.* and soybean cyst nematode in gliphosate tolerant soybean. American Society of Agronomy (573) 882-2716.

110. La Hora, Confirman fumigación con hongo, 23 de agosto del 2000. Quito.

111. Ley Orgánica del Sistema Nacional de Salud (2002) y su Reglamento (2003). Art. 3.

112. Lacera-Rúa, A. (2000). Enfermedades asociadas con aspersión aérea de agroquímicos en áreas de cultivos ilícitos. Universidad de Magdalena. Santa Marta. Colombia.

113. Legarth Schmidt, A. (2003) Poisonous Spray on a Course Towards Drinking Water. Politken, Denmark.

114. Costa, M. D.L. *et al.* (2003). Alterações de neuroimagem no parkinsonismo: estudo de cinco casos. Arq. Neuro-Psiquiatr. 61: 2B. São Paulo, Brazil

115. Leiva, P.D. (2007). Calidad de aplicación de plaguicidas. I Jornada de Control Químico de enfermedades del Trigo. Centro Internacional de Capacitación INTA -CIMMYT. http://www.argenpapa.com.ar/img/Calidad%20aplicaci%C3%B3n%20agqcos..pdf CDRom interactivo Bayer – División Agrícola.

116. Levesque, C.A., *et al.* (1992). The effect of soil heat treatment and microflora on the efficacy of glyphosate in seedlings. Leed Res. 32 (5): 363-373.

117. Levesque, C.A., *et al.* (1993). Pathogenicity and DNA restriction fragment length polymorphisms of isolates of *Pythium* spp. from glyphosate-treated seedlings. Mycol Res 97 (3): 307-312.

118. Levesque, C.A., *et al.* (1993). Fungal colonization of glyphosate-treated seedlings using a new root plating technique. Mycol Res 97 (3): 299-306.

119. Levidow, L. (2004): Sound Science as Ideology. In Science, Technology and Innovation, http://www.cid.harvard.edu/cidbiotech/comment/comment91.htm

120. MacKinnon, D. S. y Freedman, B. (1993). Effects of silvicultural use of the herbicide glyphosate on breeding birds of regenerating clearcuts in Nova Scotia, Canada. Journal of Applied Ecology 30: 395-406

121. Maldonado, A. *et col.* (2001). Reporte de Acción Ecológica sobre la Investigación de Impactos de las Fumigaciones en la Frontera Ecuatoriana. Acción Ecológica. Quito.

122. Maldonado, A., *et al.* (2002) Segundo informe Misión de Verificación "Impactos en Ecuador de las fumigaciones realizadas en el Putumayo dentro del Plan Colombia". Acción Ecológica. Quito.

123. Maldonado, A., *et al.* (2006) Estado de la Nutrición en Escuelas Ecuatorianas de la Frontera Norte Afectadas Por las Aspersiones Aéreas del Plan Colombia. Quito. Acción Ecológica, IETM, CIF. Quito.

124. Mann, R.M., *et al.* (2004). The Toxicity of Glyphosate and Several Glyphosate Formulations to Four Species of Southwestern Australian Frogs. Archives of Environmental Contamination and Toxicology 36 (2).

125. Mañas-Torres, F. *et al.*, (2006) La genotoxicidad del herbicida Glifosato evaluada por el ensayo cometa y por la formación de micronúcleos en ratones tratados. Theroria 15(2):53-60

126. Marassas, W.F.O., *et al.* (1984). Toxigenic *Fusarium* species: Identity and Mycotoxicology. Pennsylvania State University Press.

127. Marc, J., *et al.* (2004a). Formulated glyphosate activates the DNA-response checkpoint of the cell cycle leading to the prevention of G2/M transition. Toxicological Science 82:436-442.

128. Marc, J,. *et al.* (2004b) Glyphosate-based pesticides affect cell cycle regulation. Biology on the Cell 96:245-249.

129. Marmot, M. (2005). Social Determinants of Health. Ed. Michael Marmot and Richard Wilkinson. Oxford: Oxford University Press.

130. Marrs, Williams, Frost y Plant. (1989) Effects of herbicides on higher plant. In *Pesticide drift and impact* (ed. B.N.K. Davis), pp. 5-27. NERC contract report to Nature Conservancy Council/Department of Environment). NERC, Swindon.

131. Massey, R., *et col.* (2003). Amicus Curiae desde Estados Unidos. Plicación del Principio de Precaución al Programa de Fumigación en Colombia. Declaración ante el Consejo de Estado, Bogotá, Colombia. 18 de septiembre del 2003.

132. Mekwatanakarn, P. y Silvassithamparam, K. (1987), Effect of certain herbicides on soil microbial populations and their influence on saprophytic growth in soil and pathogenicity of take-all fungus. Biol. Fertil. Soils 5: 75 - 180.

133. Messina J.P. y Delamater, P.L. (2006). Defoliation and the war on drugs in Putumayo, Colombia. International Journal of Remote Sensing. 27(1)121 -128.

134. Mestanza, V. (2002). Carta dirigida al Ing. Roger Mera, Jefe Regional en Sucumbíos del Ministerio del Ambiente. 14 de octubre del 2002

135. Minard, A. (2007). Plaguicidas flotan desde fincas distantes a bosques protegidos, según estudio en Costa Rica. National Geographic News. http://infoagro.net/es/apps/news/record_view.cfm?vsys=a2&id=12823

136. Monqueiro, P. A., *et al.* (2003). Dinâmica do banco de sementes em áreas com aplicação freqüente do herbicida glyphosate. *Planta Daninha* 21(1): 63-69.

137. Monroy, C.M. *et al.* (2005). Cytotoxicity and genotoxicity of human cells exponed in Vitro to glyphosate. Biomedica 25(3):335-345

138. Monsanto (2005). Summary of the Health Risk Assesssment and Safety Evaluation on Glyphosate and Roundup Herbicides. Updated on May 2005.

139. Morillo, Undabeytia y Maqueda (1997) Adsorption of Glyphosate on the Clay Mineral Montmorillonite: Effect of Cu(II) in Solution and Adsorbed on the Mineral. Environ. Sci. Technol.

140. Naranjo, C. (2006). Comportamiento del Viento en la Zona Fronteriza Ecuador – Colombia. Quito: Dirección de Gestión Meteorológica, Instituto Nacional de Meteorología e Hidrología (INAMHI).

141. Nemoto, M. C., *et al.* (2002). Germinação de canídeas y crescimento micelial de *Bipolartis euphorbiae* influenciados por herbicidas e surfactantes. Brasil. Journal of Microbiol. 33: 352-357.

142. Neskovic N.K., *et al.* (1996). Biochemical and histopathological effects of glyphosate on carp, Cyprinus carpio L. Bull. Environm. Contam Toxicol. 5: 259 – 302.

143. New Herald, Washington experimenta en Ecuador con un hongo peligroso. 17 de julio del 2000. Miami.

144. New York Medical Collegue. Office of Research Administration. Technology Development & Industry Sponsored Research. Visitado el 11 de marzo del 2007. www.nymc.edu

145. Newell D.W., Barth A., Ricciardi T.N., Malouf A.T. (1997). Glycine causes increased excitability and neurotoxicity by activation of NMDA receptors in the hipocampus. Exp. Neurol. 145: 235-244.

146. Nivia, E. (1999). Efectos sobre la salud y el ambiente de herbicidas que contienen glifosato. Seminario-Taller "Medio ambiente, cultivos ilícitos y desarrollo alternativo: Herramientas para la evaluación y la toma de decisiones". 1 y 2 de julio. Bogotá.

147. Nivia, E., (2001a) Efectos sobre la salud y el ambiente de herbicidas que contienen glifosato. Boletín electrónico de la UITA. http://www.rel-uita.org/Agrotoxicos

148. Nivia, E. (2001b). Las fumigaciones aéreas sobre cultivos ilícitos si son peligrosas – Algunas aproximaciones. Ponencia presentada en: Conferencia "Las Guerras en Colombia: Drogas, Armas y Petróleo". Instituto Hemisférico de las Américas - Universidad de California, Davis, Mayo 17-19.

149. Nivia, E. (2002). Evaluando las fumigaciones con ciencia, conciencia y corazón. Ponencia presentada en: Foro Internacional: 3 de diciembre, Día Mundial del no uso de Plaguicidas. Bogotá – Colombia.

150. ONIC (2007). Fumigaciones y pueblos indígenas. Ponencia presentada en: Preaudiencia del Tribunal Permanente de los Pueblos. 22 de febrero del. Medellín.

151. Ordoñez, J. Carta a Acción Ecológica. Septiembre 2002.

152. Organizaciones Ecuatorianas (2007). Informe Misión de Verificación "Impactos en Ecuador de las fumigaciones realizadas en el Putumayo dentro del Plan Colombia": http://derechos.ecoportal.net/content/view/full/21564

153. Ossa Escobar, C. (2003). Informe de la Contraloría General de la República sobre el Plan Colombia. Recogido en Plan Colombia Hoy: Seminario internacional "Plan Colombia-No, impactos de la intervención". Edit. Colectivo de Abogados José Alvear Restrepo. Noviembre. Bogotá.

154. Pabón, A. (2001). Consolidado general de las pérdidas por la fumigación hasta el 31 de enero de 2001. Municipio Valle del Guamués. Inspección de Policía Municipal.

155. Panus, D.P. (1980). Vesicular-Arbuscular Mycorrhizae Affect Lowland Tropical Rain Forest Plant Growth. Ecology 61(1): 151-162

156. Pazmiño, J.L. (2003). Laboratorio de Suelos, Aguas y Plantas del Vicariato Apostólico de Aguarico -Francisco de Orellana- Informe 1923

157. Paz-y-Miño, C. *et al.* (2000). Monitoreo citogenético en población ecuatoriana expuesta ocupacionalmente a pesticidas. Rev. Fac. Cs. Med. 25(1):15-21

158. Paz-y-Miño, C. *et al.* (2002). Cytogenetic Monitoring in a population occupationally exponed to pesticidas in Ecuador. Environ Health Pespect 110:1077-1080

159. Paz-y-Miño, C. *et al.* (2002). Genética Toxicológica y Carcinogénesis. PUCE-FUNDACYT. Quito

160. Paz-y-Miño, C. *et al.* (2002). Should gaps be included in chromosomal aberration análisis? Evidence based on the comet assay. Mutation Research 516:57-61.

161. Paz-y-Miño, C., *et al.* (2004). Chromosome and DNA damage analysis in individuals occupationally exposed to pesticides with relation to genetic polymorphism for CYP 1ª1 gene in Ecuador. Mutation Research 8:562(1-2):77-89

162. Paz-y-Miño, C., *et al.* (2005). Chromosomal aberration, comet assay and CYP 1A1 gen evaluation in individually exposed to 27 kinds of pesticides and glyphosate in Ecuador, South America. Pacific Basin Consortium Conference. Pesticides an Human Health. Abstracts Book, Honolulu.

163. Paz-y-Miño, C., *et. al.* (2007) Evaluation of choromosome and DNA damage related to glyphosate mixture exposure in Ecuadorian population. Genetics and Molecular Biology (in press MS2006/100).

164. Paz-y-Miño, C. et al (2007) Efecto del Glifosato en diversas concentraciones sobre cultivos de linfocitos humanos de sangre periférica. Informe del Proyecto Daños genéticos por glifosato. PUCE. Quito.

165. Pérez, H. (s.f.). Manual de Técnicas de Aplicación. Principios y fundamentos, Syngenta. Colombia.

166. 166. Peterson H.G., *et al.* (1994). Aquatic phyto-toxicity of 23 pesticides applied at expected environmental concentrations. Aquatic Toxicology 28(3-4): 275- 292

167. Piccolo, A.; Celano, G.; Arienzo, M.; Mirabella, A.; J. (1994) Adsoption and desorption of glyphosate in some european soils. Environ. Sci. Health, Part B 1994, 29, 1105.

168. Pimiento, S. (2001). El uso de armas biológicas en la erradicación de cultivos y el Convenio sobre Diversidad Biológica. En: El uso de armas biológicas en la guerra contra las drogas. Memorias de la conferencia. Ed. Gallardo, L., *et al.* Quito.

169. Pinzón, C.A. (2003). Recurso de Apelación a la Sentencia de junio 13 de 2003, por el Tribunal Administrativo de Cundinamarca a la Acción Popular Nº 01-022 presentada por Claudia San Pedro y Otros, contra el Ministerio del Medio Ambiente y la Dirección Nacional de Estupefacientes y fallada por la Dra. Ayda Vides Paba.

170. Plataforma Interamericana de Derechos Humanos, Democracia y Desarrollo (2007). Informe publicado en sitio web. http://www.pidhdd.org/article.php3?id_article=248

171. Plazas, L. A. (2004). Oficio Nº CMFS-46-2004 Rad. DNE E-2004-19728DE 23/03/04 dirigida al Dr. Juan Carlos Palacios Burneo como Presidente de la Comisión Científico Técnica Ecuatoriana con fecha 14 de abril del 2004 y firmada como Director de la Dirección Nacional de Estupefacientes.

172. Potts G.R. y Vickerman G.P. (1994). Studies of the cereal ecosystem. Advances in Ecological Research 8: 107 – 197

173. Prata, F., *et al.* (2003). Glyphosate Sorption and Desorption in Soils with Distinct Phosphorus Levels. Scientia Agricola 60(1): 175 – 180.

174. Puyana, A.M. (2007). Fumigaciones químicas como estrategia anti narcóticos en Colombia: tres décadas de perversidad e ineficacia. Ponencia de la autora en la Preaudiencia sobre biodiversidad, fumigaciones y militarización en Colombia. Medellín.

175. Rahe, J.E., *et al.* (1997). Synergistic role of soil fungi in the herbicidal efficacy of glyphosate. A-C-S-Symp-Ser-Am-Chem-Soc. (439): 260-275

176. Relyea, R. (2005). The Impact of Insecticides and Herbicides on the Biodiversity and Productivity of Aquatic Communities. Journal Ecological Applications.

177. Richard, S. *et al.* (2005). Differential effects of Glyphosate and Roundup on human placental cells and aromatase. Environ Health Perspect 113: 716-720.

178. Richie, D.C., *et al.* (1987). Glyphosae treatment and deer mice in clearcut and forest. Northwest Sci. 61(3): 199 – 202.

179. Rizzardi, M. A., *et al.* (2003). Ação de herbicidas sobre mecanismos de defesa das plantas aos patogenos. Ciência Rural. 33(5):957-965.

180. Rodríguez, E. (2003). Sierra Nevada, significado de la hoja de coca, fumigaciones y situación del pueblo Kankuamo. Recogido en Plan Colombia Hoy. En: Seminario internacional "Plan Colombia-No, impactos de la intervención". Edit. Colectivo de Abogados José Alvear Restrepo. Noviembre. Bogotá.

181. Sanogo, S., *et al.* (2000). Effects of herbicides on Fusarium solani f. sp. glycines and development of sudden death syndrome in glyphosate-tolerant soybean. Phytopathology 90 (1): 57-66.

182. Santillo, D. J., *et al.* (1989). Response of songbirds to glyphosate-induced habitat changes on clearcuts. J. Wildl. Manage. 53:64-71.

183. Santos, A. y Flores, M. (1995) Effects of glyphosate on nitrogen-fixing of free living heterotrophic bacteria. Letters in Applied Microbiology 20(6): 349 – 352.

184. Sedell, J.R., *et al.* (1989). The River Continuum Concept: A Basis for Expected Ecosystem Behavior of Large Rivers?. Can. Spec. Publ. Fish. Aquat. Sciences 106: 49 – 55.

185. Sicard, T.L., Burgos J., Toro, C., Luengas, C., Ruiz, C., Romero, C.P. (2005). Observaciones al "Estudio de los efectos del programa de erradicación de cultivos ilícitos mediante aspersión con herbicida Glifosato (PECIG) y de los cultivos ilicitos en la salud humana y e http://www.idea.unal.edu.co/public/docs/Observ_IDEA_a_doc_CICAD.pdf

186. Smiley, R.W. (1992). Influence of glyphosate on *Rhizoctonia* root rot, growth, and yield of barley. Plant Dis 76: 937 – 942

187. Solomon, K., *et al.* (2005). Estudios de los Efectos del Programa de Erradicación de Cultivos Ilícitos Mediante la Aspersión Aérea con el Herbicida Glifosato (PECIG) y de los Cultivos Ilícitos en la Salud Humana y en el Medio Ambiente. Washington: CICAD, División de la Organización de los Estados Americanos (OEA), 31 de marzo.

188. Souza, I.F. (1982). Comportamento dos herbicidas no solo. Informe Agropecuario 87: 38-44.

189. Sparling, D.W., *et al.* (2006). Toxicity of glyphosate as Glypro and LI700 to red-eared slider (*Trachemys scripta elegans*) embryos and early hatchlings. Environmental Toxicology and Chemistry 25 (10): 2768-74.

190. Springett J. A. y Gray R.A.J. (1992). Effect of repeated low doses of biocides on the earthworm *Aporrectodea caliginosa* in laboratory culture. Soil. Biol. Biochem 24 (12):1739-1744.

191. St. Clair, Jeffrey. (2002). The Drug War According to Dr. Mengele. Agent Green Over the Andes. December 24, 2002.

192. Stavenhagen (2005). Sobre su misión a Colombia (8-12 de marzo de 2004). E/CN.4/2005/88/Add.2. 10 de noviembre.

193. Stavenhagen (2006). Informe del Relator Especial sobre la situación de los derechos humanos y las libertades fundamentales de los indígenas, Sr. Rodolfo Stavenhagen. Misión a Ecuador: A/HRC/4/32/Add.2. 28 de diciembre de 2006.

194. Stephen M., *et col.* (1997). Efecto del borde y del Aspecto del borde en el Microclima de un Bosque Fragmentado en Atherton, Tableland, Nor-Este de Australia. En: Tropical Forest Remnants: Ecology, Management, and Conservation of Tropical Forest Remnants: Ecology, Management, and Conservation of Fragmented Communities. Editado por William F. Laurance y Richard O. Bierregaard, Jr.

195. Suárez, L. y Ulloa, R. (1993). La Diversidad Biológica del Ecuador. En : La investigación para la conservación de la diversidad biológica del Ecuador. P.A. Mena y L. Suárez (Eds) EcoCiencia. Quito.

196. Supliguicha, V., *et col.* (2006). Consecuencias psicológicas en niños y niñas del cordón fronterizo afectados directamente por el conflicto del Plan Colombia: Escuelas: Leonidas Plaza, Cinco de Agosto, y Manuelita Sáenz GIA-MB

197. Tate T.M., *et al.* (1997). Effect of Glyphosate on the Development of Pseudo-succinea columella snail. Arch. Environ. Contam. Toxicol. 33: 286 – 289.

198. Tirira, D. (1999). Mamíferos del Ecuador. Publicación Especial 2. PUCE. Quito.

199. Tribunal Constitucional del Ecuador, Caso No. 0371-04-RA.

200. Tribunal Constitucional, Resolución del 15 de marzo de 2005, Caso No. 0371-04-RA.

201. Tuffi Santos, L. D., *et al.* (2005). Exsudação radicular do glyphosate por Brachiaria decimbens e seus efeitos em plantas de eucalipto e na respiração microbiana do solo. Planta Daninha. 23(1):143-152

202. Unicamp. (2001). Glifosato: Herbicida, Mas ñao Só. 13 de septiembre del 2001. www.boasaude.com

203. Velasco, J.M. (1971) El Código de Salud. Quito

204. Velasco, V. (2002). Oficio Nº 511-GS-2002, dirigida a Lourdes Luque, Ministra del Ambiente, con fecha 16 de octubre del 2002.

205. Victoria, R. L., *et al.* (2004). Biogeochemistry of the Amazon River Basin: the role of aquatic ecosystems in the Amazon functioning. Smithsonian/NASA ADS Physics Abstract Service

206. Vides, A. (2003). "Claudia Sanpedro y otros". Sentencia Tribunal Administrativo de Cundinamarca en el expediente Nº 02-022, 13/junio/2003

207. Von Weizsäcker, C. (2006). Precaution Goes Without Saying, but Comes with Controversies Opening. Presentation Vienna: Expert Conference "The Role of Precaution in GMO Policy" initiated jointly by the Austrian Federal Ministries, of Agriculture, Forestry, the Environment and Water Management and of Health and Women within the framework of the Autrian EU-Presidency. Hofburg, 18 – 19 April.

208. Wan, M.T. (1989) Effects of different dilution water types on the acute toxicity to juvenile Pacific salmonids and rainbow trout of glyphosate and its formulated products. Bulletin of environmental contamination and toxicology. 43 (3): 378-385

209. Wan, M.T. (1991). Acute toxicity to juvenile Pacific Northwest salmonids of Basacid Blue NB755 and its mixture with formulated products of 2,4-D, glyphosate, and triclopyr. Bulletin of Environmental Contamination and Toxicology. 47(3): 471-478

210. Wan, M. T., *et al.* (1998). A New Technique for Determining the Sublethal Toxicity of pesticides to the Vesicular-Arbuscular Mycorrhizal Fungus *Glomus intrardices.* Environmental Toxicology and Chemistry 17(7): 1421 – 1428

211. Williams, J. (2003). Entrevista grabada como representante de la Embajada de los EEUU en Bogotá y publicada en el documental "Plan Colombia: Guerra Anti-Drogas o Pro-Petróleo" distribuída por Free-will Productions y firmada por Ungerman, G. y Brío, A.

212. World Helath Organization. (2005). Glyphosate and AMPA in drinking-water. WHO/WSH/03.04/97

213. Wynne, B. (1992). Uncertainty and Environmental Learning: Reconceiving Science and Policy in the Preventive Paradigm. Global Environmental Change. 2.2: III-27

214. Wynne, B. (2001) Managing Scientific Uncertainty in Public Policy. Cambridge: Presented at Biotechnology and Global Governance: Crisis and Opportunity. April. www.cid.harvard.ecu/cidbiotech/comments91 visitado en marzo 2007.

215. Yousef, M.I., *et al.* (1995). Toxic effects of carbofuran and glyphosate on semen characteristics in rabbits. J. Environ. Sci. Health B 30: 513-34.

216. Zablotowicz, R.M. y Reddy, K. N. (2004). Impact of Glyphosate on the *Bradyrhizobium japonicum* Simbiosis with Glyphosate-Resistant Transgenic Soybean: A Mini review. J. Environ. Qual. 33: 825–831.

OTRA BIBLIOGRAFÍA CONSULTADA

217. Agencia Nacional de Vigilancia Sanitaria (2005). Relatorio do Seminario Nacional Sobre Agrotóxicos, Saude e Ambiente em Brasil. Pernambuco: octubre 6 e 7.

218. Arbuckle, T.E. *et al.* (2001). An exploratory analysis of the effect of pesticide exposure on the risk of spontaneous abortion in an Ontario farm population. Environ Healt Perspect. 109:851-857.

219. Burger, M. y Fernández, S. (2004). Exposición al herbicida glifosato: aspectos clínico toxicológicos. Rev Med Uruguay 20:202-207.

220. Carlisle, S. M. y J. T. Trevors (1988) Glyphosate in the environment. Water, Air Soil Pollut. 39:409-420.

221. Comunidad Andina. (2000) Autoridades ambientales rechazan utilización del hongo *Fusarium oxysporum* en territorio de Comunidad Andina. Notas de prensa.

222. De Roos, A. J. *et al.* (2005). Cancer incidence among Glyphosate-exposed pesticide applicators in the agricultural health study. Environ Health Perspect 113:49-54.

223. Departamento de Salud y Servicios para personas mayores de New Jersey (2003). Hoja Informativa sobre Substancias Peligrosas: Isopropilamina.

224. Gamboa, E.N. *et al.* (2005). Efectos toxicos causados por la exposicion al glifosato en roedores tipo hamster. Universidad Industrial de Santander. Facultad de Salud. Bucaramanga.

225. Garcés, E. *et al.*, (2001) Fusarium oxysporum, el hongo que nos falta conocer. Acta Biológica Colombiana.

226. Garry, V.F. *et al.* (2002). Birth Defects, season of Conception, and sex of children born to pesticide applicators living in the Red River Valley of Minnesota, USA. Environ Health Perspect 110 (3):441-449.

227. Ho, M.W. (1997) The Unholy Alliance. The Ecologist 27(4)

228. Hua-Van, A., *et al.* (1998). Three highly divergent subfamilies of the impala transposable element coexist in the genome of the fungus *Fusarium oxysporum* Mol. Gen Genet. 259: 354-62.

229. Hua-Van, A., *et al.*, (2000) Genome organization in *Fusarium oxysporum:* clusters of class II transposons. Curr Genet 37: 339-47

230. Julie, M., *et al.* (2004). Formulated Glyphosate Activates the DNA-Response Checkpoint of the Cell Cycle Leading to the Prevention of G2/M Transition. Toxicological Sciences 82: 436-442, September 16.

231. Kale, P.G., *et al.* (1995). Mutagenicity testing of nine herbicides and pesticides currently used in agriculture. Environ Mol Mutagen 25(2):148-153.

232. Kastan, M.B. y Bartek, J. (2004). Cell-cycle checkpoints and cancer. Nature 432:316-323

233. King, C.A. (2001). Plant growth and nitrogenase activity of glyphosate-tolerant soybean in response to foliar glyphosate applications. Agronomy Journal 93: 179-186.

234. Kissmann, K. (1997). Adjuvantes para caldos de produtos fitosanitarios. XXI Congresso Brasileiro para o Controle de Plantas Daninhas. Caxambu-Mg.

235. Kistler, H.C. (1997). Genetic diversity in the plant-pathogenic fungus Fusarium oxysporum. Phytopathology 87:474-479.

236. Marc, J. *et al* (2005) A glyphosate-based pesticide impindes on transcription. Toxicol Appl Phramacol 203(15):1-8.

237. Ministerio del Ambiente *et al.*, (2003). Misión de Verificación: Impactos en el Ecuador de las fumigaciones realizadas en el Departamento del Putumayo dentro del Plan Colombia. Art. 16.

238. Monsanto Europe SA (2004). Ficha de Datos de Seguridad Producto Comercial: http://www.monsanto.es/monsantoes/FUSTA%2004.rtf

239. Montemayor, C. (2006). Universidad pública y privatización del conocimiento. La Jornada 20/12/06.

240. Nivia, E. (2004). Ecosistemas colombianos en peligro por cultivos de uso ilícito y estrategias de fumigación. Boletín de Ecofondo (25):19-25.

241. Rippon JW. (1988). Medical Mycology. 3rd ed. W.B.Saunders Co., Philadelphia, pp. 797.

242. Rodrigues, N. B., *et col.* (1998). Guía de Herbicidas. 4ª Ed.

243. Romo, L.A. (2006) Fumigaciones aéreas de plantaciones ilícitas. Ciencia y Tecnología 5(1): 65-72

244. Sanderson, J.B., *et al.* (1999). Glyphosate application and timing of tillage of red clover affects potato response to N, soil N profile, and root and soil nematodes. Can Journal Soil Sci. Ottawa. 79 (1): 65-72

245. Servizi, J.A., *et al.* (1987). Acute toxicity of Garlon 4 and Roundup herbicides to salmon, *Daphnia* and trout. Bull. Environ. Contam. Toxicol. 33: 355 - 361

246. Sivikova, K., and Dianovsky, J. (2006). Cytogenetic effect of technical glyphosate on cultivated bovine peripheral lymphocytes. Int J Hyg Environ Health 209(1):15-20

247. Stanton, K., *et al.* (2002). Cumplimiento con las Condiciones de Fumigación en la Iniciativa Antidrogas Andina. RFK Memorial, Latin America Working Group, Amazon Alliance, Center for Internacional Policy. Abril/2002.

248. Taylor, J., *et al.* (1999). The evolution of asexual fungi. Annual Rev. Phytopath 37,197-246. Citado en Cunning, J. ISIS report, 2000.

249. Tu, M. *et al.* (2001). Glyphosate. Weed Control Methods Handbook. The Nature Conservancy. USA

250. USDA Forest Service. Forest Health Protection (2003) Glyphosate. Human Health and ecological risk assessment. Final report. http://www.fs.fed.us/foresthealth/pesticide/risk_assessments/04a03_glyphosate.pdf

251. Vicente, C. (2001). Informe sobre la reunión interministerial del Protocolo de Cartagena sobre Bioseguridad llevada a cabo en Montpellier. Biodiversidad en América Latina. http://www.biodiversidadla.org

252. Viqfusson, N.V. y Vyse, E.R. (1980) The effect of the pesticides Dexon, Captan and Roundup, on sister-chormatid exchanges in human lymphocites in vitro. Mutat. Res 79(1): 53-57

253. Wang, Y.S. (1994). Accumulation of 2,4-D and glyphosate in fish and water hyacinth. Water, Air and Soil Pollution Apr. 74 (3/4): 397-403

254. Weed Science Society of America. (2006). Herbicide Resistant Weeds Summary Table. Monday, June 26.

ANNEX 158

Charles A. Menzie, PhD, Pieter N. Booth, MS & Susan B. Kane Driscoll, PhD,
with contributions/advice from Angelina J. Duggan, PhD,
Charlotte H. Edinboro, DVM, PhD, Anne Fairbrother, DVM, PhD,
Marion Joseph Fedoruk, MD, CIH, DABT, FACMT, Janci Chunn Lindsay, PhD,
Katherine Palmquist, PhD & Brian J. Prince, MRQA,
Evaluation of Chemicals Used in Colombia's Aerial Spraying Program and Hazards Presented to People, Plants, Animals, and the Environment in Ecuador
(Apr. 2009)

ANNEX 158

Exponent®

Evaluation of Chemicals Used in Colombia's Aerial Spraying Program, and Hazards Presented to People, Plants, Animals, and the Environment in Ecuador

ANNEX 158

Exponent®

Evaluation of Chemicals Used in Colombia's Aerial Spraying Program, and Risks Presented to People, Plants, Animals, and the Environment in Ecuador

Prepared for

Government of Ecuador

Prepared by

Charles A. Menzie, Ph.D.; Pieter N. Booth, MS; and Susan B. Kane Driscoll, Ph.D.

with contributions and advice from:

Angelina J. Duggan, Ph.D.; Charlotte H. Edinboro, DVM, Ph.D.; Anne Fairbrother, DVM, Ph.D.; Marion Joseph Fedoruk, MD, CIH, DABT, FACMT; Janci Chunn Lindsay, Ph.D.; Katherine Palmquist, Ph.D.; and Brian J. Prince, MRQA

Exponent
1800 Diagonal Road, Suite 300
Alexandria, Virginia 22314

April 2009

© Exponent, Inc.

Doc. no. MY03197.000 0210 0409 CM07

Contents

		Page
List of Figures		**iv**
Acronyms and Abbreviations		**v**
Executive Summary		**vi**
1 Authors and Qualifications		**1**
2 Approach		**3**
3 Overview of Chemicals Used in Colombia's Aerial Spraying Program		**4**
3.1	Glyphosate	4
3.2	Surfactants	5
3.3	Other Potential Ingredients	6
4 Potential for Spray Drift		**9**
4.1	Spray Operation Parameters	10
4.2	Off-Target Release of Spray	12
4.3	Ground-Based Hostilities	13
4.4	Localized Weather Conditions	13
4.4.1	Thermal Inversions	14
4.4.2	Local Wind Circulation	14
4.4.3	Variations in Wind Speed between the Airport and Mission Locations	15
4.4.4	Temperature	15
4.5	Eyewitness Accounts	15
5 Hazards to Health, Agriculture, and the Biologically Diverse Ecosystems of Ecuador Associated with Exposures to Chemicals in the Aerial Spray Mix		**17**
5.1.1	Health Hazards to Humans	17
5.1.2	Conclusions	20
5.2	Hazards to Agriculture	20
5.2.1	Direct Effects on Non-target Crops	20
5.2.2	Chronic Effects on Nontarget Crops	23

5.2.3 Direct Effects on Domestic Animals 25
5.2.4 Effects on Aquaculture (Fish) 26
5.3 Hazards to Ecuador's Biodiverse Ecosystems 27
5.3.1 Hazards to Native Vegetation 28
5.3.2 Hazards to Insects 28
5.3.3 Hazards to Aquatic Biota, with Emphasis on Frogs 31
5.4 Hazards Associated with Misuse of Herbicide Products 38
6 Bibliography of Relevant Literature 41

Attachment A Resumes

List of Figures

		Page
Figure 1.	Photo of AT-65 spray plane, from Solomon et al. 2005	10
Figure 1.	From Solomon et al. 2005.	11
Figure 3.	Intensity of aerial spraying conducted in Putamayo along the northwest Ecuador border during 2001–2004	28
Figure 5.	Adult poison dart frogs with tadpoles on their backs	35
Figure 6.	Bromeliads plants provide habitat and water for certain tree frogs	36
Figure 7.	Eggs laid on plant surfaces and guarded by adults	37
Figure 8.	Section 5.0 of label from Roundup Pro as sold in U.S.	40

Acronyms and Abbreviations

ae/ha	acid equivalents per hectare
ATSDR	Agency for Toxic Substances and Disease Registry
EPA	U.S. Environmental Protection Agency
EPSP	5-enolpyruvylshikimate-3-phosphate
GHS	Globally Harmonized System
GOC	Government of Colombia
LC50	exposure concentration at which 50% of the exposed organisms would die
MSDS	material safety data sheet
POEA	polyoxyethyleneamine
USDA	U.S. Department of Agriculture
VMD	volume mean diameter

April 14, 2009

Executive Summary

This document provides Exponent's evaluation of the potential hazards to Ecuador associated with the Government of Colombia's (GOC's) application of herbicide spray on illicit crops in Colombia near the border with Ecuador. Our approach involved:

1. Identifying the chemical constituents (generic categories and/or specific compounds) in the herbicide spray mixture used by Colombia
2. Examining factors that could result in spray or spray drift entering Ecuador
3. Assessing the potential hazards associated with the spray program.

Our evaluation indicates that the program is atypical of spray programs used elsewhere for weed control in agricultural settings. Both the customized herbicide formulations used by Colombia and the enhanced risk of spray drift presented by Colombia's aerial spraying operations led to hazards to Ecuador. The following lines of evidence all point toward the potential for hazards associated with the spray program.

Colombia's efforts to enhance the efficacy of the herbicide formulation heightens the potential for adverse effects

- While the active agent in the formulation—glyphosate—is well known and commonly used safely in numerous agricultural applications, Colombia engaged in an experimental program to heighten the efficacy of their formulations.
- The compositions of these formulations changed over time, and there is considerable uncertainty regarding what was added to the formulation. Government reports indicate that additives, including formaldehyde and various surfactants, were included; further additives have been tested as possible constituents.
- There has been a concerted effort to improve the efficacy of the formulation to kill coca plants, and this has entailed the addition of surfactants and/or other additives that are not currently used in U.S. formulations. While the exact composition and amounts of the various surfactants and other additives are unknown, the addition of these chemicals brings with it increased hazards to non-target plants, agriculture, agriculture, the environment, and potentially to people.

Numerous factors increase the likelihood of spray drift

- The likelihood of spray drift is increased when pilots fail to recognize or adhere to operational and environmental constraints for spraying.

- Thermal inversions and variable wind speeds would lead to increased drift. Both occur along the Ecuador-Colombia border. In particular, thermal inversions would not be recognized by pilots.
- The area that receives spray drift increases as release height is increased. Several lines of evidence indicate that pilots would release spray at heights in excess of the forest canopy and well above the uneven terrain. The presence of hostile ground fire would also raise the heights of release.
- The area affected by spray drift increases with decreasing droplet size. Evidence indicates that conditions could lead to smaller droplets and thus an increase in spray drift.
- Studies of spray drift conducted in the United States have shown that depending on environmental factors, a substantial portion of the spray can leave the target area as spray drift and can be carried for miles beyond the target.

Chemicals in the spray drift would pose a hazard to people

- Irritation of the eyes, skin, and throat are among the most common and consistent effects reported by people in Ecuador and Colombia who claim they have been exposed to spray. These effects are associated with the types of chemicals known to be included in the spray, particularly the surfactants that are common to glyphosate formulations.
- Reports of nasal and throat irritation and breathing difficulty are consistent with the effects that could occur from inhalation of glyphosate formulations.
- Nausea, vomiting, and diarrhea have been reported by a number of people following spray events. These types of effects are consistent with those that could occur from ingestion of Roundup formulations or one or more chemical constituents added to the spray mix. Exposure could occur from ingestion of local exposed water or food or from inhalation of foul-smelling spray.
- Many of the reports of adverse effects following spray events have involved children. Ecuadorian children may be vulnerable to certain effects of the herbicide formulations by virtue of either greater exposure potential and/or possibly greater sensitivity to one or more of the chemicals in the formulation.
- Children with underlying nutritional deficiencies and malnutrition may be particularly vulnerable to diarrhea, should this occur as a result of exposure to the herbicide formulation. Diarrhea is a concern, because it causes dehydration and could lead to other health effects.

Chemicals in the spray drift would pose a hazard to agricultural crops, domestic animals, and fish

- Spray drift that falls upon non-target crops can kill or damage those plants. The drift associated with Colombia's customized formulation includes additives that increase the effectiveness of the herbicide. Therefore, this drift would be more toxic to non-target crops than would comparable exposure to more standard formulations.

- The reported long-term lowered or impaired productivity of crops such as coffee, yucca, and plantains are consistent with potential effects of the formulation. These long-term effects could arise from weakening of the plants and rendering them more susceptible to infections by fungi, nematodes, and other parasites. Formulations have also been reported to result in diminished soil productivity by adversely affecting nitrogen-fixing plants and their symbiotic fungi.

- Reported effects on domestic animals are consistent with potential hazards associated with the types of chemicals in the formulation. These include the direct effects that lead to irritation of eyes, skin, and throat. Exposure to additives that cause eye, skin, and systemic conditions would reduce the productivity of food-producing animals (decreased weight gain or reproductive performance). In general, young animals are more susceptible to these types of stress-related effects than are adults. Spraying with glyphosate-based herbicides may also reduce the local food supply for domesticated animals, which may lead to decreased body condition and performance in livestock and other farm animals.

- Reports of fish kills in fish aquaculture ponds and other water bodies following spray events are consistent with direct and indirect effects of chemicals in spray drift. Some of the additives are recognized as toxic to fish. In addition, spray can result in the death of aquatic plants and algae that grow densely in fish ponds. The death of these plants increases the biochemical oxygen demand, which can lead to loss of oxygen and asphyxiation of fish.

Chemicals in the spray drift would pose a hazard to Ecuador's biologically diverse ecosystems

- Biologically diverse ecosystems within Ecuador near the border with Colombia would experience exposure to spray drift that crosses the border.

- Plant communities are a critical component of Ecuador's biologically diverse ecosystems. As already noted, plants are especially susceptible to the toxic effects of herbicide formulations. Many of the native plant species are expected to be much more sensitive than coca to the effects of the spray.

- Insects are recognized as emblematic of Ecuador's biodiversity. These animals are especially susceptible to the toxic effects of surfactants and other additives in herbicide formulations.

- Amphibians are also recognized as indicative of Ecuador's biodiversity. These animals are especially vulnerable to spray drift for three reasons. First, frogs are especially sensitive to the toxic effects of the chemicals in the formulation. Second, numerous frog species in Ecuador live a primarily terrestrial existence among the vegetation. The terrestrial environments that they inhabit would receive spray drift, either directly or indirectly, from droplets that accumulate on vegetation. Third, amphibians would be susceptible at multiple life stages. The young tadpoles of terrestrial frogs may live and grow in small pockets of water. These pockets are substantially smaller than those typically assumed for the purpose of evaluating sprayed biocides. An adequate assessment of the risk presented to amphibians must consider these ecological factors.

Conclusion

We have visited the border region and interviewed villagers who have been exposed to spray drift and/or who have experienced adverse effects following spray events. We find the reports of effects to be credible based on the factors presented above. In particular, we considered the potential for spray drift to enter Ecuador; whether there is a complete exposure pathway that links spray events in Colombia to exposures of people, plants, animals, and the environment in Ecuador; the degree of consistency between the reported effects and the chemicals in the spray mixture; the sensitivity of human and ecological receptors; and whether the reported effects can be correlated over time and by location with the areas most likely to be affected by the spray. When these factors are considered together with the reports of effects and the potential for chemicals in the spray to cause those effects, the collective information is coherent and supports the conclusion that spraying along the border poses hazards to the people, agriculture, and ecosystems of Ecuador.

1 Authors and Qualifications

This report was prepared by scientists at Exponent. The assessment covered a broad range of subject areas, so the review team comprised a number of individuals with the specific expertise needed to review the various aspects of the assessment and render their views on the nature of exposures and effects. The expertise of these scientists is described in Attachment A. The authors of this report include:

- **Charles Menzie, Ph.D.—**Dr. Menzie was responsible for overall evaluation of potential risks associated with spray practices. Dr. Menzie is an expert in the areas of risk assessment and environmental fate and transport of hazardous chemicals, with a strong background in biology.
- **Pieter Booth, M.S.—**Mr. Booth was responsible for direct observations in Ecuador and assessment of ecological effects. Mr. Booth is an expert in ecotoxicology, risk assessment and determination of the causes of ecological damage, with a strong background in biology, ecology, and marine issues
- **Susan Kane-Driscoll, Ph.D.—**Dr. Kane Driscoll was responsible for assessing ecotoxicity of the spray mixture to aquatic biota and plants. Dr. Driscoll is an expert in aquatic toxicology, with special expertise in environmental chemistry and sediment toxicity, and a background in natural resources and environmental sciences.

The authors were assisted by the following contributors and advisors:

- **Marion J. Fedoruk, M.D., C.I.H., D.A.B.T., FACMT—**Dr. Fedoruk was a contributor and advisor on the direct and secondary effects of the chemicals in the mixture. Dr. Fedoruk is a medical toxicologist with special expertise in exposure and effects assessment following environmental and occupational exposures to hazardous chemicals.
- **Angelina Duggan, Ph.D.—**Dr. Duggan considered issues related to toxicity of glyphosate as amended with various surfactants, with emphasis on human health effects. She integrates toxicology, biomonitoring, exposure, physicochemical, and epidemiology data to address regulatory requirements and conduct human health environmental risk assessments. She is also experienced in the application of Structure Activity Relationships (SAR) and cluster analysis.
- **Janci Chunn Lindsay, Ph.D.—**Dr. Chunn Lindsay considered issues related to mammalian toxicity data for herbicide mixtures. Dr. Lindsay specializes in the evaluation of complex dynamics of toxicity, including exposure routes, pharmacokinentics, and dose-response relationships, and has a background in biochemistry and biology.
- **Brian Prince, B.Sc., MRQA—**Mr. Prince was a contributor and advisor on the secondary effects on plants and the significance of labeling. Mr. Price

specializes in pesticide effects and efficacy, and the regulatory process of agrochemicals, and has a background in agricultural sciences.

- **Charlotte H. Edinboro, D.V.M., Ph.D.**—Dr. Edinboro's experience in epidemiology includes cancer epidemiology, nutritional epidemiology, exposure assessment, and pharmacoepidemiology. Her research interests include potential impacts of dietary and environmental exposures on the thyroid, small-animal population disease control, and companion animals as sentinels for human health.

- **Anne Fairbrother, D.V.M., Ph.D.—**Dr. Fairbrother has more than 30 years of experience in ecotoxicology, wildlife toxicology, contaminated site assessment, and regulatory science for existing and emerging chemicals in the U.S. and Europe. She has conducted large-area (>100 sq mile) risk assessments in tropical, desert, and mountain ecosystems, determining risk thresholds for plants and wildlife.

- **Katherine Palmquist, Ph.D.—**Dr. Palmquist has a strong interdisciplinary background in insect biology/physiology, toxicology, integrated pest management, and communications. She has experience in aquatic entomology and aquatic toxicology concerning the sublethal effects of insecticide exposure to aquatic invertebrates, specifically aquatic insects.

2 Approach

This document provides Exponent's evaluation of the potential hazards to Ecuador associated with the Government of Colombia's (GOC's) application of herbicide spray on illicit crops in Colombia along the border with Ecuador. The method involves:

1. Identifying the chemical constituents (generic categories and/or specific compounds) in the herbicide spray mixture used by Colombia
2. Examining factors that could result in spray or spray drift entering Ecuador.
3. Assessing the potential hazards associated with the spray program.

The factors that we considered in arriving at our conclusions include the potential for spray drift to enter Ecuador; whether there is a complete exposure pathway that links spray events in Colombia to exposures of people, plants, animals, and the environment in Ecuador; the degree of consistency between the reported effects and the chemicals in the spray mixture; the sensitivity of human and ecological receptors; and whether the reported effects can be correlated over time and by location with the areas most likely to be affected by the spray.

Using these factors, we reviewed the available information to determine whether they constitute an overall, coherent weight of evidence with respect to potential hazards posed to Ecuador from spray drift that crosses the border from Colombia. Consistent with recent U.S. Environmental Protection Agency (U.S. EPA 2003a) cumulative risk approaches, we recognize the importance of beginning with the potentially affected communities. These include the individuals who have reported various health effects and damages to agriculture. These individuals either experienced spray drift or observed consequences following spray events to their crops, domestic animals, and in some cases, native species. Our technical analysis serves as a means of assessing the connection between the reported effects in Ecuador and the effects that could be caused by the spray.

3 Overview of Chemicals Used in Colombia's Aerial Spraying Program

Under its aerial spraying program, the GOC has conducted large-scale coca (*Erythroxyllum coca*) eradication activities near Ecuadorian territory, using aerially applied herbicides. The herbicide reportedly used is composed of a customized mixture containing glyphosate (commonly formulated as Roundup) and other chemicals that include surfactants and possibly other additives. The exact mixture used by GOC is unknown—it has been kept confidential, and we are not aware of any independent chemical analyses, other than an analysis of the percent glyphosate in various formulations (Springborn 2003). The addition of various surfactants and additives to enhance the effectiveness of the herbicide formulation has been the subject of research by the U.S. Department of Agriculture (USDA) (Collins and Helling 2002), and the composition of the formulation used in Colombia changed several times between 1994 and 2002 (Helling and Camp, date unknown). The composition of this mixture was modified at least once to address concerns regarding eye irritation (U.S. Department of State 2002a). In the following subsection, we describe the characteristics of glyphosate, surfactants (a class of chemicals added to glyphosate to increase its effectiveness), and other possible additives. This section includes a brief discussion of the health and environmental effects of these compounds; Section 5 contains a more detailed discussion.

3.1 Glyphosate

Glyphosate is a post-emergent, systemic, non-selective herbicide that is used widely for weed control in agricultural and non-agricultural applications. Non-agricultural applications include forestry, roadways, and other non-crop sites where total vegetation control is desired. Glyphosate is a highly effective herbicide. With the exception of genetically-modified glyphosate-resistant crops, glyphosate is a highly effective herbicide that affects most species of plants.

Glyphosate disrupts the function of plant cells. It is an analogue of the amino acid glycine, and it inhibits production of the aromatic amino acids phenylalanine, tyrosine, and tryptophan. This is achieved by competitive inhibition of the enzyme 5-enolpyruvylshikimate-3-phosphate (EPSP) synthase. EPSP is a key enzyme in the shikimic acid pathway for the synthesis of chorismate, a precursor for the amino acids phenylalanine, tyrosine, and tryptophan (Grossbard and Atkinson 1985; Giesy et al. 2000). The shikimic acid pathway occurs in all plants, bacteria, and fungi. Inhibition of the synthesis of these amino acids arrests protein and enzyme formation. The shikimic acid pathway does not exist in animals, which obtain amino acids from the diet.

Glyphosate has also been shown to interrupt the synthesis of the photosynthetic pigment chlorophyll, inhibit the production of phenolic compounds (e.g., indole acetic acid, a plant growth hormone that stimulates mainstem growth), and can lead to a buildup of ammonia in various tissues because of the disruption to protein synthesis (Kearney and Kaufman 1976; Grossbard and Atkinson 1985). These effects are either results of or are considered secondary

toxic effects of the inhibition of aromatic amino acid production (Grossbard and Atkinson 1985).

A plant treated with glyphosate will initially stop growing. Cessation of growth can be followed by yellowing of tissue (chlorosis), drying of leaves, leaf drop, scorching or curling of leaves, retardation of shoots, leaf deformation, bud proliferation, and finally necrosis (death). Unlike the acute effects of many other herbicides, glyphosate can also cause chronic toxic effects that can persist for many years in perennial plants and crops (Grossbard and Atkinson 1985). As discussed in more detail in Section 5, research indicates that glyphosate use may cause long-term impacts to soil conditions, microorganism communities in the soil, and nutrient uptake by plants.

3.2 Surfactants

The spray used by GOC includes surfactants in addition to the glyphosate described above. The purpose of adding surfactants to the glyphosate is to increase the uptake of glyphosate by plants and thus increase the effectiveness of glyphosate at killing plants. Surfactants increase the efficacy of the herbicide by improving adherence to the plant, enhancing the spread, dispersion, and penetration of the herbicide into plant tissues by disrupting the waxy cuticle on the foliage, and reducing the surface tension of the formulation on the surface of the plant (Solomon et al. 2005; Franz et al. 1997). Various types of surfactant compounds are available, including anionic, cationic, amphoteric, and nonionic surfactants, and many different types of surfactants have been used to enhance the effectiveness of glyphosate as an herbicide. In short, an aerial spraying program could use any one of a number of surfactants, each with different chemical compositions and effects.

Generally, because it is Confidential Business Information, the specific surfactants used are not publically available; however, the spray used by GOC is reported to include at least two: polyoxyethyleneamine (POEA) and Cosmo-Flux 411F, which are discussed briefly below.

The commercial Roundup product used by Colombia contains POEA, which is also known as tallow amine ethoxylate (CAS RN 61791-26-2). POEA is a mixture of alkyl amine ethoxylates. This compound has been reported in animal tests to cause severe skin irritation, be corrosive to the eyes, and an irritant to the gastrointestinal tract (U.S. EPA 2003B).

U.S. EPA (2003) also describes another component of the glyphosate product is described in an EPA report, but does not identify the specific chemical. This second component of the glyphosate product is described as potentially causing mild, transient eye irritation (U.S. EPA 2003B).

Cosmo-Flux 411F, which is produced in Colombia, but not manufactured or used in the U.S., is an additional surfactant used in the glyphosate formulation for the eradication of coca. The complete chemical composition of Cosmo-Flux 411F is not publically available. The U.S. Department of State (2002b) reports that it is composed of polyol fatty acid esters and polyexothylated derivatives (17%) and inert liquid isoparaffins (83%).

The health and environmental effects of the surfactants, either alone or in combination with glyphosate, are described in more detail in Section 5.

3.3 Other Potential Ingredients

Herbicide mixtures often contain a complex combination of chemicals. To our knowledge, the specific formulation of the herbicide spray used in Colombia's aerial spraying program has not been disclosed. We do know, however, that a number of chemicals have been specifically evaluated for inclusion in the herbicide spray for coca eradication, and it is possible that one or more have been included.

According to the U.S. State Department audit reports, agricultural scientists from USDA have assisted in evaluating and guiding the herbicide application program in Colombia. USDA scientists also have been conducting research to identify herbicide formulations that would be especially effective at eradicating coca (Collins 2000; Collins and Helling 2002). The results of that research provide insights into the likely additives to the herbicide formulation used in Colombia. The 2002 study examined the effectiveness of 16 additives to the herbicide formulation, including cationic, nonionic, or mixed surfactants, in aqueous or oil-based carrier systems. Several of the additives listed below were identified as enhancing the efficacy of glyphosate for controlling coca. Ultimately, two glyphosate/surfactant mixtures were found to effectively increase the phytotoxicity to coca: a mixture labeled COC/OSI-U (a combination of crop-oil concentrate, Agri-Dex, and organosilicone [Silwet L-77]) and another called CAT/ANA (a cationic surfactant/anionic surfactant [Optima]). The authors report that, as a consequence of these studies, the glyphosate mixture used in Colombia for coca eradication was modified, and the efficacy of the mixture at killing coca plants was improved. Formaldehyde has also been mentioned as an additive in the Colombia aerial spraying program (USDA 2001).

Thus, although we have no confirmation, it is entirely possible that the spray mixture has included one or more of the following chemicals or similar additives:

- Silwet-77
- Other organosilicone surfactants
- Crop oil concentrate
- Agri-Dex
- Optima
- Atplus 300F
- Defoaming agents (Cosmo-In-D)
- Formaldehyde.

Each of these chemicals can cause human health or environmental effects. A summary of the types of effects associated with these chemicals was derived from their labels and Material Safety Data Sheets (MSDSs) and other sources and is provided as follows.

Silicone-based surfactants are included in glyphosate-based herbicides to prevent the loss of herbicide from leaf surfaces during rain events, and are therefore suitable for use in high-precipitation climates (Franz et al. 1997). As a class of compounds, organosilicone surfactants are noted to cause eye and skin irritation.

Silwet L-77 is an organosilicone surfactant that has the potential to harm the human reproductive system, as stated on its label. Repeated ingestion may lead to liver and thyroid injury, as well as injury to reproductive systems. The carcinogenicity of the substance is not known, because it is a proprietary blend of substances. It may also cause irritation to the mouth and throat, abdominal discomfort, nausea, vomiting, and diarrhea. Prolonged or widespread skin exposure may result in absorption of potentially harmful amounts. Prolonged skin contact may cause itching, with redness and slight swelling. Repeated ingestion may cause liver, kidney, thyroid damage, and harm to the male and female reproductive system and blood system. Skin contact may aggravate existing dermatitis. Prolonged exposure to the eyes may cause discomfort, with swelling of conjunctiva. It is highly toxic to fish and introduction to water bodies should be avoided. The chemical is persistent and may cause long-term effects on aquatic systems.

Crop oil concentrate causes eye irritation.

Agri-Dex can cause mild to moderate irritation to eyes, skin, and throat. A precautionary statement notes that is that it is hazardous to humans and domestic animals. Over-exposure may result in formation of granulomas.

Optima can cause potential severe eye irritation, and direct contact can damage the eye. It is a slight skin irritant but can be a skin sensitizer. According to the Optima brand label, it is harmful if inhaled.

Atplus 300F can cause eye and skin irritation.

Defoaming agents can cause eye irritation. The labels for defoamers often require those engaged in their application to wear full personal protective equipment and warn against allowing the chemical to contaminate foodstuffs, feed, or fertilizer.

Formaldehyde is very hazardous in case of eye contact (irritant), or ingestion, and is hazardous in case of skin contact (corrosive, irritant, sensitizer, permeator), or eye contact. It is a mutagen and carcinogen.

In addition to the additives described above that enhance the herbicide's toxicity to plants, glyphosate formulations can also contain other herbicides. A combination of herbicides can increase the toxicity to exposed plants. For example, some glyphosate formulations include a 2,4-D IPA salt (Nalewaja and Matysiak 1992). Herbicide mixtures containing glyphosate and 2,4-D are toxic, but in some cases, the toxicity progresses slowly, so poisoned plants may not exhibit symptoms for several weeks (Baylis 2000). Fungal plant pathogens, such as *Alternaria,*

Colletotrichum, and *Fusarium*, have also been used to enhance he herbicidal action of glyphosate (Franz et al. 1997).

The possibility that the spray applied by Colombia has contained various potentially toxic constituents is supported by the extensive literature documenting field applications of glyphosate in combination with many adjuvants and other herbicides. For example, Franz et al. (1997) discuss glyphosate compositions, additives, and mixtures in detail. The authors document field applications that have enhanced the effectiveness of glyphosate, including a wide range of surfactants, oils and emulsions, ammonium sulfate, quaternary ammonium compounds, urea, humectants (e.g., glycerol, sorbitol, and polyethylene glycol), and other herbicides such as 2,4-D, dicamba, diphenyl ether herbicides, surfonylureas and imidazolinone herbicides, and chloroacetimide herbicides (alachlor and metoachlor). In the absence of definitive chemical analysis of the spray material, these and other potential additives cannot be ruled out as being present in the spray mixture and are potentially responsible for additional adverse effects in Ecuador.

4 Potential for Spray Drift

Exposures of the people, plants, animals, and the environment of Ecuador to the spray mixture may occur if there is direct overspray or when the spray drifts over the Colombia/Ecuador border. There is no doubt that aerially applied herbicides drift, or spread laterally, from the point of intended application. Drift leaving the target area can represent a substantial amount of the applied herbicide (U.S. Congressional Office of Technology Assessment, 1990). Under optimal conditions, most of the spray deposits on or near the target. However, studies have also shown that pesticides delierved through aerial spraying can be transported miles in the drift (Currier et al, 1982; Murray and Vaughn, 1970; Westra and Schwartz, 1989; Robinson and Fox, 1978); these studies have indicated that spray drift may extend as far as to four to ten miles.

In this section of the report, we describe some of the factors that would tend to increase the atmospheric transport of spray into Ecuador. Factors that affect spray drift include those associated with the spray operation itself and those associated with environmental conditions during spray events. The following operational factors are important in determining the extent and severity of spray drift:

- Spray operation parameters
  - Meteorological conditions (wind speed, humidity, temperature, inversions)
  - Elevation above ground of the aircraft flight path
  - Airspeed during spraying
  - Size distribution of droplets
- Off-target release of spray.

The following environmental conditions exacerbate the areal extent and severity of spray drift:

- Ground-based hostilities
- Localized weather conditions.

In each case, the information we have obtained about the spray events suggests that the conditions are conducive to drift that would extend considerably farther than would otherwise occur during spray applications in temperate climates, on flat land, and under more controlled conditions.

We also summarize eyewitness accounts of spray events that corroborate the intrusion of the spray into Ecuador.

4.1 Spray Operation Parameters

The manner in which the spray mixture is released can significantly affect the amount of drift. Variations in spray operations can include changes in the heights at which spray is released, the precision with which the application system is turned on and off, the amount of spray used, and the ambient conditions present during spray events.

Herbicide product documentation typically includes recommendations for application, in large part to minimize drift. For example, the product label for the commercial product Roundup SL in Colombia provides the following guidance and recommendations for aerial application:

- Only apply under the following atmospheric conditions
  - Air temperature below 29° C
  - Relative humidity greater than 60%
  - Wind speed less than 7 kph
  - Absence of thermal inversion
- Release spray at a height of 2 m above crop.

These instructions are in contrast with operational parameters that are described for Colombia's aerial spraying program. There are several documents that refer to operational parameters for Colombia's aerial spraying activities, but it is not clear which set of parameters is supposed to be followed. The operational parameters that have been documented differ considerably from the parameters recommended on the product label, and each of these differences will tend to favor extended spray drift.

Atmospheric conditions. Operational parameters restrict the atmospheric conditions under which spray operations may be carried out. According to U.S. Department of State (2002a), spraying guidelines are less strict than those indicated on the product label for the commercially available Roundup SL. For example, U.S. Department of State (2002a) asserts that missions are cancelled if wind speed at the airport is greater than 10 mph (16 kph), as compared to the limit of 7 kph specified on the product label. Colombia's Environmental Management Plan (GOC 2003) specifies a maximum ambient temperature for aerial application of 35° C (as compared to 29° C for the product label). Similar spray-mission parameters are documented by Solomon et al. (2005).

Aircraft speed. In addition to the parameters described above, operational parameters are also defined for aircraft speed. Although application rate is apparently automatically calibrated to compensate for variations in ground speed, elevated flight speeds will likely result in an increase in drift due to increase turbulence. Turbulence can cause spray droplets to break apart, and these smaller, lighter droplets have a potential to be carried further by wind currents.

The U.S. Department of State (2003) has reported that aircraft flight speed during eradication operations is 165 miles per hour. A U.S. Department of Agriculture report (USDA 2001)

indicates that spray planes operate at speeds of over 200 miles per hour. Further evidence that maximum flight speeds are exceeded is provided in at least one reported accident (reported in the U.S. Department of State Audit [USDA 2001] Document 188262548):

> *The crash investigation report revealed two significant factors that may have contributed to the crash. First, the speed of the aircraft was in excess of normal spray operations. Second, the coca field being sprayed had a slightly rising terrain in the direction of travel. This would make it more difficult for the pilot to notice a tree that was above the normal tree line.*

Application altitude. The height at which the spray is released strongly influences spray-drift distances and deposition rates. The closer to the ground, the more likely that drift is reduced. Mission parameters call for spray to be released at altitudes not to exceed 30 m above coca or poppy fields, which is 15 times higher than the application height indicated on the product label. It appears that the application is sometimes made at even higher altitudes. For example, the GOC's Environmental Management Plan (GOC 2003) states, "The highest application altitude will be 50 m; notwithstanding, the operation will be conditioned to the height of the obstacles present in the target spraying zones." Additionally, as we discuss below, conditions along the Colombia/Ecuador border would lead pilots to release spray at higher rather than lower heights. We believe it is likely that these conditions would result in releases of spray at heights even above those specified in the protocols described above.

In actual application, the release, or boom, height is likely to be highly variable due to the conditions that occur along the Colombia/Ecuador border, including complex topography that includes hills, valleys, gulleys, and forest canopy of varying height. Figure 1, taken from the Solomon et al. (2005) assessment of the aerial spray program, shows a plane flying over the uneven terrain while releasing spray.

F) AT-65 spray plane

Figure 1. From Solomon et al. 2005.

As the picture illustrates, the height above the ground at which spray is released will vary with the terrain. For this one example, winds passing through the valleys could move the spray drift greater distances because of the greater height of spray release. Pilots applying spray to fields located within the forests will necessarily have to fly above the canopy to safely apply the spray. In such cases, the spray height is affected by tree height, which in this region is considerable.

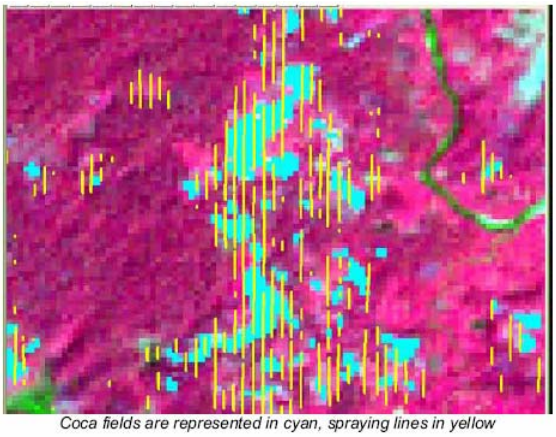
There are also many accounts from residents in Ecuador placing the release height well in excess of 30 m based on their personal observations.

Droplet size. Smaller drops of the herbicide mixture are more prone to drift than larger ones. Colombia's Environmental Management Plan (GOC 2003) states that the nozzles specified for the aircraft deliver droplets with volume mean diameter (VMD) between 300 and 1,000 microns (μm). According to tests conducted by Collins (1998), who evaluated droplet size distribution in 18 field tests conducted in Colombia, 79% of the dispersed volume was of a droplet size less than 500 µm. This suggests that a considerable portion of the sprayed amount is in the lower droplet size range of the target VMD, and thus is more susceptible to spray drift than larger droplets.

4.2 Off-Target Release of Spray

The extent of off-target spray drift is also influenced by the pilot's actions. Timing of spray release is controlled by the pilot. Spray is initiated and terminated at the pilot's discretion, depending on his/her judgment regarding the airplane's trajectory, elevation, speed, and wind direction and speed. The degree to which off-target overspray can occur due to topography and timing of release is illustrated in a graphic taken from the UNODC 2006 coca survey (Figure 1).

The parallel yellow lines in the figure are actual flight lines recorded using GPS within the flight recorder of the spray plane. The coca fields are shown in cyan. The purple coloring represents forests surrounding the fields. This graphic confirms that planes began spraying when they were still over the forest and before they traveled over the fields. Spraying continued as they exited the field and passed again over the forest. This demonstrates that the release of spray occurred at a height greater than the height of the forest canopy. It also shows that spray did reach the forest canopy. Spraying over an area broader than the target area increases the probability that non-target biota will be exposed to the spray. As noted above, spraying over a forest also requires the planes to fly at greater heights.



Coca fields are represented in cyan, spraying lines in yellow

Figure 2. Spray flight lines

4.3 Ground-Based Hostilities

The spray missions are often conducted under highly adverse and violent conditions. This is perhaps best exemplified by the fact that spray areas are commonly patrolled by helicopter gunships prior to the arrival of spray planes. Despite these precautions, spray planes have received hostile fire. This field condition is acknowledged by the U.S. State Department in numerous documents. For example, U.S. State Department (2003) includes a section titled, "Response Procedure for Attending Disasters during Spraying," which primarily addresses ground hostilities. The following are excerpts from that report:

> *The program operates in a hostile environment—eradication aircraft are often shot at from the ground—that requires helicopter gunships and a search and rescue helicopter to accompany each eradication mission. In August 2003, the Director of the Office of Aviation expressed his concern that the increased operational tempo had strained the resources and staffing available and he could not continue to ensure the operational safety of the aerial eradication program.*
>
> *But in late 2002 and during 2003, the number of ground-fire hits reported increased significantly—averaging more than 26 per month—and in 2003, for the first time, two spray aircraft crashed and two were forced to land because of ground fire. Moreover, the operational tempo more than doubled—from about 5,450 flying hours for spray aircraft in 2001 to over 11,300 hours in 2003. In general, this meant the spray aircraft and accompanying helicopters were exposed more frequently to the threat of ground fire; although other factors also came into play, such as the proximity of eradication target areas to insurgent locations. According to U.S. Embassy/Bogotá officials, the increased number of ground-fire hits occurred, at least in part, because the illicit drug producers were responding more vigorously to the success of the increased aerial eradication program.*
>
> *In an October 2003 report, DynCorp noted that the threat to the program's aircraft and pilots was causing increasing concern about pilot safety and personnel morale.*

It is reasonable to expect that the hostility would be a reason why pilots would fly higher and faster than they would during normal agricultural crop-spraying. Under those circumstances, the released spray would be prone to greater drift. In addition, the presence of hostility can create the need for evasive maneuvers or distractions from spraying, all of which can decrease the accuracy of the spraying and increase the amount of non-target areas directly affected or affected by drift.

4.4 Localized Weather Conditions

Local meteorological conditions favor the formation and persistence of thermal inversions and localized wind patterns that can increase spray drift.

4.4.1 Thermal Inversions

The label for Roundup SL cautions against aerial spraying in the presence of thermal inversions. A thermal inversion is a condition where warmer air is positioned above colder air. Thermal inversions are common in the tropics and are expected to be a frequent occurrence in the Ecuador/Colombia border area. In equatorial areas such as the Colombia/Ecuador border region, there are no cold or warm frontal systems, such as are found in the temperate latitudes. Thus, there is little daily variation in the weather. Overall, the barometric pressure in this area tends to be lower than that in more temperate zones, and wind speeds tend to be lower. All of these conditions favor formation of temperature inversions.

In an inversion, there is little vertical mixing and, typically, low wind speeds. Therefore, if the aircraft flies within a shallow inversion, the droplets will be trapped within the inversion and will not fall to the ground as readily. This limitation on the ability of the droplets to descend will allow for greater horizontal movement of the spray particles. Thus, the downwind concentration of the spray may be increased. Another scenario in which a thermal inversion increases the downwind spray concentration occurs if the aircraft flies above the inversion. Droplets could then be carried in the wind above an inversion, falling through the inversion farther downwind than intended. Either scenario could result in high concentrations of droplets at greater distance from the spray point, because small droplets are blown downwind while above the inversion, but larger droplets fall into and through the inversion.

4.4.2 Local Wind Circulation

Wind is one of the most important factors influencing spray drift. Both wind direction and velocity are important. In general, strong winds favor increased drift, and winds perpendicular to flight paths will result in greater drift than weak winds parallel to flight paths.

However, spray drift can also be increased under light wind conditions by contributing to localized circulation patterns. When light wind conditions occur in areas where there is no dominant meteorological system, local circulation can control the air flow, and spray can be carried in unexpected directions and in ways not easily predicted. Three circulation patterns are discussed below:

- **A small patch of cleared land, surrounded by jungle trees**— In this situation, the thermal characteristics of the cleared land may be quite different from those of the surrounding jungle. The cleared patch will absorb sunlight in a manner different from that of the surrounding jungle. In light wind or calm conditions, this temperature difference can create a small-scale circulation that could cause the spray to disperse in a pattern different from what would happen under more typical conditions.
- **Mountain-valley breeze**—This is a well-known phenomenon in which the daily heating and cooling of mountain slopes is different in adjacent valleys. The difference can create upslope winds in the morning and downslope winds in the evening, which can carry spray drift long distances—longer than what is typically encountered in “flat land” agricultural situations.

- **River-related circulations**—This phenomenon is again related to the thermal conditions in the air over a river, compared to those over adjacent land. The result can be a pair of vortices that move along the river, carrying spray down- or up-river, and depositing droplets farther from the release point than what would otherwise occur in the absence of the river.

The complex meteorological conditions described above could alter spray-drift patterns in unpredictable ways and could extend the drift farther than what would be expected absent these conditions.

4.4.3 Variations in Wind Speed between the Airport and Mission Locations

As just described, wind conditions may be highly local; they may also change rapidly, even in a single location. While the protocol calls for cancelling flights "at the airport," it is likely that winds at distance from the airport could at times be significantly stronger or weaker than those at the airport. This is especially the case in Ecuador/Colombia border area, where the terrain is uneven. Therefore, acceptable wind speeds "at the airport" do not necessarily represent acceptable wind speeds at spray locations. The spray locations can be a considerable distance from airports and air bases where the spray planes initiate their missions, and the differences in topography, times of day, and local wind circulation (as described above) can result in very different winds at the locations to which the planes are directed.

4.4.4 Temperature

Air temperature and relative humidity affect the volatilization rate of droplets as they fall through the atmosphere. Under hot and relatively dry conditions, more volatilization will occur than under cooler, humid conditions. Excessive volatilization will result in smaller droplets that will be carried farther in spray drift. Excessive volatilization will also result in more concentrated active ingredients, which could produce greater exposures to non-target organisms.

4.5 Eyewitness Accounts

Eyewitness accounts within Ecuador indicate that spray applied in Colombia did cross the border and enter into Ecuador. Communities in border regions of the Sucumbíos, Esmeraldas, and Carchi provinces are located immediately adjacent to areas in Colombia that were targeted for aerial spraying during the period 2000–2007. Several groups, including Ecuadorian NGOs, Ecuador's Office of the Public Defender, and U.N. Special Rapporteurs, participated in several verification missions to the border regions of both Ecuador and Colombia to document reports of effects from spraying (UN Special Rapporteur 2007; Impacto de las Fumigaciones en la Zona de Frontera Colombia-Ecuador, 2007, p. 2 [6.10]). In addition to these verification missions, dozens of witness statements have been gathered from several representative border communities, including Salinas and Puerto Escondido, Sucumbíos; several indigenous villages located across the border region; and Mataje, Esmeraldas. Witness accounts from these various

and isolated communities are very similar. In some cases, witnesses state that airplanes crossed over into Ecuador and released spray over their communities. In other cases, witnesses have stated that they were exposed to spray drift carried by the wind. Many witnesses reported feeling the spray droplets contact their skin and reported a strong odor and immediate irritation of mucosal membranes, including eyes and throat. These reports provide a separate and direct line of evidence that aerial spraying intended for illicit crops in Colombia entered Ecuador, where people and their crops, domesticated animals, soil, water, and native flora and fauna were directly exposed.

5 Hazards to Health, Agriculture, and the Biologically Diverse Ecosystems of Ecuador Associated with Exposures to Chemicals in the Aerial Spray Mix

In Section 4, we described factors that would lead to increased spray drift associated with Colombia's aerial spray program. In this section, we describe the hazards associated with exposures to the chemicals in the spray mix. We discuss the potential hazards presented to humans, agriculture (crops, farm animals and fish), and the biologically diverse ecosystems.

This section is limited to chemicals for which there is firm evidence of their presence in the spray. As noted in Section 3, many different chemicals could have been present in the spray during the course of the spray program. A few of these, such as formaldehyde, were revealed through references in U.S. government reports. Also, changes in formulation were shown to have occurred over time based on USDA and State Department records. The evidence of ongoing experimentation with the spray formulation and the lack of concrete information from Colombia indicate that formulations may have been created for and applied in the aerial spray program that were atypical of those in common use for agricultural purposes. Thus, there is considerable uncertainty about the full range of toxicity and effects associated with the various formulations. Specific testing data available for review are very limited

We do know that there was a concerted effort to improve the efficacy of the formulation to kill coca plants and that this required the addition of surfactants and other additives. While the exact composition and amounts of the various surfactants and other additives are unknown, the addition of these chemicals to improve the efficacy of the formulation to kill coca can bring with it an increased hazard associated with the presence of surfactants in the formulation. Because the formulation used in Colombia has been customized to target a resistant plant species in locations that are not conducive to normal spray applications, ecological hazards associated with the spray are likely much greater than those associated with normal and controlled agricultural applications elsewhere.

5.1.1 Health Hazards to Humans

People within Ecuador who reported experiencing spray and/or who live in areas adjacent to where spraying has occurred have reported a variety of health ailments, including eye, skin, and throat irritation, cough, shortness of breath, dizziness, nausea, vomiting, and diarrhea. In this section of the report, we examine the hazards associated with exposures to the chemicals in the spray mix. Our review of these chemicals indicates that the symptoms being reported are consistent with effects that can be associated with exposures to chemicals in the various spray formulations.

5.1.1.1 Acute Effects on Eyes and Skin

Irritation of the eyes and skin are among the most common and consistent effects reported by people in Ecuador and Colombia who claim they have been exposed to spray. Irritant effects

have also been reported with commercial formations of Roundup that include a combination of glyphosate and surfactants. Adverse effects from dermal contact that have been reported for glyphosate formulations include skin irritation and occasional reports of contact dermatitis (Maibach 1986). Periorbital edema (swelling around the eyes) has been reported when the herbicide is transferred from the hands to face, and symptoms can include paresthesia (i.e., tingling sensation) (Temple and Smith 1992).

Reports of accidental exposure to glyphosate formulations in California are maintained by the EPA Pesticide Illness Surveillance Program (CA DPR 2007). Most cases reported topical effects (e.g., eye or skin irritation) or respiratory effects, with fewer cases of possible systemic effects (e.g., nausea/vomiting, dizziness, fever, and diarrhea) (Goldstein et al. 2002).

The following is a summary of publically available hazard information for adjuvants (surfactants and other chemicals) that may be included with glyphosate in the coca eradication formulation.

POEA, also known as tallow amine ethoxylate, (CAS RN 61791-26-2), is a surfactant that is used in the aerial spraying program. POEA is a mixture of ethoxylated linear saturated and unsaturated C14-C18 alkyl amines. Publically available information on the exact chemical composition and toxicology of POEA is limited. MSDSs were reviewed as sources of general information on hazard and product use, although their usefulness is limited by the lack of detailed information in toxicological studies. An MSDS for a tallow amine product (Ethomeen® T/25) and literature searches indicate that this surfactant is moderately irritating to the skin but severely irritating to the eyes and can also irritate the throat.

Cosmo-Flux 411F is an additional surfactant that is reportedly in current use in the spray formulation used in Colombia. Cosmo-Flux is produced in Colombia, and limited information is available on its exact formulation. However, the U.S. Department of State (2002b) reports that Cosmo-Flux is composed of polyol fatty acid esters and polyexothylated derivatives (17%) and inert liquid isoparaffins (83%). The MSDS and product use information for Cosmo-Flux do not provide specific toxicity data. An MSDS for another paraffin-based surfactant (Agri-Dex) states that excessive exposure may result in eye or skin irritation.

While the MSDS and product use information for Cosmo-Flux does not provide detailed toxicity data, it does contain a description of first aid suggesting some of the potential hazards associated with the product (Cosmo-Flux Safety Data Sheet):

> ***Eye contact:*** *Wash with clean drinking water until irritation disappears or use a solution for rinsing eyes. If irritation persists, seek medical attention.*
> ***Skin Contact:*** *Wash with plenty of water; use soap if available. Remove strongly contaminated clothing, including shoes, and wash well before using.*
> ***Inhalation:*** *Using appropriate breathing apparatus, remove the person from the site into fresh air and call a doctor.*
> ***Ingestion:*** *Do not induce vomiting, keep the person at rest. Get immediate medical attention.*

5.1.1.2 Respiratory Effects from Inhalation

Inhalation is not considered a major route of exposure to typical glyphosate formulations during normal aerial applications, and data concerning adverse effects of exposure by inhalation are limited, with little detail on the absorbed dose or duration of exposure. Inhalation of the glyphosate formulations is thought to generally lead to symptoms of oral and nasal discomfort, and there have been reports of unpleasant taste, throat irritation, and tingling. However, it is difficult to determine whether the reported adverse effects are due to any one constituent (herbicide or adjuvants) in the glyphosate formulation. One case, involved a firefighter who was exposed to glyphosate formulation spray drift from a nearby field and experienced burning eyes, skin irritation, and headache (Goldstein et al. 2002).

Inhalation toxicity data for Cosmo-Flux are not available. However inhalation of isoparrafins, the main constituent of Cosmo-Flux, has caused respiratory effects. Inhalation of a spray mist at significant levels would be expected to produce respiratory tract irritation. Persons with preexisting respiratory conditions, such as persons with asthma, would be expected to be more sensitive to the effects of such an irritant.

5.1.1.3 Acute Gastrointestinal Effects

A number of people who reported being exposed to spray also reported experiencing nausea, vomiting, and diarrhea. The people in the villages depend on local water and food supplies. If these resources are heavily impacted, people that consume them could be exposed by an oral route. Nausea and vomiting are reported to result from ingestion of significant quantities of glyphosate formulations, with diarrhea reported less commonly. Thus, some of the gastrointestinal complaints are consistent with those that could occur from ingestion of glyphosate-containing formulations or chemical constituents added to the spray mix. Nausea and even vomiting have also been reported to occur as a result of exposure to noxious odors.

5.1.1.4 Potentially Vulnerable Populations

Many of the reports of adverse effects following spraying have involved children. Ecuadorian children may represent a vulnerable population to certain effects of the herbicide formulation. The likelihood of exposure to this population could be increased, because they are expected to spend considerable time outdoors and to wear less clothing than adults (e.g., shirtless or short pants).

Diarrhea has been reported following spraying events. One possible explanation for the diarrhea and other gastrointestinal symptoms is inadvertent ingestion of retained residue, although diarrhea is more commonly reported with ingestion of large doses. Children with underlying nutritional deficiencies, malnutrition, and underlying gastrointestinal disorders, including those associated with contaminated water supplies, may represent a potentially vulnerable population to diarrhea. Diarrhea is a concern, because it can lead to other health effects, especially for individuals whose health is compromised. Diarrhea causes dehydration, and children are more likely than adults to die from it because they become dehydrated more quickly (Chen et al. 1983; Basch 1999; Semba et al. 2000). Such effects may be exacerbated for people in Ecuador, where tropical temperatures may lead to increased dehydration, and many communities have

limited access to the type of medical facilities where rehydration and other appropriate treatments are available.

The impact of potential environmental stressors interacting with poverty has been recognized as being of special concern to children. The World Health Organization has also expressed concern that children may be exposed to health risks from environmental hazards, stating, "Over 40% of the global burden of disease attributed to environmental factors falls on children less than five years of age, who account for only about 10% of the world's population. Environmental risk factors often act in concert, and their effects are exacerbated by adverse social and economic conditions, particularly conflict, poverty, and malnutrition" (WHO 2009).

The potential sensitivity of children to some chemical agents is recognized and, of course, depends on both the nature of the chemical agent or mixture and the exposure incurred. In 1997, the U.S. Agency for Toxic Substances and Disease Registry (ATSDR) published a report that included more than 10 years of public health assessments, toxicological investigations, epidemiologic studies, and reviews by expert workgroups (ATDSR 1997). ATSDR concluded that children may have greater risk of adverse health effects when exposed to toxic substances. In their regulation of pesticide products, the U.S. EPA takes into account that children may be more vulnerable to environmental exposures than adults. Reasons for increased susceptibility can include:

- They eat more, drink more, and breathe more in proportion to their body size
- Their behavior (hand-to-mouth contact) may expose them more to chemicals and organisms.
- Organ systems are not fully developed and may be more susceptible to select toxicants.

5.1.2 Conclusions

Some of the symptoms reported in the Ecuadorian population have also been reported following exposure to commercial formulations of glyphosate. These include skin, eye, and respiratory irritation; nausea; and diarrhea, which raises concern that these people might have been exposed to levels of herbicide formulations of glyphosate with surfactants and other additives that account for their symptoms. As explained in Section 3, other potential ingredients in the spray that are not present in U.S. formulations present additional human health concerns.

5.2 Hazards to Agriculture

5.2.1 Direct Effects on Non-target Crops

We reviewed the reports made by people in Ecuador of damage to crops following spray events. We also visited agricultural areas along the border and held discussions with villagers. We learned that damage of crops followed spray events. Here we consider whether the conditions

reported by villagers are consistent with the potential effects associated with exposure to glyphosate and other chemicals in the spray mixture. We conclude that the effects to agricultural plants described by people in Ecuador who have been affected by aerial spraying are consistent with the known effects of glyphosate-based sprays.

Spray drift that falls upon nontarget crops can kill or damage those plants. In Section 4, we described the factors that could contribute to an increase in spray drift along the Ecuador/ Colombia border. In this section, we describe the effects of the spray mix on nontarget plants. We point out that the hazards to nontarget plants are increased, because the customized mixture used in Colombia is much more potent than the typical glyphosate formulation used elsewhere. The adjuvants included in the spray mixture increase its effectiveness at penetrating plant tissues and thereby enhance its ability to kill plants by 400%. Increasing the efficacy of the mixture for eradication of coca is necessary because of the physiology of the coca plant—a bush with woody bark and thick, waxy cuticles. We conclude that many crop plants grown in Ecuador are much more susceptible to the spray used in the aerial eradication program, because they do not have the same thick, waxy leaf cuticles and other resistant properties as the coca plant.

As discussed earlier, surfactants are commonly combined with glyphosate to increase phytotoxicity (i.e., the chemicals' ability to kill a plant). Surfactants are typically employed to increase the absorption of glyphosate through the leaf cuticle and increase translocation via phloem, transporting the herbicide to metabolic tissues faster. Some solubilized oil formulations can facilitate uptake through the bark of woody tissues as well (Grossbard and Atkinson 1985).

The physiology of a plant can affect its susceptibility to glyphosate-based herbicides. Because glyphosate is a broad-spectrum herbicide that is toxic to almost all plants, differences in sensitivity to glyphosate among different species are mostly due to differences in glyphosate uptake and translocation rates. These rates are determined largely by anatomical features on the outer surfaces of plants. Such features include leaf size, presence or absence of a waxy cuticle (the outermost skin of a plant), cuticle thickness, composition of epicuticular wax, and the presence or absence of bark. Once glyphosate has penetrated these surfaces, resistance to toxic effects is highly unlikely in most species, and depending on the dose, phytotoxicity can be expected. As noted in Section 3, some plants have also been genetically modified to resist glyphosate.

The properties of the leaf cuticle are particularly important, because glyphosate enters plants primarily through their leaves. The composition of the leaf cuticle can influence uptake rates of glyphosate and appears to play an important role in species-specific sensitivity (Grossbard and Atkinson 1985). The cuticle varies in thickness depending on species, as do the amount and composition of epicuticular wax, both of which serve to retain moisture and solutes inside the leaf and act as a barrier to pathogens. Glyphosate is generally formulated as an amine salt (such as the isopropyl amine salt) that enters a plant as an anion and thus requires a hydrophilic pathway through the cuticle. Cutin and carbohydrate fibers in the cuticle provide such a pathway within the otherwise waxy, hydrophobic cuticle (Grossbard and Atkinson 1985). Differences in the thickness and composition of the cuticle, and in the amount and composition of epicuticular wax, can result in differences in glyphosate uptake rates and, ultimately, phytotoxicity (Grossbard and Atkinson 1985; Gaskin and Holloway 1992). Coupland (1984)

demonstrated that glyphosate applied to the adaxial surface of the leaf sheath of *Apocynum cannabinum*, where there is no epicuticular wax, resulted in greater phytotoxicity compared to application to the lamina base, which is protected by a dense coat of wax. This study demonstrated the cuticle as a key factor in determining sensitivity to glyphosate. Gaskin and Holloway (1992) observed different uptake rates between wheat (*Triticum aestivum*) and field bean (*Vicia faba*). Wheat leaves have a cuticle with a microcrystalline layer of wax that is more water repellent than the leaves of field bean, which have very little wax and no crystalline deposits in the cuticle. These physiological differences were overcome by the addition of surfactants, which resulted in a greater increase in the rate of uptake in wheat.

A drier cuticle will take up glyphosate more slowly than a well-hydrated cuticle. Hydration of the plant cuticle can increase the uptake rate of hydrophilic compounds such as glyphosate. A high level of plant hydration or increased ambient humidity, as is found in the Ecuador/ Colombia border region, can increase the water content of the cuticle and thus increase uptake (Kearney and Kaufman 1976).

Once glyphosate has been taken up through the cuticle, it diffuses into mesophyll cells and then diffuses into the phloem. This process appears to occur via passive transport and at a slower rate than uptake through the cuticle. Once in the phloem, glyphosate is translocated in the sap to target metabolic tissues, such as roots, rhizomes, and apical meristems (Kearney and Kaufman 1976; Grossbard and Atkinson 1985; Giesy et al. 2000). This process of diffusion throughout the plant also differs among plants, and thus, may also contribute to differences in glyphosate phytotoxicity.

We rely on the Collins and Helling (2002) research to provide an estimate of the toxicity of the herbicide formulation used in Colombia relative to unenhanced Roundup for which glyphosate is the active phytotoxic agent. Collins and Helling report that the addition of adjuvants to the formulation resulted in a fourfold increase in glyphosate phytotoxicity: 1.1 kg acid equivalents per hectare (ae/ha) of glyphosate with surfactant was equivalent to 4.4 kg ae/ha glyphosate without added surfactant. This four-fold increase in toxicity can be found in various reports related to the spray program. However, the basis for it appears to come from the USDA research.

To understand how the degree to which the fourfold increase in toxicity can be applied to plants in general, it is necessary to consider the mechanism by which the additives result in increased toxicity. If this mechanism of enhancing toxicity is applicable to all plants, then it is reasonable to expect that the presence of certain additives in the Colombian herbicide formulation not only increases toxicity to coca and poppy by four times, but also increases toxicity to other plant species to a similar degree. The evaluation presented in the following subsections supports the following statements:

1. Glyphosate exerts its toxic action by being absorbed into the plant
2. Absorption of glyphosate into plants is influenced by the presence of a cuticle on plant surfaces

3. Plants vary in the degree to which this cuticle is developed, and this can contribute to the differences in sensitivity to glyphosate that is observed among plants
4. Surfactants can weaken the cuticle and increase the ability of glyphosate to penetrate into the plant
5. Coca has a thick cuticle, and additives were used to penetrate this cuticle, to enable penetration of glyphosate so that the plants could be killed
6. The additives used in the formulation enhanced the toxicity of glyphosate to coca by four times
7. Because the mechanism of increasing the toxicity of glyphosate is related to weakening of the cuticle and enhancing glyphosate penetration, a similar degree of enhanced toxicity can be expected for other plant species.

Crops that lack the thick, waxy cuticle of coca will be most susceptible to the effects of the spray. For this reason, spray drift associated with the program will be more toxic to plants than drift from "normal" Roundup. Because the efficacy of the spray mixture needed to be enhanced to make it effective on coca, it follows that many other species will be more sensitive to the spray. These could include many of the crop species grown in Ecuador, such as yucca, plantain corn, and fruit trees.

In sum, we conclude that many of the crop plants grown in the border region of Ecuador and Colombia are more susceptible to glyphosate-based herbicides than the coca plant. The increased potency of the spray used by Colombia makes it more likely that crop plants would be affected, even in small quantities. The effects on agricultural plants that have been reported in the border region of Ecuador and Colombia, including yellowing, withering and drying, and rotting of roots and other plant tissues, are consistent with the known effects of glyphosate-based herbicides.

5.2.2 Chronic Effects on Nontarget Crops

During our field visits to agricultural areas along the border, we were shown plantains, palms, and coffee plants that exhibited weakened conditions and dwarfed fruits. We were informed that these conditions began after the spray events and that they had persisted for one or more years. Similar characteristics associated with long-term effects have been reported for crops in Colombia. We examined the literature to determine whether these longer-term effects were consistent with exposures to the chemicals present in the herbicide mix.

As mentioned earlier, the glyphosate mixture used in the aerial spraying program has been documented to be four times more toxic than other typical commercial formulations used. This increased potency increases the risk of toxicity to nontarget plants that may be exposed to spray drift. In addition to direct mortality to nontarget plants, there are several ways in which spray drift may result in chronic long-term effects, including loss of plant vigor for years following exposure. In addition, glyphosate mixtures have been reported to result in diminished soil productivity mediated by adverse effects on nitrogen-fixing plants and their symbiotic fungi.

Finally, evidence indicates that glyphosate exposure weakens plants' immunity to fungal infections.

Exposures to herbicide mixtures below those that kill the plants can cause damage that persists. Many species of plants are susceptible to being damaged and weakened by glyphosate, and timing of exposure can be an important factor in determining sensitivity. Late-summer exposures to glyphosate produced high mortality and reduced shoot and sucker growth in black cottonwoods. Glyphosate exposure caused long-lasting damage to certain bush and shrub species, including several berry-producing species, with reduced vigor observed three years after exposure (Balfour 1989). The observations of long-term effects on perennial crops in Ecuador are consistent with the potential for the herbicide formulations to cause those effects. The literature suggests that some cultivated perennial plants may be very sensitive to glyphosate spray drift, and that chemical damage may persist in individual plants for several years following exposure. Severity of effects appears to be species dependent and may also vary with seasonal timing of exposure. Although generally considered robust, conifers were much more susceptible to exposures that occurred during periods of active growth, and high-potency glyphosate adjuvants increased conifer damage (Balfour 1989).

Sublethal effects on plants can be manifested through disruption of the plant's physiological processes. On the individual level, there is significant evidence that glyphosate can interfere with a number of important plant physiological processes. Sugar beets exposed to glyphosate exhibited altered photosynthetic rates and carbon allocation. Significantly reduced foliar starch was observed four hours after exposure, as was reduced stomatal conductance and diminished leaf net carbon exchange (Geiger et al. 1986). These responses were similar to what was observed following a reduction in available CO_2. Also, the exposure resulted in an accumulation of shikimate at night, which further interfered with sucrose synthesis in the leaves.

Significant alterations in soil productivity and nitrogen fixation rates have also been linked to glyphosate contamination. Glyphosate exposure was shown to reduce nodule formation in sub-clover (*Trifolium subterraneum*), a nitrogen-fixing plant; growth of the symbiotic fungi *Rhizobium spp* was also slowed following glyphosate application (Eberbach and Douglas 1989). This suggests that glyphosate use may interfere with plant-fungus interactions that are vital to soil health. Similarly, laboratory experiments indicate that glyphosate use may cause long-term impacts to soil conditions and microorganism communities. Research indicates that glyophosate can be translocated in target plants from foliage to roots and into the rhizosphere, where is it more persistent (Neumann et al. 2006). Glyphosate contamination in the rhizosphere was subsequently linked to decreased plant acquisition of micronutrients. Exposure to the herbicide resulted in slowed mycelial growth and reduced mycelial dry weight of five important soil fungal species: *Hebeloma crustuliniforme*, *Laccaria laccata*, *Telephora americana*, *Telephora terrestris*, and *Suillus tomentosus* (Chakravarty and Sidhu 1987). Glyphosate was also shown to be very toxic to the ectomycorrhizal fungus *Pisolithus tinctorius,* with a greater than 45% reduction in growth following exposure to 1 ppm glyphosate (Estok et al. 1989).

Reductions in soil fungi responsible for nitrogen fixation or nutrient mobilization will lower the productivity of soils, a significant negative impact in agricultural areas. Further, there is evidence that plant mortality following glyphosate spraying will increase the rate of soil denitrification 20 to 30 times that of untreated land (Tenuta and Beauchamp 1996). Nitrogen is

essential for plant growth, and as it is diminished, the productivity of plants can decline. Accelerated loss of nitrogen from the soil via denitrification can thus contribute to nutrient limitation and reduced plant viability and productivity.

While some fungi are beneficial to plants and soil health, other fungal species can be pathogenic to plants. Research suggests that glyphosate contamination can weaken plants' defenses against fungal infections. For example, glyphosate exposure altered the symbiosis between an orchid species (*Orchis morio*) and a fungus species (*Rhizoctonia spp.*) to that of a parasitic relationship; fungal growth in treated plants was haphazard and highly active, eventually resulting in orchid protocorm death (Beyrle et al. 1995). Another study demonstrated that glyphosate exposure reduced accumulation of phytoalexins (antibiotic and antifungal chemicals produced by plants) in bean seedlings (*Phaseolus vulgaris* L.) parasitized by *Colletotrichum lindemuthianum* fungus (Johal and Rahe 1988). This resulted in advanced mycelial growth and eventually in the death of the plant. These studies suggest that sublethal glyphosate exposure is likely to interfere with the plant defense mechanisms that prevent fungal infections.

These effects are largely sublethal, chronic impairments of plant vitality. While these impacts are generally less immediate than direct mortality, they can ultimately result in inhibition of plant reproductive cycles due to loss of plant vigor. Loss of vigor, poor fruiting, and reduced crop yields were observed consistently in areas in Ecuador affected by spray drift, in crops including coffee, yucca, rice, corn, plantains, pineapple, and cacao. These observations are consistent with the chronic effects of glyphosate, including its secondary effects on soil and plant health, documented above.

5.2.3 Direct Effects on Domestic Animals

We reviewed the reports made by people in Ecuador about effects on domestic animals following spray events. This included holding discussions with villagers. We learned that the reported effects followed spray events. Here we consider whether the conditions reported by villagers are consistent with the potential effects associated with exposure to glyphosate and other chemicals in the spray mixture. In addition to direct effects caused by exposure via dermal or ocular routes or by ingestion, the chemicals in the spray mixture may have important secondary effects. We conclude that many of the effects reported in animals are consistent with the known risks of glyphosate-based sprays.

We reviewed available documentation regarding glyphosate and surfactants, including POEA and Cosmo-Flux 411F. These included MSDSs and other product information. We have summarized here the potential effects to livestock, poultry, and other domestic animals that may result from exposure during an aerial spray event. In addition to this potential risk, even greater concerns about effects on mammals and birds from aerial spraying of glyphosate relates to compounds added to the tank mix to enhance foliar penetration and uptake (Bradberry et al. 2004). Primary hazards noted for several of the potentially added surfactants are eye irritation (moderate to severe) and, to a lesser extent, skin irritation. Prolonged exposures to eye irritants may lead to permanent eye damage, including corneal opacities.

In addition to direct irritation caused by surfactants, secondary irritation may occur when animals remove topical compounds that have been deposited on their skin by preening, body

and eye rubbing, and grooming, leading to dermal or ocular trauma as well as gastrointestinal upset. Secondary infections may occur from abraded skin, either because of the irritation caused by the spray mix or from self-inflicted wounds from excessive rubbing and grooming.

Short exposures (15 days) to formulated Roundup result in reduced growth rates and changes in plasma testosterone levels (Oliveira et al. 2007). Toxic effects of POEA or Cosmo Flux 411F to chickens are unknown, because they have not been tested on birds. However, given that these chemicals cause irritation to eye, skin, and mucus membranes in all species that have been tested, it is likely that similar effects would occur in poultry. When stressed, as would occur following this type of irritation, chickens frequently curtail egg-laying for a period of time.

Still further effects may be caused by ethylene oxide, a potential contaminant of POEAs. Its known hazards include carcinogenicity. At high concentrations, spontaneous abortions have been reported (OSHA 29 CFR). Possible effects of inhalation of ethylene oxide are nausea, vomiting, and breathing difficulties, including pulmonary edema. Our information regarding compounds that may have been used with glyphosate is incomplete regarding the presence of ethylene oxide.

Some product information also highlighted ingestion hazard (Monsanto product label for Roundup Ultra). In particular, chronic dietary exposure to glyphosate formulations is associated with temporary gastrointestinal irritation, resulting in vomiting, diarrhea, and colic. Campbell and Chapman (2000, as cited by Solomon et al. 2005), reported severe gastrointestinal upset in dogs acutely exposed to glyphosate, including salivation, vomiting, diarrhea, and irritation and swelling of lips. Reduced weight gain also has been observed in mammalian studies, although the cause of this is unclear and may be related to unpalatability of glyphosate-exposed diet (Bradberry et al. 2004).

In addition to the risks presented by direct ingestion of the chemicals, spraying with glyphosate-based herbicides may reduce the food supply for domesticated animals. The potential reduction in available forage for browsing or grazing may lead to decreased body condition and performance in livestock and other farm animals. In addition to compromised nutrition, exposure to adjuvants that cause eye, skin, and systemic conditions would reduce the productivity of food-producing animals (decreased weight gain or reproductive performance). In general, young animals are more susceptible to these types of stress-related effects than are adults.

It is inadvisable for people to let their animals consume contaminated feed, pasture etc. for several days following spray events. In addition people should avoid consuming livestock or other animal products (such as milk and eggs) following a spray event.

5.2.4 Effects on Aquaculture (Fish)

As discussed in Section 5.3.3 below, many of the chemicals present in the mix can be toxic to fish. Fish kills have been reported in fish farm ponds in Ecuador following spray events. We visited two locations where such effects were reported to occur and discussed the fish kill events with the owners of those aquaculture ponds. We learned that the kills occurred shortly after a

spray event. In addition, we learned that similar kills were reported in Colombia following spray events. These included:

- Reports from municipal officials in La Hormiga and Valle de Guamez, Putumayo, cited several hundred complaints of damage, including reports that hundreds of fish had washed up on the banks of the Guamuez River (Wilson 2001; Williams 2001; Municipality of Valle de Guamez 2001).
- An inspection and accounting by the municipal police in the single township of Valle del Guamuez (population 4,289), in the Province of Putumayo, found that 17,912 acres had been sprayed with herbicides as of February 21, 2001. Among the losses in the 59 settlements and neighborhoods that make up the township were 128,980 fish (from aquaculture) (Municipal Police Inspector, Valle de Guamuez 2001).
- In June, the Colombian government launched a spray campaign against the northern Colombian community of El Catatumbo, in the State of Norte de Santander, near the Venezuelan border. According to press reports, residents reported the loss of thousands of fish. One community leader reported in an interview that many fish have been appearing dead in the Catatumbo River (El Tiempo 2002).

Fish kills could occur either because of direct effects of the toxic chemicals or indirectly through the death of aquatic plants. The latter would result in a decrease in available oxygen in the ponds, and this could result in asphyxiation of the fish. These mechanisms are described in greater detail in Section 5.3.3.

5.3 Hazards to Ecuador's Biodiverse Ecosystems

Our analyses indicate that herbicide spray drift from Colombia that enters Ecuador could have adverse effects on ecological receptors in Ecuador. We focus our analyses on plants, insects, and aquatic biota, with an emphasis on amphibians. These groups of biota are often identified as representative of the biodiversity of Ecuador. Loss of biodiversity is of great concern to Ecuador, because the country is recognized for its rich diversity of plant species, frog species, and other assemblages of animals. Two regions in Ecuador are consistently listed as biodiversity hot spots and conservation priorities: the western coastal areas of Ecuador, and the tropical Andes of Ecuador (Myers 1988; Myers et al. 2000; Brooks et al. 2001). These regions have extremely high biodiversity and endemism, and have also suffered tremendous loss of habitat in recent years (Brooks et al. 2001).

Our analysis considers the threats that spraying within Ecuador poses to the country's rainforests along its northwest border. Figure 3 depicts the intensity of aerial spraying conducted in the Colombia province of Putamayo along the northwest Ecuador border during 2001–2004. This region is collocated with Amazon rainforest within Ecuador.

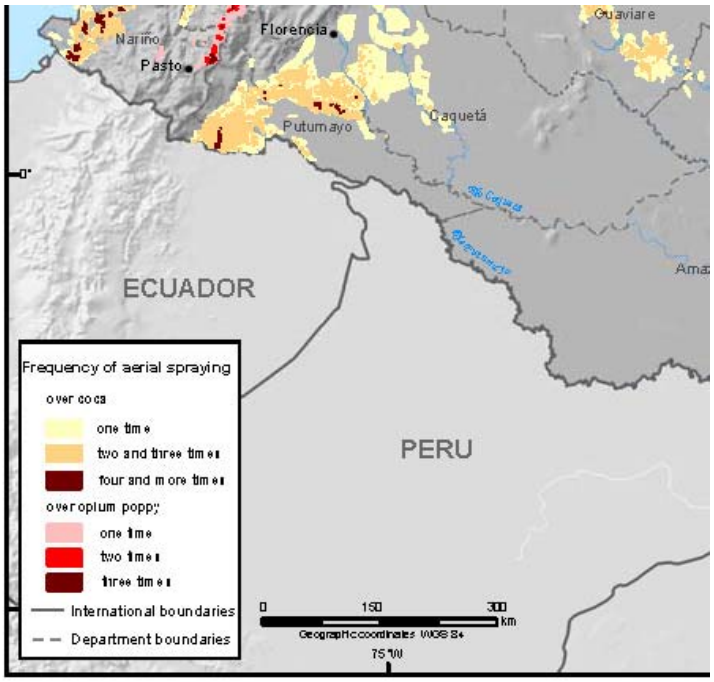


Figure 3. Intensity of aerial spraying conducted in Putamayo along the northwest Ecuador border during 2001–2004

5.3.1 Hazards to Native Vegetation

We described earlier the potential impacts of spray drift on nontarget crop plants within Ecuador. However, Roundup is toxic to all taxa of plants. Because the plant toxicity of the customized formulation of Roundup applied in Colombia has been increased by the addition of specialized surfactants, the herbicide spray is expected to have an even greater adverse effect on nontarget native vegetation. As a result, the spray drift could affect nontarget native plant species, along with the nontarget crops. Impacts on native plants have broad implications for biodiversity, because the diverse assemblage of rainforest plants provides habitat and food for the diverse assemblage of animals that live there. In short, the biodiversity within the rainforest is related, in part, to the diverse habitats and food items provided by the plants. Therefore, loss of components of the plant community will directly affect the components of the animal community that rely on them. Ecologically significant losses of plants can occur even if large-scale vegetation damage is not visually evident.

5.3.2 Hazards to Insects

We describe first the ecological importance of insects in the ecosystem and point out that they are one of the groups of animals considered especially important to the biodiversity of the

system. We then describe the potential toxic effects of spray drift on these animals. In particular, we consider the hazards associated with the presence of surfactants in the spray mix. Our evaluation indicates that spray drift would pose a hazard to the insect fauna.

5.3.2.1 Ecological Importance of Insects in Ecuador

It has been estimated that nearly half of Earth's biological diversity exists in the tropics; this is readily visible in the array of insect species that reside there. Tropical climates exhibited greater past geological stability, as opposed to temperate areas, which promoted proliferation of insect species. Ecosystems in tropical regions also appear to provide a large number of ecological niches, promoting invertebrate propagation. High insect densities produced by stable climatic conditions and large numbers of available niches resulted in heightened competition and predation, which in turn led to increased insect biodiversity (Basset 2008). Estimates of tropical insect species range from under 1.5 million, but the exact number is unknown; only a small number of species have been appropriately identified and cataloged (Erwin 1982). Even less is known about the ecological roles performed by individual species.

Biological surveys indicate that tropical insect communities are characterized by high species richness with a low abundance per species (Price et al. 1995). This suggests that the diversity of tropical insects is not necessarily indicative of large populations, and the low populations of individual species may indicate that species may be susceptible to habitat loss or other anthropogenic impact. Given these factors, and the sheer number of insect species in the tropics, some of which are still being discovered, it is possible that species could decline or disappear without human detection.

Beyond serving as an indicator of tropical biodiversity, insects play important roles in tropical ecosystems. Insect species are also important decomposers in tropical ecosystems, and as such are integral to nutrient and carbon cycles. Termite densities in the tropics of Cameroon have been documented to reach up to 10,000 individuals/m^2 (Jones et al. 1998), signifying their essential contribution to tropical decomposition. Similarly, herbivorous insects selectively feed on young plants, helping to maintain proper plant age structure (Basset 2008). Tropical insect species also provide a diverse and dense prey source for insectivorous organisms, including many obligate insectivores. Bats, in particular, are voracious predators of tropical insects, and their phenology and population structure may be driven in part by insect availability (Estrada and Coates-Estrada 2001). In tropical systems, the terrestrial adults of semi-aquatic insect species are estimated to account for an average of 21% of riparian insect biomass in the dry season, and half of riparian insect biomass in the wet season (Chan et al. 2007).

The integral role of insects in ecosystems means that a disturbance to their populations may have a cascading effect on plants and other species. Complex plant/insect relationships fostered in tropical conditions have led to specialized nutrient cycling, pollination, and seed dispersal mechanisms; in many cases, these interactions are highly specific, requiring certain species and exact behaviors (Coley and Barone 1996; Basset 2008). Among the unique examples of this are ant/plant mutualisms in which resident ants remove and kill herbivorous invertebrates, and plants provide refuge and food in the form of nectar secretions (Levey and Byrne 1993).

The pollination of fig trees, a tropical keystone species, is also dependent on species-specific relationships with tiny wasp species (Agaonidae, Chalcidoidea). In the absence of the necessary wasp species, fig trees will not bear fruit and reproduce (Nason et al. 1998). In a similar vein, habitat disturbance was shown to disrupt pollination of the Amazonian tree *Dinizia excelsa*, indicating that a highly localized pollinator is responsible for *D. excelsa* reproduction (Dick et al. 2003). This supports the theory that tropical ecosystems are characterized by highly complex and local species interactions, in which insects undoubtedly play integral roles.

5.3.2.2 Toxicity of Spray Mix to Insects

Although generally considered to be non-toxic to invertebrate species, pure glyphosate has been shown to adversely affect populations of certain invertebrates, either through direct toxic effect or through indirect effects on plant community diversity. Laboratory-determined toxicity of 40 different pesticides used regularly in orchards indicated that glyphosate was highly toxic to the predatory mite *Amblyseius fallacies*. In fact, glyphosate toxicity was similar to that of paraquat, diazinon, fenvalerate, and permethrin (Hislop and Prokopy 1981). Life spans of collembola, isopods, and Carabidae beetles were reduced following laboratory glyphosate exposures approximating field application rates (Cox 1995).

Customized formulations of glyphosate such as the one developed for and used in Colombia are much more toxic than the active ingredient glyphosate. Even formulations that have not been enhanced in the manner as that of Colombia can be toxic to insects. Newly applied formulated RoundUp was found to be acutely toxic to beneficial insects, including parasitoid wasps, lacewings, and predatory beetles (Cox 1995). Other insect species suffered population declines following field applications of glyphosate, although it is unknown whether these declines resulted from direct toxicity or from herbicide-mediated alteration in plant communities. For instance, populations of the big eye bug (*Geocoris punctipes*), an important natural enemy of agricultural pests, declined in fields of Roundup Ready® soybeans the weeks following glyphosate applications (Jackson and Pitre 2004). The authors stated that density reductions occurred either as a result of direct glyphosate toxicity or through a reduction of non-soybean refugia plants. Similarly, a comparison of glyphosate-treated and non-treated loblolly pine forests indicated that the herbicide had a significant effect on the populations of the Nantucket pine tip moth (*Rhyacionia frustrana*), an important pest of a number of pine species, including shortleaf, Virginia, loblolly, and scotch pines. Populations of *R. frustrana* in glyphosate-exposed forests were prone to highly variable population fluctuations and experienced reduced pupal weights (Guiseppe et al. 2006).

Surfactants are common adjuvants of commercial insecticide mixtures that promote the penetration of insecticidal compounds through the insect exoskeleton, thereby increasing the efficacy and potency of applied insecticides (Goodwin and McBrydie 2000). The surfactant compounds used in these insecticide mixtures have the same mode of action as those used in herbicide mixtures, and frequently, the same surfactant chemicals are used in both insecticide and herbicide formulations. Although surfactants can greatly increase insecticide potency, there is also significant evidence that surfactants alone are toxic to insects. The toxicity appears to result from the surfactant-mediated alteration in the interaction of water and invertebrate cuticle and tracheal system, causing the exposed individual to become waterlogged and drown (Cowles et al. 2000). At sublethal surfactant exposures, this can result in disorientation and altered

behavior, as exposed insects react to the injury to the exoskeleton and respiratory system (Goodwin and McBrydie 2000). Because available moisture would be a strong determinant of surfactant potency and effects, it is likely that surfactant toxicity would be enhanced in areas of high humidity and moisture (Cowles et al. 2000).

Given that surfactants disrupt insect respiratory process and interfere with exoskeleton defenses, population-level impacts are likely to be far-reaching and fairly unpredictable from laboratory experiments. Significant sublethal effects, including behavioral changes, are probable, but extrapolating these effects to the population and community level is difficult. Impacts on different life stages are also likely to precipitate population-level effects, particularly in a repeated exposure scenario.

The potential for surfactants to increase the toxicity of formulations is especially relevant to the issues of concern in Ecuador. The above discussion indicates that, to the extent that toxicity to insects is related to the strength of surfactants, the addition of special surfactants to the Colombia formulation to kill coca could also result in increased toxicity to insects over and above that observed for Roundup or glyphosate.

5.3.3 Hazards to Aquatic Biota, with Emphasis on Frogs

Based on results from laboratory bioassays, the surfactants added to the spray mixture are highly toxic, and significantly more toxic to nontarget organisms than the glyphosate itself.

Researchers have determined that the Roundup surfactant POEA was primarily responsible for the toxicity of the formulated compound to several freshwater invertebrates and fish. The enhanced toxicity of formulations relative to glyphosate is seen through a comparison of basic toxicity data. Glyphosate LC_{50}s (the exposure concentration at which 50% of the exposed organisms would die) ranged between 97 and 150 mg/L for a number of aquatic organisms, including rainbow trout, midge larvae, fathead minnows, catfish, and bluegills. In contrast, the toxicity of POEA is much greater, as revealed by the lower LC50 values. POEA LC50s (exposure concentrations at which 50% of the exposed organisms would die) for the same organisms were determined to be between 1.4 and 18 mg/L (Folmar et al. 1979). Additionally, Roundup surfactant POEA was also found to be toxic to a number of aquatic bacteria, algae, and protozoa with IC50s and LC50s ranging between 0.57 and 10.2 mg/L (Tsui and Chu 2003).

Laboratory toxicity assays with different formulated products bolster the argument that surfactants are the primary determinants of toxicity. Toxicity of glyphosate compounds to frogs was found to be largely dependent on the formulations tested. Glyphosate-based herbicide formulations were determined to be toxic to these species. This suggests that surfactant-mediated toxicity is essential in determining the risk to nontarget organisms (Mann and Bidwell 1999).

There is significant evidence that commercial formulations of glyphosate are acutely toxic to larval amphibians. Relyea (2005) reported that Roundup overspray was highly lethal to three species of amphibians (*Rana pipiens*, *Bufo americanus*, and *Hyla versicolor*), with mortality rates of 96% to 100% observed in larval amphibians. Mortality of post-metamorphic (juvenile) amphibians was 68% to 86% within one day of Roundup application. Sediment composition of

exposed mesocosms had no impact on the potency of Roundup, indicating that chemical sequestration in sediment would not prevent toxic exposure. The rapid mortality observed in larval and juvenile amphibians (e.g., within days of exposure) is a strong indication that Roundup is directly and highly toxic to these species. Similarly, Smith (2001) concluded that exposure to "relatively low concentrations for a short period of time, as might be expected…with an application to clear aquatic vegetation, appears to induce high mortality in tadpoles." Larval *Pseudacris triseriata* survival was reduced to 45% following exposure to 1 ppb Kleeraway® glyphosate product, and higher concentrations (e.g., 1 ppm and greater) resulted in complete mortality of exposed larvae. In addition, toxicity of formulated products was found to be strongly associated with glyphosate formulation and the potency of adjuvants; formulations containing POEA (e.g., Kleeraway®, Roundup, Touchdown®) were much more toxic to aquatic amphibian life stages (Smith 2001).

Exposure to formulated glyphosate products also has been documented to cause a number of sublethal effects in amphibian species. *Rana pipiens* larvae chronically exposed to both POEA and commercial glyphosate formulations containing POEA exhibited tail damage, gonadal abnormalities, and increased time to metamorphosis (Howe et al. 2004). Tail damage can decrease swimming ability and increase availability to predators, while physical abnormalities and delayed metamorphosis may prevent mating and reproduction.

Data presented in Solomon et al. (2005) concerning the toxicity of glyphosate, Roundup formulations, and glyphosate + Cosmo Flux provide specific insight into the toxicity of the formulation used in Colombia. These data indicate that the toxicity to aquatic biota of the formulation used in Colombia is substantially greater than the toxicity of glyphosate alone, or that of other formulations. Despite the toxicity of the spray, these data may actually underestimate the toxicity of the formulation used in the aerial spraying program prior to 2003, when a change was reported in the surfactant blend.

Figure 4 presents the distribution of toxicity values. The most toxic values are located on the left side of the graph, because the lower the toxic concentration the higher the toxicity. The lines running through the various data reflect the distribution in the sensitivity of species exposed to the same types of materials. The most sensitive species are lower and to the left on each of the lines. The figure shows three different lines. The one on the far right, in violet, is for glyphosate alone. The units of toxicity are expressed as LC50s, which indicate the exposure concentration at which 50 percent of the exposed organisms would die. Note that because an LC50 is a mid-point and relates to lethality, toxic effects of the herbicides occur at even lower concentrations. The figure clearly indicates that glyphosate alone is less toxic to aquatic organisms than are the formulations.

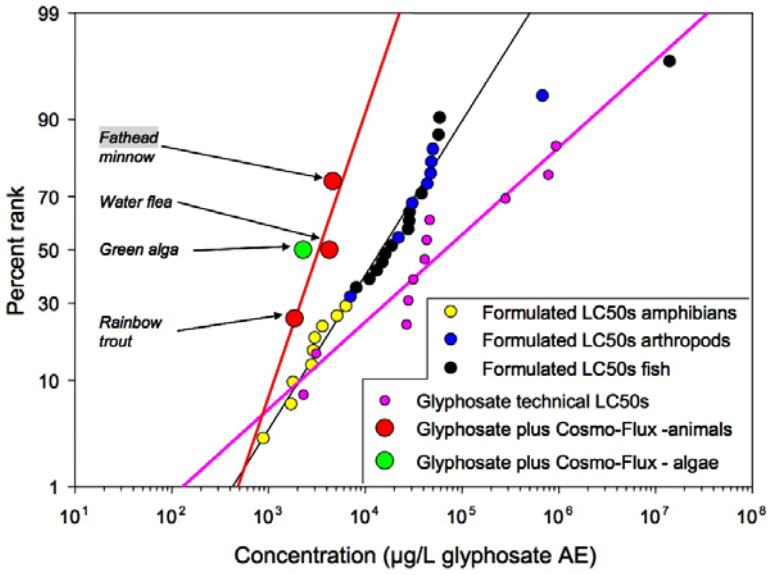


Figure 24 Distribution of toxicity values for glyphosate technical, formulated glyphosate (Roundup®) in all aquatic organisms and in fish and the glyphosate and Cosmo-Flux® 411 mixture as used in Colombia

Figure 4. Reproduction of Figure 24 from Solomon et al. (2005), page 70

The dark line in the middle links toxicity data for species tested with herbicide formulations, but not that used in Colombia. Because this line is further to the left of the violet line for glyphosate alone, the line indicates that these formulations are more toxic to aquatic biota than glyphosate alone. The formulations' increased toxicity to aquatic biota is well known and is related to the additives.

The line in the middle also shows that amphibians (larval frogs) are even more sensitive to the formulations than are fish or aquatic arthropods (small crustaceans). This is revealed by the presence of yellow circles on the left and lowest portion of the formulation line. Larval frogs are at least 10 times as sensitive to the toxic effects of formulations as fish or arthropods.

The test data for glyphosate + Cosmo Flux are on the most left-hand side of the graph, indicating that this formulation is the most toxic one tested on aquatic life. The test data shown by Solomon et al. (2005) include fish, arthropods, and algae. This data set does not include results for larval frogs. Based on the sensitivity distribution observed for other formulations, had larval frogs been tested with glyphosate + Cosmo Flux, even lower lethal concentrations would have been derived. It is unfortunate that data are not available for larval frogs, because these are clearly the most sensitive species and are a group of special interest with respect to the biodiversity of Colombia and Ecuador. If the toxicity of the glyphosate + Cosmo Flux formulation to larval frogs is 10 times as great as that for fish such as the rainbow trout, then the toxic values for these species would be in the range of 100 to 200 µg/L.

Solomon et al. (2005) conclude, based on their experience, that Cosmo-Flux was the likely cause of the increased toxicity of the glyphosate + Cosmo Flux formulation. The toxicity results summarized by Solomon et al. (2005) are tied to dilution concepts and are expressed as concentrations in water. As discussed later in this report, this exposure metric is appropriate for aquatic environments, and those can include the small pockets of water used by many neotropical frog species. However, as discussed later, the eggs, larvae, and adults of many rainforest frogs could be exposed to full-strength herbicide when the animals are in terrestrial habitats. This exposure would involve deposition of spray droplets on egg masses, developing larvae being transported by adults, juvenile frogs undergoing metamorphosis, and adult frogs. Those exposure concentrations would be orders of magnitude greater than the exposure amounts that cause death in the studies presented by Solomon et al. (2005).

Frogs are also considered to reflect the biodiversity of the Amazonian rainforest. They are the aquatic animal group considered by Solomon et al. to be most sensitive to herbicide spray (Solomon et al. 2005, p. 71). For the assessment of potential ecological effects on aquatic animals, Solomon et al. (2005) relied on a North American and European framework for considering ecological effects on aquatic species such as frogs. However, this framework misses important exposure pathways associated with the ecological characteristics of many frog species in the tropics. Solomon et al. assume that effects to animals commonly thought of as "aquatic" occur solely in open water bodies (Solomon et al. 2005, Section 3.1.4):

> If water is directly over-sprayed during a spray operation, contamination of surface waters will result. Some coca fields are located near to ponds and lakes and some are near to streams and rivers (Helling 2003). While surface waters are not deliberately sprayed by the pilots, some over-spray of small watercourses and the edges of ponds, reservoirs, and lakes may occur. In the absence of measured concentrations immediately after spraying in surface waters located close to the fields, estimates of exposure were made using worst-case assumptions (Table10) based on water depth assumptions used by U.S. EPA (Urban and Cook 1986) and the EU (Riley et al. 1991).

Many neotropical frogs have life histories that are completed in whole or in part within terrestrial systems. As a result, eggs, larvae, and adults of these species can experience exposures associated with spraying that are much greater than those assumed by studies such as Solomon et al. (2005), which assumed that worst-case exposures take place in shallow surface waters where the chemicals are somewhat diluted. This can include direct contact of animals with spray droplets (no dilution) and/or minimal dilution because of the small pockets of water that can support frogs of the Amazonian rainforest.

The limitations of the conceptual exposure model applied by Solomon et al. (2005) have been pointed out by others, including the Interamerican Association for Environmental Defense (AIDA 2005). Solomon et al. (2005) missed ecologically important exposure pathways, because a temperate climate exposure framework was applied to a tropical environment. Given the complexity of tropical habitats, other exposure scenarios not explored in Solomon et al. (2005) could be critical in determining the total impact of glyphosate-containing products on amphibian populations. For instance, the larvae of several tropical frog species have been documented inhabiting tree hollows and associated bromeliads (McDiarmid and Foster 1975;

Savage 1968; Starrett 1960); it is possible that these tadpoles could be exposed to high concentrations of glyphosate-containing compounds, either through direct dermal contact or by concentration of sprayed compounds in the tiny pools they inhabit.

All frogs have an egg, larval (tadpole), and adult life stage. In North America and Europe, the eggs and tadpoles occur primarily in ponds and other water bodies. They are typically considered "aquatic." However, in the tropics, many frogs complete their entire life in the terrestrial environment, and the adults are entirely terrestrial. Examples include a diverse group of frogs commonly known as the poison arrow frogs (subfamily Colostethinae; several members of this subfamily have been found in the Ecuador/Colombia border region, including *Ameerega bilinguis*, *A. picta, A. trivittata, and E. boulengeri*). These tiny frogs are basically black with bright markings of red, green, orange, or yellow. Most poison arrow frogs live on the ground in the leaf litter. The frog's eggs are usually laid on a leaf, and when they have hatched, the female allows the tadpoles to climb, one at a time, onto her back (Figure 5).

Figure 5. Adult poison dart frogs with tadpoles on their backs

The parent can let the larvae wriggle off into a pool of water, where they feed on mosquitoes and insect eggs. However, some carry their tadpoles up into trees to protect them from danger. There are a number of reports of frogs using small pockets of water present in trees. These include the cavities provided by bromeliad plants that grow attached to trees (see Figure 6). These bowl-shaped plants can hold water, and they play an important ecological role (Zahl 1975).

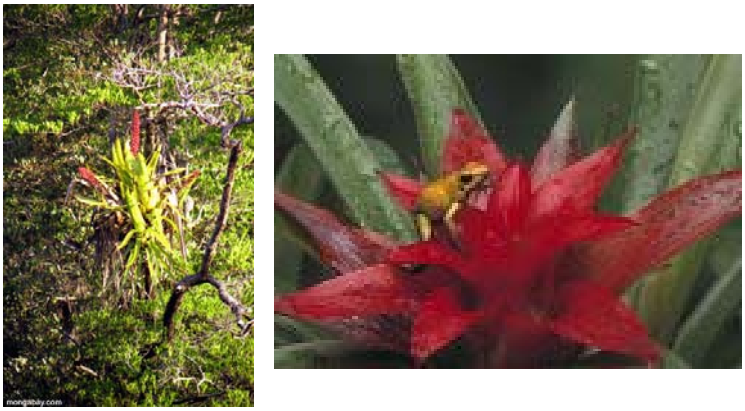


Figure 6. Bromeliads plants provide habitat and water for certain tree frogs

Several subfamilies of neotropical frogs lay their eggs in terrestrial, rather than aquatic, environments (Heying 2008; Lynch 2008; Cisneros-Heredia and McDiarmid 2007). In these locations, the adults, eggs, and hatching larvae would be directly exposed to spray without the benefit of dilution by water. One subfamily, the Leptodactylinae, is primarily terrestrial, foam-nest-building frogs. The males secrete mucus from their skin and reproductive tracts, which they then beat into foam with their legs. Mature individuals produce nests that protect the young from desiccation and other physical risks. In several species, a parent remains with the non-feeding tadpoles at the nest.

Another subfamily, the Centrolenidae, is composed of arboreal frogs endemic to America. They occupy riverine, understory, and canopy layers of evergreen and semi-deciduous forest, rainforests, cloud forests, and páramo habitats from southern Mexico to Panama and through the Andes from Venezuela to Bolivia, with species in the Amazon basin (Cisneros-Heredia and McDiarmid 2007). These frogs are commonly referred to as glass frogs, because many species have a transparent ventral skin through which the internal organs are visible. As far as is known, all species of this frog subfamily lay their egg clutches either on leaves overhanging water or on stones next to streams or waterfalls. Furthermore, many of these frog species exhibit parental care behaviors. For example, the male may remain nearby, next to, or even straddling the egg clutches located on the upper or underside of leaves or on rocks (usually at night but in some species during day and night), sometimes for considerable periods. Cisneros-Heredia and McDiarmid (2007) note that the clutches are usually placed on exposed surfaces, allowing hatching tadpoles direct access to water. If a male is successful in attracting females to the site, he may continue to attend the clutches until all have hatched (see Figure 7). In some instances, this may continue for a few weeks, depending on the periodicity of female arrival. Under these conditions, guarding parents are subjected to extended stressful conditions (i.e., high levels of solar radiation, dry air currents, high temperatures) that may provoke high evaporative water loss (even in parents that retreat during the day, as they typically go to nearby leaves also located in exposed areas of the vegetation).

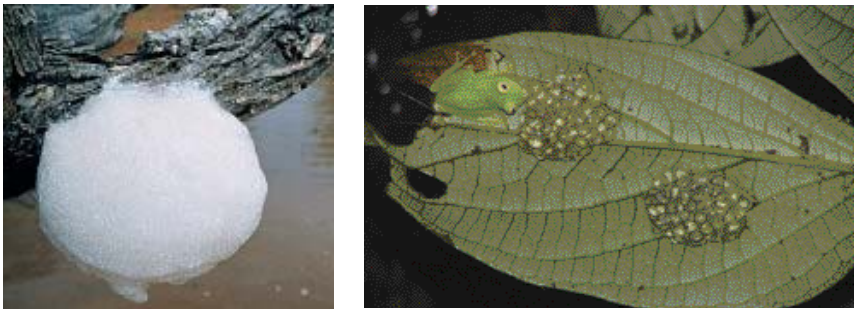


Figure 7. Eggs laid on plant surfaces and guarded by adults

Many neotropical frog species make use of puddles (including along roadsides) or man-made structures such as cisterns to lay their eggs. Tadpoles of the frog sub-families Khinophrynidae, Leptodactylidae, and Centkolenidae have been collected from these environs (Starrett 1960). Puddle environments and other manmade or natural pockets of water can have water depths and dilution volumes substantially smaller than those considered by Solomon et al. (2005). Therefore, the "worst-case" exposure estimates assumed by Solomon et al. for evaluating exposures to frog life stages, will underestimate actual exposures to sensitive frog life stages using puddles in locations below the spray drift. The underestimate of exposure to frogs by Solomon et al. (2005) is especially significant, because this group of animals appears to be particularly sensitive to the glyphosate + Cosmo-Flux formulation, as described above.

The toxicity results summarized by Solomon et al. (2005) are tied to dilution concepts and are expressed as concentrations in water. This exposure metric is appropriate for aquatic environments, which can include the small pockets of water used by many neotropical frog species. However, as already noted, the exposure concentrations in these small pockets of water can be greater than the worst-case assumption used by Solomon et al. (2005). Therefore, exposures can be higher, and the formulation more toxic to larval frogs living in small pockets of water, than assumed by Solomon et al. (2005).

Because many of the frogs species have one or more terrestrial life stages, there is also the potential that they will be exposed to full-strength herbicide formulation delivered as droplets falling directly upon them. And as they move across the plant surfaces, they would encounter additional herbicide droplets that have fallen upon these. Even at lower deposition rates, there could still be a large number of individual droplets falling upon surfaces.

Laboratory and field toxicity assays indicate that glyphosate-containing formulated products are highly toxic to several life stages and species of amphibians. Acute toxicity was shown to arise from concentrations similar to those following over-spray, and chronic effects on frog fitness include physical deformities and delayed development. Given their unique life histories

(e.g., development in bromeliads and tree hollows), it is likely that many tropical species may be exposed to much higher concentrations than those tested on North American species. As such, although tropical species have not been as thoroughly studied as temperate amphibians, it is likely that tropical populations are much more sensitive to the effects of glyphosate poisoning.

5.4 Hazards Associated with Misuse of Herbicide Products

The previous sections describe the hazards that arise from exposures to the chemicals in the herbicide mixture used in the Colombia aerial spray program. The likelihood of these hazards increases when herbicide products are misused. Because of the inherent hazards associated with herbicide and pesticide products, industry and government utilize labeling to communicate the possible hazards. Labels also describe how the products should be applied so that these hazards are reduced. In this section of the report, we first describe labeling guidelines. We then present the labels for the common constituents in the spray mixture used in Colombia.

In the U.S. and most countries, including Colombia, pesticides—including glyphosate-based herbicides and adjuvants—must be registered and labeled before the pesticide can be sold or distributed within the country. Pesticide labeling provides legally binding requirements to control when and under what conditions a pesticide can be applied, mixed, stored, loaded or used. Labels also prescribe when fields can be re-entered after application and when and how crops can be harvested. Labeling requirements are also imposed to specify what type of product containers must be used and how they should be disposed.

U.S. EPA pesticide legal labeling requirements are specified the Federal Insecticide, Fungicide, and Rodenticide Act, Section 2(p)(2). These regulations also cover all other written, printed, or graphic material accompanying a pesticide or application device. General pesticide labeling requirements and example statements for pesticide labels are set forth in the Code of Federal Regulations 40 CFR § 156.10 (http://www.epa.gov/oppfead1/labeling/lrm/2006-lrm-chap-03.pdf). Labels must include certain mandatory statements to ensure proper use:

> Mandatory statements generally relate to the actions that are necessary to ensure the proper use of the pesticide and to prevent the occurrence of unreasonable adverse effects on the environment, which is defined by statute. Mandatory statements include directions for use and precautions that direct the user to take or avoid specific actions. The directions and precautions specify where, when and how a pesticide is to be applied. Mandatory statements are generally written in imperative or directive sentences (e.g., "Wash application equipment...," "Do not use ...," "Users must...," "Apply to corn at a maximum rate of one to two pounds per acre 30 days prior to harvest"). Either EPA or the registrant may develop mandatory labeling statements. When writing mandatory statements, both EPA and the registrant need to ensure that such statements meet the criterion above that the statement is necessary to ensure proper use of a pesticide and to prevent unreasonable adverse effects on the environment. The following directions and precautions are examples of mandatory statements: *"Wear chemical resistant gloves." …"Do not apply directly to water." ..."Do not enter into treated*

> *areas for 12 hours." ...*"*Do not apply when wind speed exceeds 15 mph*." (EPA Label Review Manual p. 3-4.)

Many countries around the world have adopted similar regulations; some of them are modeled on U.S. EPA labeling rules. To help ensure greater international consistency (harmonization) of pesticide labels, U.S. EPA is supporting The Globally Harmonized System (GHS) of Classification and Labelling of Chemicals. The GHS is a worldwide initiative to promote standard criteria for classifying chemicals according to their health, physical, and environmental hazards. It uses pictograms, hazard statements, and the signal words "Danger," "Warning," and "Caution" to communicate hazard information on product labels and safety data sheets in a logical and comprehensive way. The primary goal of GHS is better protection of human health and the environment by providing chemical users and handlers with enhanced and consistent information on chemical hazards. GHS will provide a harmonized basis for the first step in the sound management of chemicals—identifying hazards and communicating them. (http://www.epa.gov/oppfead1/labeling/lrm/chap-12).

Harmonized registration and labeling requirements have also been developed at the regional level. The Andean Community has developed a common system for the registration and control of pesticides (Andean Community 1998), and regional labeling requirements (Andean Community 2002). The European Union (1991) has also developed a harmonized system for the regulation of pesticides, including labeling requirements.

As an example, Roundup SL, a glyphosate-based herbicide sold in Colombia, includes the following mandatory statements and pictograms:

> *Do not store or transport with seeds and food for human or animal consumption. Do not store in living areas. Keep locked in a dry and ventilated place in the original packaging. Use glasses, gloves, rubber boots and protective clothing during use and application. Do not smoke, eat or drink while preparing or applying this product. Rinse empty containers three times and empty them into the spray tank. Puncture and destroy the containers.* ***No container which has held pesticides should be used to store food or drinking water.*** *Apply under calm wind conditions. Avoid contact with eyes and skin. Causes irritation. Upon completion of work, change clothes and wash with plenty of soap and water. Do not contaminate water sources. Do not apply to or pour surplus product directly over water bodies. During application, avoid allowing the product to fall on leaves or green parts of the stems of crops. Suspend the application if rain is imminent.*

As described in Section 4, some product labels provide specific guidance regarding aerial spraying. For example, the label for Roundup Pro, a product marketed in the United States, includes the following precautions regarding spray drift management:

SPRAY DRIFT MANAGEMENT

AVOID DRIFT. EXTREME CARE MUST BE USED WHEN APPLYING THIS PRODUCT TO PREVENT INJURY TO DESIRABLE PLANTS AND CROPS.

Do not allow the herbicide solution to mist, drip, drift or splash onto desirable vegetation since minute quantities of this product can cause severe damage or destruction to the crop, plants or other areas on which treatment was not intended.

Avoiding spray drift at the application site is the responsibility of the applicator. The interaction of many equipment- and weather-related factors determines the potential for spray drift. The applicator and the grower are/is responsible for considering all these factors when making decisions.

Figure 8. Section 5.0 of label from Roundup Pro as sold in U.S.

The Roundup Pro label (Section 5.0) also provides specific guidance regarding factors that affect spray drift, including droplet size, wind, temperature, humidity, temperature inversions, and swath adjustment.

6 Bibliography of Relevant Literature

Affeld, K., K. Hill, L.A. Smith, and P. Syrrett. 2003. Toxicity of herbicides and surfactants to three insect biological control agents for *Cytisus scoparius* (Scotch broom). pp. 375−380. In: Proc. of the XI International Symposium on Biological Control of Weeds. Canberra, Australia, 27 April–2 May 2003.

AIDA. 2005. Rethinking Colombia's aerial spraying program: Critical omissions in the CICAD environmental and health assessment of the aerial eradication program in Colombia. Available at: www.aida-americas.org/templates/aida/uploads/ docs/AIDA_CICAD_ Critique.pdf. Asociación InterAmericana para la Defensa del Ambiente.

Amore, M., N. Zazzeri, and M. Montanari. 1992. Stress and spontaneous abortion. Stress Health 8(3):171−173.

Andean Community. 1998. Decision 436, Andean norms for the registration and control of chemical pesticides for agricultural use. A*vailable at* http://www.comunidadandina.org/normativa/dec/D436.htm

Andean Community. 2002. Resolution 630, Andean technical manual for the registration and control of chemical pesticides for agricultural use. *Available at* http://www.comunidadandina.org/normativa/res/R630sg.htm (click on link at bottom of page).

Arcos, C. Mueckay, Q. Celi, F. Bonilla, et al. 2005. Misión de verificación de al situación en la línea frontera del las Provincia de Sucumbíos, Ecuador—07 y 08 de Julio de 2005. Defensor del Pueblo de Ecuador, Quito, Ecuador.

ATSDR. 1997. Healthy children—toxic environments acting on the unique vulnerability of children who dwell near hazardous waste sites. Report of the Child Health Workgroup presented April 28, 1997 to the Board of Scientific Counselors. U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, Atlanta, GA.

Balfour, P.M. 1989. Effects of forest herbicides on some important wildlife forage species. FDRA Report. ISSN 0835-0752: 020. British Columbia Ministry of Environment.

Basch, P. 1999. Textbook of international health. Oxford University Press, New York, p 19.

Bashour, H. 2001. Psychological stress and spontaneous abortion. Int. J. Gynecol Obstetrics 73(2):179−181.

Basset, Y. 2008. Global ecology: Insect plant interactions in tropical rainforests. Available at: http://striweb.si.edu/basset/PdFs/Basset2008_Global_ecology.pdf. Smithsonian Tropical Research Institute, Panama.

Baylis, A.D. 2000. Why glyphosate is a global herbicide: Strengths, weaknesses and prospects. Pestic. Manage. Sci. 56:299−308.

Beyrle, H.F., S.E. Smith, R.L. Peterson, and C.M.M Franco. 1995. Colonization of *Orchis morio protocorms* by a mycorrhizal fungus: Effects of nitrogen nutrition and glyphosate in modifying the responses. Can. J. Bot. 73:1128−1140.

BINFLA. 2002. Report on issues related to the aerial eradication of illicit coca in Colombia. Available at: www.mindfully.org/Pesticide/2002/Eradication-Coca-Colombia-INLFASep02. Bureau for International Narcotics and Law Enforcement Affairs.

Bradberry, S.M., A.T. Proudfoot, and J.A. Vale. 2004. Glyphosate poisoning, review article. Toxicol. Rev. 23(3):159−167.

Breder, Jr., C.M. 1946. Amphibians and reptiles of the Rio Chucunaque drainage, Darien, Panama, with notes on their life histories and habits. Bull. Amer. Mus. Nat. Hist. 86(8):375−436.

Brooks, T., L. Hannah, G.A.B. da Fonesca, and R.A. Mittermeier. 2001. Prioritizing hotspots, representing transitions. Trends Ecol. Evol. 16:673.

California Department of Pesticide Regulation. 2009. Pesticide Illness Surveillance Program. *Available at* http://www.cdpr.ca.gov/docs/whs/pisp.htm.

Campbell, A., and M. Chapman. 2000. Handbook and poisoning in dogs and cats. Blackwell Sciences, Oxford, UK.

Chakravarty, P., and S.S. Sidhu. 1987. Effect of glyphosate, hexazinone, and triclopyr on *in vitro* growth of five species of ecotmycorrhizal fungi. Eur. J. For. Pathol. 17:204−210.

Chan, E.K.W, Y. Zhang, and D. Dudgeon. 2007. Contribution of adult aquatic insects to riparian prey availability along tropical forest streams. Mar. Freshwat. Res. 58:725−732.

Chen, L., and N. Scrimshaw (Eds). 1983. Diarrhea and malnutrition: Interactions, mechanisms, and interventions. Plenum Press, New York.

Cisneros-Heredia, D.F., and R.W. McDiarmid. 2007. Revision of the characters of Centrolenidae (Amphibia: Anura: Athesphatanura), with comments on its taxonomy and the description of new taxa of glassfrogs. *Zootaxa* 1572. Magnolia Press, Auckland, New Zealand.

Cohen, M. 2007. Environmental toxins and health impacts of pesticides. Aust. Fam. Physician 36(12):1002−1004.

Coley, P.D., and J.A. Barone. 1996. Herbivory and plant defenses in tropical forests. Ann. Rev. Ecol. Syst. 27:305−335.

Collins, R. 1998. Glyphosate aerial application to control *Erythroxylum* sp. In: Colombia Spray Droplet Evaluation. U.S. Department of Agriculture, Weed Science Laboratory Agricultural Research Service, Beltsville, MD.

Collins, R. 2000. Comparison of the control of *Erythroxylum coca var coca* by the best surfactants from research between 1995 and 1997 along with surfactants testing in Colombia and Rage with Roundup Ultra.

Collins, R.T., and C.S. Helling. 2002. Surfactant-enhanced control of two *Erthroxylum* species by Glyphosate. Weed Technol. 16: 851-859.

Comisión Intenacional. 2001. Informe técnico de la comisión internacional sobre los impacots en territorio ecuatoriano de las fumigaciones aéreas en Colombia y recomendaciones de las organizaciones indígenas, campesinas, y sociales. Quito, Ecuador.

Cosmoagro. 2003. Material safety data sheet for Cosmo-Flux 411F.

Coupland, D. 1984. . Metabolism of glyphosate in plants. pp. 25−34. In: The Herbicide Glyphosate. E. Grossbard and D. Atkinson (eds). Butterworths, London.

Cowles, R.S., E.A. Cowles, A.M. McDermott, and D. Ramoutar. 2000. "Inert" formulation ingredients with activity: Toxicity of trisiloxane surfactant solutions to twospotted spider mites (Acari: Tetranychidae). J. Econ. Entomol. 93:180−188.

Cox, C. 1995. Glyphosate fact sheets, Glyphosate, Part 1: Toxicology. J. Pestic. Ref. 15:1−27.

Cserhati, T., E. Forgacs, and G. Oros. 2002. Biological activity and environmental impact of anionic surfactants. 396 Environ. Int. 28:337−348.

Currier, W.W., G.B. Maccollom, and G.L. Baumann. 1982. Drift residues of air-applied carbaryl in an orchard environment. J. Econ. Entomol. 75:1062−1068.

de Ruiter, H., A.J.M. Uffing, and E. Meinen. 1996. Influence of surfactants and ammonium on glyphosate phytotoxicity of quackgrass (*Elytrigia repens*). Weed Technol. 10(4):803−808.

Diamond, G.L., and P.R. Durkin. 1997. Effects of surfactants on the toxicity of glyphosate, with specific reference to RODEO. SERA TR 97-206-1b. Prepared for Animal and Plant Health Inspection Service. Syracuse Environmental Research Associates.

Dick, C.W., G. Etchelecu, and F. Austerlitz. 2003. Pollen dispersal of tropical trees (*Dinizia excelsa*: Fabaceae) by native insects and African honeybees in pristine and fragmented Amazonian rainforest. Mol. Ecol. 12:753−764.

Dunn, E.R. 1941. Notes on *Dendrobates auratus.* Copeia 1941:88–93.

Eberbach, P.L., and L.A. Douglas. 1989. Herbicide effects on the growth and nodulation potential of *Rhizobium trifolii* with *Trifolium subterraneum* L. Plant and Soil 119:15−23.

Erwin, T.L. 1982. Tropical forests: Their richness in Coleoptera and other arthropod species. Coleopterists Bulletin. 36:74−75.

Estok D., B. Freedman, and D. Boyle. 1989. Effects of the herbicides 2,4-D,glyphosate, hexazinone, and triclopyr on the growth of three species of ectomycorrhizal fungi. Bull. Environ. Contam. Toxicol. 42:835−839.

Estrada, A., and R. Coates-Estrada. 2001. Species composition and reproductive phenology of bats in a tropical landscape at Los Tuxlas, Mexico. J. Trop. Ecol. 17: 627−646.

European Union. 1991. Council Directive 1991L0414 (15 July), Article 3, para. 3 (requiring European Union Member States to ensure proper use of pesticides, including compliance with labeling requirements). *Available at* http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:1991L0414:20051201:EN:PDF; DIRECTIVE 1999/45/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL, concerning the approximation of the laws, regulations, and administrative provisions of the Member States relating to the classification, packaging, and labeling of dangerous preparations (31 May 1999), *available at* http://ecb.jrc.it/legislation/1999L0045EC.pdf

FIDH, FIAN, RAPAL, OCIM, CEAS, and CIF. 2005. Observaciones de la misión internacional a la frontera ecuatoriana don Colombia: 20, 21, y 22 de junio del 2005. Mision Internacional a la Frontera ecuatoriana con Colombia. Quito, Ecuador

Folmar, L.C., H.O. Sanders, and A.M. Julin. 1979. Toxicity of the herbicide glyphosate and several of its formulations to fish and aquatic invertebrates. Arch. Environ. Contam. Toxicol. 8:296−278.

Franz, J.E., K.M. Michael, and J.A. Sikorski. 1997. Glyphosate: A unique global herbicide. ACS Monograph 189. American Chemical Society, Washington, DC.

Gaskin, R.E., and P.J. Holloway. 1992. Some physicochemical factors influencing foliar uptake enhancement of glyphosatemono(isopropylammonium) by polyoxyehtylene surfactants. Pestic. Sci. 34:195−206.

Geiger, D.R., S.W. Kapitan, and M.A. Tucci. 1986. Glyphosate inhibits photosynthesis and allocation of carbon to starch in sugar beet species. Plant Physiol. 82:468−472.

General Accounting Office. 2004. July 2004 drug control aviation program safety concerns in Colombia are being addressed, but State's planning and budgeting process can be improved.

Giesy J.P., S. Dobson and K.R. Solomon. 2000. Ecotoxicological risk assessment of Roundup® herbicide. Rev. Environ. Contam. Toxicol. 167:35−120.

GOC. 2003. Environmental management plan for the illicit crop eradication program using aerial spraying with the herbicide glyphosate (ICEPG). Available at: www.state.gov/p/inl/rls/rpt/aeicc/27399.htm. Government of Colombia.

Goldstein DA, Acquavella JF, Mannion RM, Farmer DR (2002). An analysis of glyphosate from the California Environmental Protection Agency Pesticide Illness Surveillance Program. J Toxicol Clin Toxicol 40(7):885-92.

Goodwin, R.M., and H.M. McBrydie. 2000. Effect of surfactants on honey bee survival. New Zealand Plant Protect. 53: 30−234.

Gosner, K.L. 1960. A simplified table for staging anuran embryos and larvae with notes on identification. Herpetologica 16:183–190.

Grossbard, E., and D. Atkinson. 1985. The herbicide glyphosate. Butterworths, London. 490 pp.

Grosscurt, A.C., and B. Jongsma. 1987. Mode of action and insecticidal properties of diflubenzuron. In: Chitin and Benzoylphenyl Ureas. J.E. Wright and A. Retnakaran (eds). DR W. Junk Publishers, Dordrecht, The Netherlands.

Guiseppe, K.F.L., F.A. Drummond, C. Stubbs, and S. Woods. 2006. The use of glyphosate herbicides in managed forest ecosystems and their effects on non-target organisms with particular reference to ants as bioindicators. Technical Bulletin 192. University of Maine, Maine Agricultural and Forest Experiment Station.

Helling, C.S., and M.J. Camp. Date unknown. Verifying coca eradication effectiveness in Colombia.

HERA. 2005. Human and environmental risk assessment on ingredients of European household cleaning products. Alcohol ethoxylates. Human & Environmental Risk Assessment.

Heying. 2008. *Mantella laevigata*. Available at: www.bamboofrog.org/research.htm.

Hill, A.B. 1965. The environment and disease: Association or causation? Proc. Royal Soc. Med. 58:295–300.

Hislop, R.G., and R.J. Prokopy. 1981. Integrated management of phytopahgous mites in Massachusetts (USA) apple orchards. 2: Influence of pesticides on the predator mite *Amblyseius fallacius* (Acarina: Phytoseiidae) under laboratory and field conditions. Protect. Ecol. 3:157−172.

Howe C.M., M. Berrill, B.D. Pauli, C. Helbing, K. Werry, and N. Verldhoen. 2004. Toxicity of glyphosate-based pesticides to four North American frog species. Environ. Toxicol. Chem. 23: 1928-1938

Jackson, R.E., and H.N. Pitre. 2004. Influence of Roundup Ready soybean production systems and glyphosate application on pest and beneficial insects in narrow-row soybean. J. Agri. Urban Entomol. 21:61−70.

Johal, G.S., and J.E. Rahe. 1988. Glyphosate, hypersensitivity and phytoalexin accumulation in the incompatible bean anthracnose host-parasite interaction. Physiol. Mol. Plant Pathol. 32:267−281.

Jones, D.T., F.X.Susilo, D.E. Bignell, and H. Suryo. 1998. Species richness, functional diversity, and relative abundance of termites under differen land use regimes. In: The Insects: Structure and Function. R.F. Chapman (ed). The Cambridge University Press.

Kearney, P.D., and D.D. Kaufman. 1976. Herbicides. Volumes 1, 2, and 3. Dekker, New York.

Las Palmas Technical Department. 2004. Glyphosate (10.4L/Ha) and three adjuvants, for the control of illicit coca crops (*Erythroxyllum* spp.): Agronomic efficacy testing of doses of glyphosate on illicit crops. Final Report. Bogotá, Colombia.

Levey, D.J., and M.M. Byrne. 1993. Complex ant-plant interactions: rainforest ants as secondary dispersers and post-dispersal seed predators. Ecology 74:1802−1812.

Lynch, J.D. 2008. *Osteocephalus planiceps* Cope (Amphibia: Hylidae): Its distribution in Colombia and significance. Rev. Acad. Colomb. Cienc. 32(122):87−91.

Maibach, H.I. 1986. Irritation, sensitization, photo irritation and photosensitic assays with glyphosate herbicide. Contact Dermititis 15 152−156.

Maldonado, A., L. Gallardo, T. Alvarez, et al. 2002. Informe de verificación: "Impactos en Ecuador de las fumigaciones realizadas em el Putumayo dentro del Colombia's aerial spraying program—Octubre 2002. Acción Ecologica, Quito, Ecuador.

Mann, R., and J. Bidwell. 1999. Toxicological issues for amphibians in Australia. pp. 185−201. In: Declines and Disappearances of Australian Frogs. A. Campbell (ed). Environment Australia, Canberra.

McDiarmid, R.W., and M.S. Foster. 1975. Unusual sites for two neotropical tadpoles. J. Herpetol. 9:264−265.

Menzie, C.A., M.M. MacDonell, and M. Mumtaz. 2007. A phased approach for assessing combined effects from multiple stressors. Environ. Health Perspect. 115(5):807–816.

Messina, J., and P. Delamater. 2006. Defoliation and the war on drugs in Putumayo, Colombia. Int. J. Remote Sensing 27(1)121:128.

Ministerio de Ambiente, Ministerio de Agricultura y Ganadería, Consejo Provincial de Sucumbíos, et al. 2003. Segundo Informe de la Misión de Verificación: Impactos en el Ecuador de las fumigaciones realizadas en el Departamento del Putumayo dentro del Colombia's aerial spraying program—julio, 2003.

Monnig, N., and K.W. Bradley. 2008. Impact of fall and early spring herbicide applications on insect populations and soil conditions in no-till soybeans. Crop Protect. 27:143−150.

Municipality of Valle de Guamez. 2001. Consolidated account of losses from fumigations through February 21, 2001. Department of Putumayo, Municipal Police Inspection.

Municipal Police Inspector. 2001. General summary of losses due to fumigation through 21 February 2001. Luz Angela Pabón, España, Valle de Guamuez, Putumayo, Colombia.

Murillo, T., and L.F. Jiron. 1994. Egg morphology of *Anastrepha obliqua* and some comparative aspects with eggs of *Anastrepha fraterculus* (Diptera: Tephritidae). Florida Entomol. 77:342−348.

Murray, J.A., and L.M. Vaughan. 1970. Measuring pesticide drift at distances to four miles. J. Appl. Meteorol. 9:79−85.

Myers, N. 1988. Threatened biotas: "Hot spots" in tropical forests. The Environmentalist 8:187−208.

Myers, N., R.A. Mittermeier, C.G. Mittermeier, G.A.B da Fonesca, and J. Kent. 2000. Biodiversity hotspots for conservation priorities. Nature 403:853−858.

Nalewaja, J.D., and R. Matysiak. 1992. Species differ in response to adjuvants with glyphosate. Weed Technol. 6(3):561−566.

Nason, J.D., E.A. Herre, and J.L.Hamrick. 1998. The breeding structure of a tropical keystone plant resource. Nature 391:685–687.

Nelson, S.C. 2008. Personal communication (telephone conversation with P. Booth and D. Rowan, Exponent, Bellevue, WA, on January 25, 2008, regarding effects of glyphosate on tropical crops). University of Hawaii at Manoa, College of Tropical Agriculture and Human Resources, Department of Plant and Environmental Protection Sciences, Hilo, HI.

Neumann, G., S. Kohls, E. Landsberg, K. Stock-Oliveira Souza, T. Yamada, and V. Rohmnel. 2006. Relevance of glyphosate transfer to non-target plants via the rhizosphere. J. Plant Dis. Protect. Special Issue 20: 963-969.

O'Day, W.T. 1967. Some aspects of the breeding biology of dendrobatid frogs. Org. Trop. Stud., Student Res. Rpt., Fundamentals Course, July–August 1967.

Oliveira, A.G., L.F. Telles, R.A. Hess, G.A.B. Mahecha, and C.A. Oliveira. 2007. Effects of the herbicide Roundup on the epididyman region of *Drakes Anas platyrhynchos*. Reprod. Toxicol. 23(2):182−191.

ONU. 2006. Informe de la mission técnica preliminary de naciones únidas para proponer estudios sobre el impoacto de las aspersionse aéreas y acciones complementarias en la frontera norte de Ecuador. Quito, Ecuador, Quito, Ecuador, abril de 2006.

Orians, G.H., and D.R. Paulson. 1969. Notes on Costa Rican birds. Condor 71:426–431.

Pastoral Social. 2007. Impacto de las fumigaciones en la zona de frontera Colombia-Ecuador: Misión de observación realizada por la Pastoral Social de al Iglesia de San Miguel de Sucumbíos, ISAMIS-Ecuador y Pasotral Social del a Diócesis de Mocoa-Sibundoy, Putumayo.

Payne, N. 1992. Off-target glyphosate from aerial silviculture applications and buffer zones required around sensitive areas. Pestic. Sci. 34:1–8.

Price, P.W., I.R. Diniz, H.C. Morais, and E.S.A. Marques. 1995. The abundance of insect herbivore species in the tropics: the high local richness of rare species. Biotropica. 27:468−478.

Reigart, J.R., and J.R. Roberts. 1999. Recognition and management of pesticide poisonings. Fifth Edition. Available at: www/epa.gov/pesticides/safety/healthcare. Accessed April 9, 2009. U.S. Environmental Protection Agency, Office of Pesticide Programs, Washington DC.

Relyea, R.A. 2005. The lethal impact of Roundup on aquatic and terrestrial amphibians. Ecol. Appl. 15(4):1118−1124.

Robinson, E., and L.F. Fox. 1978. 2,4-D herbicides in central Washington. Air Pollut. Cont. Assoc. 28(10):1015−1020.

Savage, J.M. 1968. The dendrobatid frogs of Central America. Copeia 1968:745–776.

Semba, R., and M. Bloem. 2000. Nutrition and health in developing countries. Humana Press, Totowa, NJ, p. 19.

Shapiro, J.P., W.J. Schroeder, P.A. and Stansly. 1998. Bioassay and efficacy of *Bacillus thuringiensis* and an organosilicone surfactant against the citrus leafminer (Lepidoptera: Phyllocnistidae). Florida Entomol. 81:201−210.

Sicard, T.L., J. Salcedo, C. Pérez, C. Baquero, C. Rojas, and C, Hernández. 2005. Observaciones al Estudio de los Efectos del Programa de Erradicación de Cultivos Ilícitos Mediante la Aspersion Aéreac con el Herbicida Glifosato (PECIG) y de los Cultivos Ilícitos en la Salud Humana y en el Medio Ambiente. Universidad Nacional de Colombia, Instituto de Estudios Ambientales (IDEA). Bogotá, Colombia

Smith, G. R. 2001. Effects of acute exposure to a commercial formulation of glyphosate on the tadpoles of two species of anurans. Bulletin of Contamination and Toxicology **67**:483–488.

SNUE. 2004. La frontera norte del Ecuador: Evaluación y recomendaciones de la misión interagencial del sistema de las Naciones Unidas en Ecuador. Sistema de las Naciones Unidas en el Ecuador, Quito, Julio de 2004. Quito, Ecuador

Solomon, K.R., A. Anadón, A.L. Cerdeira, J. Marshall, and L-H. Smith. 2005. Environmental and human health assessment of the aerial spray program for coca and poppy control in Colombia. Prepared for the Organization of Amercian States, Inter-American Drug Abuse Control Commission, Washington, DC.

Springborn. 2003. Purity analysis for glyphosate of spray-Charlie (active ingredient). SLI Study No. 3596.15. March 21, 2003. Springborn Laboratories.

Starrett, P. 1960. Descriptions of tadpoles of middle American frogs. University of Michigan, Museum of Zoology, Ann Arbor, MI.

Taylor, E.H. 1942. Tadpoles of Mexican anura. Univ. Kansas Sci. Bull. 28:37–55.

Temple, W.A., and N.A. Smith. 1992. Glyphosate herbicide poisoning experience in New Zealand. New Zealand Med. J. 105:173−174.

Tenuta, M., and E.G. Beauchamp. 1996. Denitrification following herbicide application to a grass sward. Can. J. Soil Sci. 76:15−22.

Teske, M.E., and H.W. Thistle. 2003. AGDISP version 8.07 user manual. C.D.I. Technical Note No. 02-06. June.

Tipping, C, V. Bikoba, G.J. Chander, and E.J. Mitcham. 2003. Efficacy of Silwet L-77 against several arthropod pests of table grape. J. Econ. Entomol. 96:246−250.

Tosi, Jr., J.A. 1969. Republica de Costa Rica, mapa ecologico. Centro Cientifico Tropical, San Jose, Costa Rica.

Tsui, M.T., and L.M. Chu. 2003. Aquatic toxicity of glyphosate-based formulations: Comparison between different organisms and the effects of environmental factors. Chemosphere 52:1189−1197.

UNODC and GOC. 2003. Colombia: Coca survey for December 2002 and semi-annual estimate for July 2003. Available at: www.unodc.org/pdf/publications/colombia_report_2003-09-25.pdf. Accessed January 29, 2008. United Nations Office on Drugs and Crime and the Government of Colombia.

UNODC and GOC. 2006. Colombia: Coca cultivation survey for 2006. Available at: www.unodc.org/pdf/research/icmp/colombia_2006_en_web.pdf. Accessed February 18, 2008. United Nations Office on Drugs and Crime and the Government of Colombia.

UN Special Rapporteur on the right of everyone to the enjoyment of the highest attainable standard of physical and mental health, Preliminary note on the mission to Ecuador and Colombia, Addendum (4 Mar. 2007), p. 4 [6.10].

U.S. Congress. 1990. Beneath the bottom line: Agricultural approaches to reduce agrichemical contamination of groundwater. Report No. OTA-4-418 Available at: www.princeton.edu/~ota/disk2/1990/9006/9006.PDF. U.S. Congress, Office of Technology Assessment. U.S. Government Printing Office, Washington, DC.

U.S. Department of Agriculture. 2001. April 2001 Colombia coca eradication verification mission trip report (13 June 2001). U.S. Department of Agriculture.

U.S. Department of State. 2002a. Report on issues related to the aerial eradication of illicit coca in Colombia: Chemicals used for the aerial eradication of illicit coca in Colombia and conditions of application. Available at: http://www.state.gov/p/inl/rls/rpt/aeicc/13234.htm. U.S. Department of State.

U.S. Department of State. 2002b. Report on issues related to the aerial eradication of illicit coca in Colombia. Department of State's comments on EPA August 19, 2002 letter. Available at: http://www.state.gov/p/inl/rls/rpt/aeicc/13249.htm. U.S. Department of State.

U.S. Department of State. 2003. Updated report on chemicals used in the Colombian aerial eradication program. Available at: http://www.state.gov/p/inl/rls/rpt/aeicc/26581.htm. U.S. Department of State.

U.S. EPA. 1989. Risk assessment guidance for Superfund: Volume I. Human health evaluation manual (Part A). Interim Final. Available at: //www.epa.gov/oswer/ riskassessment/ragsa/pdf/rags-vol1-pta_complete.pdf. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC.

U.S. EPA. 1997. Ecological risk assessment guidance for Superfund: Process for designing and conducting ecological risk assessments. Interim Final. EPA 540-R-97-006. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC.

U.S. EPA. 2002. Responses from EPA Assistant Administrator Johnson to Secretary of State, August 19, 2002. Available at: www.state.gov/p/inl/rls/rpt/aeicc/13237.htm#section1. U.S. Environmental Protection Agency.

U.S. EPA. 2003a. Framework for cumulative risk assessment. Risk Assessment Forum. Washington, DC 20460EPA/630/P-02/001F

U.S. EPA. 2003b. Details of the 2003 consultation for the Department of State. Use of pesticide for coca and poppy eradication program in Colombia. Available at: www.state.gov/documents/ organization/27516.pdf. U.S. Environmental Protection Agency, Office of Pesticides Program.

U.S. EPA. 2006. Inert reassessments: Five exemptions from requirement of a tolerance for petroleum hydrocarbons. Available at www.epa.gov/opprd001/inerts/decisiondoc. U.S. Environmental Protection Agency.

U.S. EPA. 2009. Children's health protection. Available at: yosemite.epa.gov/ochp/ ochpweb.nsf/content/homepage.htm. Accessed April 9, 2009. U.S. Environmental Protection Agency.

Vargas, R. 2005. A few comments about the OAS-CICAD study of the impact of glyphosate used in the eradication of illicit crops in Colombia. Available at: http://www.tni.org/ detail_page.phtml?page=archives_vargas_cidad. Transnational Institute: Drugs & Democracy.

Westra, P., and H.F. Schwartz. 1989. Potential herbicide volatility and drift problems on dry beans. Service in Action. Colorado State University Cooperative Extension.

Williams, N, 2001. Criticism of Colombia' s drug war looms as U.S. talks near. Atlanta Journal-Constitution, February 25.

Wilson, S. 2001. Aerial attack killing more than coca. Washington Post, January 7.

WHO. 2005. Environmental Health Criteria Document No. 159: Glyphosate (1071-83-6). Available at: http://www.inchem.org/pages/ehc.html. Updated January 28, 2005. World Health Organization.

WHO. 2009. Introduction to the 3rd WHO international conference on children's health and the environment: From research and Knowledge into policy and action. June 7−10, 2009, Busan, Republic of Korea. Available at: www.ceh2009.org/. Accessed April 9, 2009. World Health Organization.

Wolfenbarger, D.A., M.J. Lukefahr, and W.L. Lowry. 1967. Toxicity of surfactants and surfactant-insecticide combinations to the bollworm, tobacco budworm, and pink bollworm. J. Econ. Entomol. 60:902−904.

Young, B.E., S.N. Stuart, J.S. Chanson, N.A. Cox, and T.M. Boucher. 2004. Disappearing jewels: The status of New World amphibians. NatureServe, Arlington, VA.

Zahl, P.A. 1975. Secret worlds inside plants. National Geographic.

ANNEX 158

Exponent®

Attachment A

ANNEX 158

Exponent
15375 SE 30th Place
Suite 250
Bellevue, WA 98007

telephone 425-519-8700
facsimile 425-519-8799
www.exponent.com

Pieter N. Booth
Principal

Professional Profile

Mr. Pieter Booth is a Principal in Exponent's EcoSciences practice. He has 28 years of experience as an environmental scientist and program manager specializing in ecotoxicology and risk assessment, natural resource damage assessment (NRDA), and restoration of natural systems. Mr. Booth is nationally recognized for his NRDA work, particularly his role in technical negotiations on behalf of industry for favorable restoration-based settlement at several of the largest NRDA cases in the country, including Saginaw River and Bay and Lake Hartwell/Twelvemile Creek NRDAs. He has been the project manager or consulting expert on NRDAs for industrial clients in several other high-profile natural resource damage cases. In these roles, he has provided technical support to legal teams in the development of case strategy and in the supervision and preparation of materials for litigation support under CERCLA, RCRA, the Clean Water Act, and the regulatory programs of various states.

He has directed many complex multidisciplinary projects to assess ecological risks and impacts from releases of hazardous substances, including oil. Mr. Booth has a particularly strong background in managing and directing evaluations of the potential impacts of PCBs and metals on fish, birds, and mammals; ecological risks posed by sediment contamination; and options for sediment management. Mr. Booth has developed and managed a corporate program for a Fortune 500 manufacturing company, to implement risk assessment guidance for program managers in the remediation group and provide site-specific ecological risk assessments at numerous sites nationwide.

For other industrial clients, Mr. Booth has assisted in developing overall strategies for environmental issues, designing site-specific assessments, and negotiating risk-based response actions with state and federal agencies. In addition, he has supervised the study design, collection, and analysis of environmental data and the development of PC- and web-based data management, analysis, and visualization tools. Mr. Booth has led numerous projects directed at the characterization and remediation of contaminated sediments in the United States and South America, and he has helped to create guidance and policy for regional sediment management programs in Puget Sound and San Francisco Bay.

Academic Credentials and Professional Honors

M.M.A., Marine Affairs, University of Washington, 1984
I.P.A. Certificate, Integrative Program in Administration, University of Washington Graduate School of Business, 1983
B.A., Biology, University of the Pacific, 1977

Licenses and Certifications

Hazardous Waste Operations and Emergency Response 40-hour training program; Hazardous Waste Operations Management and Supervisor 8-hour training program

Publications

Booth PN, Salatas, JH, Kaetzel RS, Gard NW, Yost LJ, O'Boyle RA, Mackay CE. Risk assessment as a decision-making tool for treatment of emissions at a new aluminum smelter in Iceland: 1. Background and introduction. J Hum Ecol Risk Assess, 2009, in press.

Kaetzel RS, Yost LJ, O'Boyle RA, Booth PN. Risk assessment as a decision-making tool for treatment of emissions at a new aluminum smelter in Iceland: 2. Human health risk assessment. J Hum Ecol Risk Assess, 2009, in press.

Salatas JH, Booth PN, Gard NW, O'Boyle RA, Mackay CE. Risk assessment as a decision-making tool for treatment of emissions at a new aluminum smelter in Iceland: 3. Ecological assessment. J Hum Ecol Risk Assess, 2009, in press.

Menzie CA, Booth P, Law SA, von Stackelberg K. Use of decision support systems to address contaminated coastal sediments: Experience in the United States. In: Decision Support Systems for Risk-Based Management of Contaminated Sites. Marcomini A, Suter II GW, Critto A (eds), Springer Verlag, 439 p, 2009.

Booth P, Gard N, Law S, Davis R. Sustainability: Considerations for including eco-assets in a company's bottom line. American Bar Association Climate Change, Sustainable Development, and Ecosystems Committtee Newsletter 2007; 11(1):7–11.

Booth P, Gribben K. A review of the formation, environmental fate, and forensic methods for PAHs from aluminum smelting processes. Environ Forens 2005; 6(2):133–142.

Booth PN, Bigham G, Gasch, Jr. M. Natural resource damage looms as major liability issue. Environ Corp Counsel Report 1994; 1(2):5–8.

Booth PN, Jacobson MA. Development of cleanup standards at Superfund sites: an evaluation of consistency. J. Air Waste Manage Assoc 1992; 42:762–766.

Booth PN, Becker DS, Pastorok RA, Sampson JR, Graham WJ. Evaluation of restoration alternatives for natural resources injured by oil spills. Prepared for the American Petroleum Institute, Washington, DC, API Publication No. 304, 1991.

Jacobson MA, Booth PN. A review and evaluation of hazardous waste cleanup standards implemented after the enactment of the Superfund Amendments and Reauthorization Act. In: Proc. Haztech International '90. Institute for International Research, Inc., New York, NY, 1990.

Booth PN, Becker DS, Barrick RC, et al. A screening-level approach to estimating natural resource damages from contaminated marine sediments. In: Proc. Sixth Symposium on Coastal and Ocean Management. American Society of Civil Engineers, New York, NY, 1989.

Pastorok RA, Booth PN, Williams LG. Estimating potential health risks of chemically contaminated seafood. Puget Sound Notes, U.S. Environmental Protection Agency Region 10, Seattle, WA, May 1986.

Presentations

Booth P, Salatas J, Gard N, Mackay C, O'Boyle, R. A predictive ecological risk assessment for evaluating treatment options for aerial emissions at an aluminum smelter is Reyðarfjörður East Iceland. Presented at Society of Toxicology, Charlotte, NC, March 25–29, 2007.

Salatas JH, Booth P, Gard N, Mackay C, O'Boyle R. Using predictive risk assessment to evaluate aluminum smelter treatment options for protection of mammalian communities in Iceland. Presented at Society of Environmental Toxicology and Chemistry 27th Annual Meeting, Montreal, Quebec, November 5–9, 2006.

Salatas JH, Booth P, Gard N, Mackay C, O'Boyle R. Using predictive risk assessment to evaluate treatment options for aluminum smelter emissions. Session: Challenges and Innovations in the Evaluation of Birds in Ecological Risk Assessments. Presented at Society of Environmental Toxicology and Chemistry 27th Annual Meeting, Montreal, Quebec, November 5–9, 2006.

Booth P, Harman W, Kirchof C. Dam removal as out-of-kind compensatory restoration for CERCLA Releases: The case of Twelvemile Creek/Lake Hartwell, SC. SETAC, Interactive Poster Presentation, Abstract Reference No. BOO-1117-819783, November 16, 2005.

Booth P, Gard N, Bodishbaugh R. Tools for Streamlining Ecological Risk Assessments at RCRA Corrective Action Facilities. SETAC, Poster Session, Abstract Reference No: BOO-1117-829805, TP20 Ecological Risk Assessment, November 15, 2004.

Booth P, Edwards M, Nielsen DL. Spatial and temporal trends of PCBs in fish in response to natural recovery in sediments. 4th SETAC World Congress 25th Annual Meeting in North America, Portland, OR, November 14–18, 2004.

Booth PN, Medved JB, Williams L. Wetland restoration under the Saginaw River and Bay NRD settlement. Presented at SETAC 24th Annual Meeting, Austin, TX, November 9–13, 2003.

Mackay CE, Becker S, Law S, Booth P. Probabilistic assessment of the risk to terrestrial birds and mammals in a small urban lake; Harris Lake, MI. Presented at the 23rd Annual Society of Environmental Toxicology and Chemistry Meeting, Austin, TX, November 9–13, 2003.

Medved JB, Booth PN, Moore M, Nielsen D, Goode D. Use of GIS with dynamically linked database tools in quantitative ecological assessment—A case study. Interactive poster presentation at the Society of Toxicology and Environmental Chemistry Annual Meeting and Conference, Philadelphia, PA, November 14–18, 1999.

Booth P, Medved J, Moore M, Mackay C, et al. Estimated vs. measured dietary exposure of terrestrial wildlife to contaminants in soil. Presented at the 15th Annual Conference on Contaminated Soils, Amherst, MA, October 18–21, 1999.

Booth PN, Ecological risk assessment and management: updating the tools to provide more value. General Motors Corporation Global Environmental Conference, Dearborn, MI, October 1999.

Booth PN, Henson KA. Multiuser sites for contaminated sediment disposal. In: Proc. ASCE Specialty Conference, Water Forum '92, Baltimore, MD, August 22–24, 1992.

Project Experience

Natural Resource Damage Assessment (NRDA)

Consulting restoration expert on behalf of Dow Chemical Company in the Tittabawasse River and Saginaw River and Bay NRDA matter. Responsible for developing and negotiating technical approaches for this cooperative NRDA and harmonizing these approaches with injury quantification efforts. Focus is on identifying and scaling restoration projects to compensate the public for alleged interim losses resulting from releases of dioxins, furans, and potentially other substances.

Project manager and consulting expert on behalf of industry for restoration-based settlement discussions in the Ottawa River NRDA matter. Primary issues include evaluation of alleged injury due to releases of PCBs, PAH, and metals relative to general ecological degradation due to baseline conditions, and identification and scaling of potential restoration projects to foster cooperative, restoration-based settlement.

Managing and providing technical support as consulting expert to Alcoa and General Motors in settlement negotiations in the St. Lawrence River environmental natural resource damage matter. Technical issues center on PCBs and polycyclic aromatic hydrocarbons in sediment of the Grasse, Raquette, and St. Lawrence rivers. Overseeing development and negotiation of all technical aspects of the matter, including potential injury and service reductions to benthic macroinvertebrates, fish, piscivorous and insectivorous birds, mammals, aquatic plants, and herptiles. Have a lead role in identification, scaling, and development of compensatory restoration projects for ecological services. Developed and presented technical positions and exhibits during negotiations with the New York State Department of Environmental Conservation, New York Attorney General's office, U.S. Department of the Interior, National Oceanic and Atmospheric Administration, and St. Regis Mohawk Indian Tribe.

Project manager on behalf of General Motors for all aspects of technical support on the Saginaw River and Bay NRDA matter. Played a key role in the development and implementation of

technical strategies that were implemented successfully to achieve a favorable settlement for General Motors in this landmark natural resource damage case. The underlying technical issues were related to developing realistic baseline conditions for allegedly injured resources, counter-positions to the injuries alleged by the trustees, and an innovative and cost-effective restoration package. Provided detailed evaluations of causation on a variety of injuries, including bioaccumulation of PCBs by fish and reproductive effects of PCBs on fish and birds. General Motors recognized the contribution by bestowing a Worldwide Facilities Group 1998 Crew Award.

Managed and was lead consulting expert for Schlumberger in support of settlement negotiations in the Lake Hartwell natural resource damage case. Key technical issues revolved around allegations of fisheries-related impacts due to bioaccumulation of PCBs, and putative impacts of PCBs on benthic macroinvertebrate communities, fish, insectivorous birds, and piscivorous birds and mammals. Another key issue was the rate of recovery from alleged PCB-mediated injury, given EPA's selected remedy of monitored natural recovery. Directed the development of technical positions regarding the likely extent of injury and reductions in ecological services, if any, that were likely to have resulted from injuries. Presented technical positions during negotiation sessions with federal trustees and trustees from the states of Georgia and South Carolina, and provided technical assistance for selecting and determining the scale of the preferred compensatory restoration projects. Was co-author and technical editor of the Lake Hartwell restoration and compensation determination plan.

Managed a natural resource injury assessment for ARCO in support of settlement negotiations in the Clark Fork River natural resource damage case. The injury assessment included modeling past, present, and future water quality based on sediment/water interactions and provided critical comments on the trustee's case regarding sediment injury. The critique included a detailed evaluation of available sediment quality criteria and an evaluation of ecological risks posed by sediments with elevated concentrations of metals.

Managed tasks to quantify baseline injuries and project cumulative future injury for groundwater, geologic, and surface-water resources at the Anaconda mining complex in the Clark Fork River natural resource damage case. The analyses of injury provided the basis for litigation support and support during settlement negotiations in a natural resource damage claim.

Managed technical support activities for a national-level NRDA program. Determined contaminant transport and fate, habitat degradation, bioaccumulation, and resource injury. Responsible for studies at more than 100 Superfund sites. Studies characterized risks to natural resources, assessed injury and potential damages to natural resources, and offered recommendations for future investigations, including restoration.

Managed a task to characterize historical activities at a large industrial site and evaluate regional waste management activities in terms of potential effects to a lake environment. Regional waste management activities were characterized to aid in apportioning injury and damages in preparation for an NRDA. Developed materials balance calculations for more than 100 years of activities at a soda ash plant and more than 50 years of activities at two chlor-alkali plants and a chlorinated benzene plant.

Managed tasks to develop technical memoranda describing economic theory for NRDAs, the applications of the theory, and approaches to assessing damages to groundwater from hazardous waste sites. Memoranda were used by the Washington State Department of Ecology to develop a state program for NRDAs.

Managed NRDAs at five hazardous waste sites. Activities included biological and economic assessment of damages to recreational fisheries and benthic infauna and strategic evaluation of use and nonuse damage estimates. Developed an approach for assessing the decrease in economic value associated with benthic community effects.

Ecological Risk Assessment

Managed novel comparative human health and ecological risk assessments for air emissions of sulfur dioxide, hydrogen fluoride, PAH, and particulate material from a proposed aluminum smelter in Reyðarfjörður, Fjarðabyggð, Iceland. The primary objective of this predictive risk assessment was to determine whether there would be consequential differences in the level of risk posed by air emissions from the smelter operation with and without seawater scrubbers. A matrix of air modeling data was obtained for more than 10,000 receptor points under 99 discrete simulation scenarios to support the risk assessments. Spatially and temporally explicit exposure modeling was used in a probabilistic framework to evaluate risks to plants, birds, and mammals. The risk assessment resulted in a favorable outcome for the client who was able to obtain a permit without having to install costly seawater scrubbers.

Managing and providing corporate support on all site-specific ecological risk assessments for General Motors. Also developing corporate guidance for ecological risk assessment for General Motors project and program managers. Responsibilities for this $7 million program include overseeing development of corporate strategy on ecological risk assessment; participating in negotiations with state and federal regulatory agencies on policy and regulatory issues, as well as scope and direction of site-specific assessments; and ensuring consistency among all ongoing site ecological risk assessments. Managed over 30 risk assessments under this program, ranging from habitat characterization to multimillion dollar and multi-year investigations.

Managing a quantitative risk assessment to develop an ecologically based site remediation strategy for a stream, associated wetlands, and abandoned stormwater detention basin in Framingham, Massachusetts. This multi-phase risk assessment includes design and implementation of a state-of-the-science, site-specific bioavailability study of PAH in conjunction with 42-day *Hyallela azteca* sediment toxicity testing. Results of this novel approach indicate that sediment toxicity is driven by metals (lead and zinc) rather than PAH, despite PAH concentrations in the many hundreds of parts per million. Remedial design based on the results of the risk assessment represents a cost savings of more than $2 million over a remedy based on default cleanup levels.

Managed a quantitative probabilistic risk assessment to develop an ecologically based remediation strategy for an urban lake and associated wetlands and uplands in Pontiac, Michigan. Results of the risk assessment indicated that that no further action was needed to address ecological risk from PCBs and metals in wetland and upland soils or to address risk to piscivorous wildlife feeding in the lake. Surveys of benthic macroinvertebrates indicated

significant population and community effects in the lake; however, a detailed limnological study indicated that the major stressor was related to seasonal stratification and low dissolved oxygen. These findings were used to negotiate and implement a limited sediment capping project saving the client over $12 million compared to sediment removal.

Managed and conducted an ecological risk assessment to meet Michigan Part 201 requirements at a site involved in settlement negotiations for a major natural resource damage case. Developed innovative strategic approaches to ecological risk assessment and extensive negotiation of technical and procedural issues with Michigan State agency representatives and the federal trustee. Successfully demonstrated low bioavailability of elevated concentrations of metals in soil.

Provided technical support to an industry client in negotiating the ecological risk assessment and sediment assessment components of the Ohio Voluntary Action Program rule. Participated in several negotiation meetings, and developed solid scientific positions on issues such as toxicity testing, bioindicators, and use of reference area comparisons.

Contaminated Sediment Management

Managed a project investigating sediment contamination in access channels to the Port of Buenos Aires, Argentina, in support of a navigation dredging project. Evaluated the applicability of international sediment standards and contaminated-sediment management practices to develop a suitable and economically viable disposal option. Designed, implemented, and concluded a sediment sampling program within a 3-week period. Geochemical analysis of metals contamination demonstrated no significant environmental impacts, allowing the project to go forward in a timely and cost-effective manner using open-water unconfined disposal for the majority of dredged material.

Managed a sediment investigation in the lower Hudson River at Sleepy Hollow, New York. This work is being performed in anticipation of the demolition of a manufacturing complex and the multimillion dollar redevelopment of waterfront property. The sediment investigation focused on identifying spatial patterns of distribution of metals in sediment and the association of the metals contamination with local point and nonpoint sources.

Managed a project providing technical assistance and oversight for field activities, data evaluation and validation, community relations, enforcement support, and RI/FS support at a naval installation. This complex site presented a wide range of contamination problems in soils, groundwater, surface water, biota, and sediments.

Managed a project that evaluated the feasibility of implementing a multiuser disposal site program for contaminated sediments in Puget Sound, Washington. Results indicated that a lack of disposal capacity was threatening the Puget Sound sediment cleanup program, as well as navigation maintenance and improvement projects. The greatest challenges to program implementation were site selection (upland, nearshore, and aquatic sites) and liability management. Document was used by the client to formulate recommendations for implementing a regional program that was presented to state and federal agencies and the state legislature.

Managed a project evaluating disposal alternatives for dredged material in San Francisco Bay. Alternatives were evaluated for aquatic disposal in dispersive and nondispersive sites with material rehandling, disposal in diked baylands and other nearshore areas, and disposal in upland sites.

Analyzed regulations and guidelines and documented the decision-making framework for open-water unconfined disposal of dredged material in Puget Sound, Washington.

Evaluated mitigation actions and coordinated the preparation of an EIS on developing and implementing numerical sediment quality standards. Standards focused on establishing sediment impact and recovery zones and a sediment cleanup decision process for Puget Sound, Washington. Evaluation included quantifying disproportionate effects to small business enterprises.

Managed a project to assess the long-term bacteriological effects on freshwater sediments from a spill of untreated sewage and storm water. Sediments were sampled from three combined sewer overflows to compare indicators of human fecal contamination. Results of the $17,000 study were successfully used to save the client more than $250,000 in cleanup and restoration costs.

Participated in developing numerical criteria based on sediment chemistry; amphipod, Microtox®, and oyster larvae bioassay; and benthic community structure for guiding sediment remedial action at a Superfund site in Washington.

Environmental Impact Assessment and Policy Analysis

Managed the visual and avian impacts components of an environmental impact assessment for a 500-kV power line project in the Esteros del Iberá wetland area of northern Argentina. The World Bank is currently using this work as the standard for projects of this type in Latin America. The conclusions and recommendations developed by Exponent on these highly controversial issues allowed the project to be completed ahead of schedule and below previously projected costs for mitigation.

Managed and supervised the development of multijurisdictional action plans to control toxic contaminant loading from point and nonpoint sources to five urban bays of Puget Sound, Washington. Action plans represented the culmination of lengthy and complex negotiations among source control programs of numerous federal, state, and local agencies and citizen groups. In some cases, negotiations spanned 2 years.

Developed and implemented a conceptual model for performing marginal analyses to determine optimal degrees of restoration following oil spills. Marginal analysis was designed to assess natural resource damages based on restoration costs and residual damages in an economically efficient manner. Results were used as an industry policy document for developing federal oil spill damage assessment regulations.

Managed the review of more than 200 record of decision documents to compile information on

cleanup standards, remedial actions, and applicable regulations in support of Washington State Department of Ecology efforts to develop cleanup standards for uncontrolled hazardous waste sites. Project was the first analytical documentation of cleanup standard development at federal sites following the enactment of SARA.

Analyzed local, state, and federal government programs and policies to recommend institutional mechanisms for managing a comprehensive environmental monitoring program for Puget Sound, Washington.

Served as project manager for the compilation and synthesis of all existing Puget Sound data relating to toxic and bacterial contamination, environmental impacts, and human health risks for inclusion in a document for public distribution.

Professional Affiliations

- Society for Environmental Toxicology and Chemistry
- Ecological Society of America
- Society for Ecological Restoration

Exponent
10850 Richmond Avenue
Suite 175
Houston, TX 77042

telephone 832-325-5700
facsimile 832-325-5799
www.exponent.com

Janci Chunn Lindsay, Ph.D.
Senior Scientist

Professional Profile

Dr. Lindsay is a Senior Scientist in Exponent's Health Sciences Center for Toxicology and Mechanistic Biology. Dr. Lindsay has 16 years of scientific experience, with an emphasis on the study of pulmonary pathologies resulting from environmental, occupational, and chemotherapeutic exposures. Her expertise within Exponent centers on evaluating the complex dynamics of toxicity, such as toxicant pharmacology, exposure route, dose/response, host metabolism, and subsequent cellular effects as they relate to the contribution of specific substances to human disease.

Dr. Lindsay holds a doctorate in Biochemistry and Molecular Biology and has extensive experience in analyzing the molecular profile of pharmacologic responses as they pertain to the dose/response relationship, specifically in terms of analyzing and evaluating molecular markers of disease, or "Toxicogenomics." Additionally, she brings her expertise in evaluating toxicant contributions to lung pathologies—such as asthma, reactive airway disease, chronic obstructive pulmonary disease (COPD), bronchiolitis obliterans, organizing pneumonitis, interstitial pneumonia, and pulmonary fibrosis—that may be claimed following chemical, drug, or particulate exposure.

Academic Credentials and Professional Honors

Ph.D., Biochemistry and Molecular Biology, Graduate School of Biomedical Sciences, University of Texas, 2006
B.S., Biological and Physical Sciences, University of Houston, Downtown, 1993

Dean's Research Award, GSEC, University of Texas Medical School, Houston, Texas, 2005; T.C. Hsu Scholarship in Genetics & Cell Biology, UT MD Anderson Cancer Center, Houston, Texas, 2005; University of Texas Golf Scholarship, UTHSC-Houston, 2004, 2005; Excellence in the Pre-Health Sciences Award, University of Houston-Downtown, 1993

ANNEX 158

Publications

Mi T, Abbasi S, Zhang H, Uray K, Chunn JL, Xia LW, Molina JG, Weisbrodt NW, Kellems RE, Blackburn MR, Xia Y. Excess adenosine in murine penile erectile tissue contributes to priapism via A_{2B} adenosine receptor signaling. J Clin Invest 2008; 118(4):1491–1501.

Chunn JL, Mohsenin A, Young HY, Lee CG, Elias JA, Kellems RE, Blackburn MR. Partially adenosine deaminase deficient mice develop pulmonary fibrosis in association with adenosine elevations. Am J Physiol Lung Cell Mol Physiol 2006; 290:579–587.

Willems L, Reichelt ME, Molina JG, Sun CX, Chunn JL, Ashton KJ, Schnermann J, Blackburn MR, Headrick JP. Effects of genetic deletion of adenosine deaminase and A1 receptors in normoxic and ischaemic hearts. Cardiovasc Res 2006; 1:71(1):79–87.

Sun CX, Zhong H, Molina JG, Belardinelli L, Zeng D, Mohsennin A, Chunn JL, Blackburn MR. Role of A_{2B} Receptor signaling in adenosine-dependent pulmonary inflammation and injury. J Clin Invest 2006; 116(8):2173–2182.

Reichelt ME, Willems L, Molina JG, Sun CX, Chunn JC (Noble), Ashton KJ, Schnermann J, Blackburn MR, Headrick JP. Genetic deletion of the A1 adenosine receptor limits myocardial ischemic tolerance. Circ Res 2005; 18:96(3):363–367.

Chunn J, Molina JG, Mei T, Xia Y, Kellems R, Blackburn MR. Adenosine dependant pulmonary fibrosis in adenosine deaminase deficient mice. J Immunol 2005; 175:1937–1946.

Blackburn MR, Lee CG, Young HWJ, Chunn JL, Banerjee SK, Elias JA. Adenosine is an important mediator of IL-13 induced inflammation in the lung: Evidence for an IL-13-adenosine amplification pathway. J Clin Invest 2003; 112:332–343.

Chunn JL, Young WJ, Colasurdo GN, Banerjee SK, Blackburn MR. Adenosine-dependent airway inflammation and hyperresponsiveness in partially adenosine deaminase deficient mice. J Immunol 2001; 167:4676–4685.

Blackburn MR, Volmer JB, Chunn JL (Thrasher), Crosby JR, Lee JJ, Kellems RE. Metabolic consequences of adenosine deaminase deficiency in mice are associated with defects in alveogenesis, pulmonary inflammation and airway obstruction. J Exp Med 2000; 192:159–170.

Zhong H, Chunn JL, Volmer JB, Fozard JL Blackburn MR. Adenosine mediated mast cell degranulation in adenosine deaminase-deficient mice. J Pharmacol Exp Ther 2000; 298(2):433–440.

Blackburn MR, Wubah JA Chunn JL, Thompson LF, Knudsen TB. Transitory expression of the A2b adenosine receptor during implantation chamber development. Develop Dynam 1999; 216:127–136.

Skinner SM, Kieback DG, Chunn JL, Jones LA, Metzger DA, Malinak LR, Dunbar BS. Identification of a meiotically expressed carbohydrate antigen in ovarian carcinoma II. Association with proteins in tumors and peritoneal fluid. Anticancer Res 1997; 17:901–906.

Book Chapters

Dunbar BS, Chunn JL. Multimedia methods in molecular biology. In: Techniques in Electrophoresis. Roultledge (ed), Chapman and Hall, Inc., Hampshire, U.K., 1997.

Wagner M, Chunn JL. Allergy. In: The Encyclopedia of Epidemiology, 2007.

Chunn JL. Asthma. In: The Encyclopedia of Epidemiology, 2007.

Published Abstracts

Fernandez P, Trzaska S, Chunn JL, Blackburn MR, Cronstein BN, Chan ESL. Adenosine deaminase deficiency promotes dermal fibrosis. 8th International Symposium on Adenosine and Adenine Nucleotides. Universita Degli Studi Di Ferrara, Italy, 2006.

Chunn Noble JL, Molina TM, Yang X, Rodney KJ, Blackburn MR. Adenosine induced pulmonary fibrosis in adenosine deaminase-deficient mice. American Thoracic Society, San Diego, CA, 2005.

Chunn Noble JL, Molina JG, Blackburn, MR. Examining the role of adenosine in an experimental model of pulmonary fibrosis. International Purine Meeting, Chapel Hill, NC, 2004.

Chunn JL, Young HWJ, Blackburn MR. Examining the role of adenosine in bleomycin-induced lung fibrosis. American Thoracic Society Annual Meeting, Atlanta, GA, 2002.

Chunn JL, Young HWJ, Colasurdo GN, Blackburn MR. Chronic elevations in adenosine are associated with severe lung inflammation and fibrosis in partially adenosine deaminase deficient mice. American Thoracic Society Annual Meeting, San Francisco, CA, 2001.

Blackburn MR, Zhong H, Chunn JL, Volmer JB. Adenosine deaminase deficient mice as models of adenosine mediated lung inflammation. 96th American Thoracic Society Meeting, P209:D21, 2000.

Prasad SV, Chunn JL, Skinner SM, DeMayo F, Dunbar BS. Generation of mice transgenic for the human homologue of the rabbit 55kd zonae pellucida sperm receptor protein. Mol Biol Cell 7:481a; Annual Meeting for the Society for the Study of Reproduction, Davis, CA, 1996.

Chunn JL, Skinner SM, Dunbar BS. Biological reproduction characterization of secretory proteins of rabbit ovarian surface antigens. Annual Meeting for the Society for the Study of Reproduction, Davis, CA, 1995.

Prior Experience

Graduate Research Assistant, The University of Texas Medical School, UTHSC, Department of Biochemistry and Molecular Biology, 2000–2006
Research Assistant II, The University of Texas Medical School, UTHSC, Department of Biochemistry and Molecular Biology, 1998–2000
Research Assistant I, Baylor College of Medicine, The Children's Nutrition Research Center, Department of Pediatrics, Houston Medical Center, 1998
Research Technician III, Baylor College of Medicine, Department of Neonatology, Houston Medical Center, 1997–1998
Research Technician II, Baylor College of Medicine, Cell Biology Department, 1993–1996

Professional Affiliations

- American Thoracic Society (member)
- American Chemical Society (member)
- Society of Toxicology (member)

Exponent
3 Clock Tower Place
Suite 205
Maynard, MA 01754

telephone 978-461-1226
facsimile 978-461-1223
www.exponent.com

Susan B. Kane Driscoll, Ph.D.
Managing Scientist

Professional Profile

Dr. Susan Kane Driscoll is a Managing Scientist in Exponent's EcoSciences practice. She is an aquatic toxicologist, with 19 years experience in toxicology, specializing in ecological risk assessment, environmental chemistry, sediment toxicity testing, and the toxicity and bioavailability of sediment-associated contaminants to aquatic organisms and wildlife. Dr. Driscoll has directed or participated in numerous ecological risk assessments for RCRA, Superfund, and hazardous waste sites, serving a variety of industrial, utility, and governmental clients. She has extensive experience in designing and conducting laboratory and field aquatic toxicity and environmental fate studies in accordance with rigorous quality assurance practices. She has designed and contributed to numerous environmental programs that were used to develop technically defensible solutions to environmental problems and has negotiated their acceptance with state and federal authorities.

Dr. Driscoll is a specialist in the field of sediment toxicology and her original research and publications in the areas of bioavailability and toxicity of sediment-associated contaminants are widely cited. She has extensive knowledge of sediment toxicity testing, the technical basis and predictive ability of various sediment quality benchmarks, and has served as a reviewer for the development of emerging benchmarks.

Academic Credentials and Professional Honors

Ph.D., Environmental Sciences, University of Massachusetts, 1994
B.S., Natural Resources, University of Rhode Island, 1981

Integrated Risk Assessment Paper of the Year for 2002 for "A Comparative Screening-Level Ecological and Human Risk Assessment for Dredged Material Management Alternatives in New York/New Jersey Harbor," Human and Ecological Risk Assessment 8:603–626

Publications

Kane Driscoll SB, Burgess RM. An overview of the development, status, and application of equilibrium partitioning sediment benchmarks for PAH Mixtures. Hum Ecol Risk Assess 2007; 13:2:286–301.

Kane Driscoll SB, Amos CB, McArdle ME, Southworth B, Menzie CA, Coleman A. Use of Equilibrium Partitioning Sediment Benchmarks (ESBs) to predict toxicity of PAH contaminated sediments. Electric Power Research Institute (EPRI), Palo Alto, CA, 1010371, 2005.

Kane Driscoll SB, Amos CB, McArdle ME, Southworth B, Menzie CA, Coleman A. Sediment biotoxicity at former MGP and coking sites. Electric Power Research Institute (EPRI), Palo Alto, CA; New York State Electric & Gas Corporation, Binghamton, NY; Central Hudson, Poughkeepsie, NY; and PSEG Services, LLC, Newark, NJ, 1011168, 2004.

Kane Driscoll SB, McArdle ME, M.S., Menzie CA, Thompson T, Mortensen L, Fitzpatrick A. Using Polycyclic Aromatic Hydrocarbons in sediments for judging toxicity to aquatic life: Volume I and II, EPRI Final Report. Electric Power Research Institute (EPRI), Palo Alto, CA, 1005280, 2003.

Kane Driscoll SB, Wickwire WT, Cura JJ, Vorhess DJ, Butler CL, Williams LW, Moore DW, Bridges TS. A comparative screening-level ecological and human health risk assessment for dredged material management alternatives in New York/New Jersey Harbor. Hum Ecol Risk Assess 2002; 8(3):603–626.

Vorhees DJ , Kane Driscoll SB, Von Stackelberg K, Cura JJ, Bridges TS. An evaluation of sources of uncertainty in a dredged material assessment. Hum Ecol Risk Assess 2002; 8(2):369–389.

Kane Driscoll SB, Menzie CA, Burton GA, Williams J, Coleman A. Review of toxicology of PAHs in invertebrate aquatic organisms. EPRI Final Report. Electric Power Research Institute (EPRI), Palo Alto, CA, 1006594, 2001.

Landrum PF, Tigue EA, Kane Driscoll SB, Gossiaux DC, Van Hoof PL, Gedeon ML, Adler M. Bioaccumulation of PCB congeners by *Diporeia* spp.: Kinetics and factors affecting bioavailability. J. Great Lakes Res 2001; 27(2):117–133.

Kane Driscoll SB, Schaffner SC, Dickhut RM. Toxicokinetics of fluoranthene to the amphipod, *Leptocheirus plumulosus*, in water-only and sediment exposures. Mar Environ Res 1998; 45(3):269–284.

Kane Driscoll SB, Landrum PF. A comparison of equilibrium partitioning and critical body residue approaches for predicting toxicity of sediment associated fluoranthene to freshwater amphipods. Environ Toxicol Chem 1997; 16(10):2179–2186.

Kane Driscoll SB, Harkey GA, Landrum PF. Accumulation and toxicity of fluoranthene in sediment bioassays with freshwater amphipods. Environ Toxicol Chem 1997; 16(4):742–753.

Kane Driscoll SB, Landrum PF, Tigue EA. Accumulation and toxicity of fluoranthene in water only bioassays with freshwater amphipods. Environ Toxicol Chem 1997; 16(4):754–761.

Harkey GA, Kane Driscoll SB, Landrum PF. Effect of feeding in 30-day bioaccumulation assays using *Hyalella azteca* in fluoranthene-dosed sediment. Environ Toxicol Chem 1997; 16(4):762–769.

Kane Driscoll SB, McElroy AE. Elimination of sediment-associated benzo[a]pyrene and its metabolites by polychaete worms exposed to 3-methylcholanthrene. Aquat Toxicol 1997; 39(1):77–91.

Kane Driscoll SB, McElroy AE. Bioaccumulation and metabolism of benzo[a]pyrene in three species of polychaete worms. Environ Toxicol Chem 1996; 15:1401–1410.

Published Abstracts of Presentations

Kane Driscoll S, McArdle M, Menzie C. Assessing risk of metals in sediment: Experience in applying the weight-of-evidence approach to aquatic sites contaminated with heavy metals. Sediment Management Work Group Spring Sponsor Forum, Kalamazoo, MI, April 29−30, 2008.

Kane Driscoll SB. A methodology for deriving a dietary dose of PAHs that is protective of fish. Platform presentation, International Conference on Remediation of Contaminated Sediments in Savannah, GA, January 22–24, 2007. Session chair: "Bioavailability of Contaminants."

Kane Driscoll SB, Reiss M, Steevens J. Development of a novel dose-based toxicity benchmark for exposure of fish to PAHs. 26th Annual Meeting of SETAC North America, Baltimore, MD, November 16–20, 2005.

Kane Driscoll SB, Reiss M, Steevens J. Development of a database of toxic doses of PAHs to fish. 18th Biennial Conference of the Estuarine Research Federation, Norfolk, VA, October 16–20, 2005.

Kane Driscoll SB, Menzie CA, McArdle ME, Coleman A. Application of site-specific equilibrium partitioning sediment benchmarks for PAH mixtures to manufactured gas plants. 25th Annual Meeting of SETAC North America, Portland, OR, November 14–18, 2004.

Kane Driscoll SB, McArdle ME, Menzie CA, Thompson T, Coleman A. Application of sediment quality guidelines for PAHs to manufactured gas plants. 2nd International Conference on Remediation of Contaminated Sediments, Venice, Italy, 2003.

Kane Driscoll SB, T. Bridges, Cura JJ, M. McArdle, and M. Nelson. A review of comparative risk assessment methods and their applicability to dredged material management decisions. 23rd Annual Meeting of SETAC North America, Salt Lake City, Utah, November 16–20, 2002.

Kane Driscoll SB. Sediment accumulation and toxicity of Fluoranthene to freshwater amphipods. Benthic Ecology Meeting, Columbia, SC, March 7–10, 1996.

Kane Driscoll SB, Landrum PF. Bioaccumulation and critical body burden of Fluoranthene in estuarine amphipods. Society of Environmental Toxicology and Chemistry, Washington, DC, 1996.

Kane Driscoll SB, Landrum PF. Toxicokinetics and critical body burdens of Fluoranthene in amphipod bioassays with *Hyalella azteca* and *Diporeia* sp. Invited talk, Society of Environmental Toxicology and Chemistry, Vancouver, BC, 1995.

Kane Driscoll SB, McElroy AE. A comparison of bioaccumulation and biotransformation of benzo[a]pyrene in three species of polychaete worms. Society of Environmental Toxicology and Chemistry, Houston, TX, 1993.

Kane Driscoll SB, McElroy AE. Biotransformation of benzo[a]pyrene by three species of polychaete. Society of Environmental Toxicology and Chemistry, Cincinnati, OH, 1992.

Prior Experience

Senior Managing Scientist, Menzie-Cura & Assoc., Inc., 1997–2006
Post-Doctoral Research Scientist, Bioavailability and Toxicity of Sediment-Associated Organic Contaminants, Virginia Institute of Marine Science, 1996–1997
Post-Doctoral Research Scientist, Bioavailability and Critical Body Burdens of Sediment-Associated PAHs, National Oceanic and Atmospheric Administration Great Lakes Environmental Laboratory, 1994–1996

Project Experience

Developing a novel approach for EPA and the U.S. Army Corps of Engineers (the Corps) to assess the toxic effects of dietary and water-borne doses of PAHs to fish. Reviewed literature, summarized data, developed a cumulative distribution of doses, and estimated protective dose levels.

Managed an ecological and human health risk assessment for a RCRA site in Taunton, Massachusetts. Designed extensive sampling and sediment toxicity testing program that demonstrated minimal impact to aquatic organisms and wildlife from exposure to PCBs, mercury, and dichlorobenzenes in surficial sediments.

Conducted research for the Electric Power Research Institute and its utility members on the application of the EPA equilibrium partitioning sediment benchmarks for PAH mixtures to contaminated sediments at manufactured gas plant sites. Research examined influence of

various forms of "black carbon," including coal tars and coke, on reducing bioavailability and toxicity of PAHs in sediment to aquatic organisms.

Managed an ecological and human health risk assessment for a former automobile battery manufacturing site in Connecticut. Characterized potential exposure of human and ecological receptors to lead in surficial sediments of a tidal river. Designed field-sampling program, which included analyses of lead in fecal samples and eggs from resident birds, for characterization of site-specific exposure to lead. Used site-specific exposure information to back-calculate health-protective concentrations of lead in sediment.

Managed an extensive review of the available information on the toxicity of dioxin-like compounds to birds. Compiled a database of dose-response relationships that was used to develop a species sensitivity distribution for effects to avian species.

Prepared a technical review for EPA and the Corps on approaches used to characterize the toxicity of mixtures of organic contaminants to fish. Developed a cumulative distribution of toxic tissue concentrations of chlorinated cyclodiene pesticides to fish.

Conducted effects assessment for the Hudson River baseline ecological risk assessment. Reviewed literature on effects of PCBs and dioxin-like compounds on fish and aquatic wildlife. Selected toxicity reference values for use in ecological risk assessment.

Developed a comparative risk assessment framework for the Corps. The framework identifies characteristics of various placement and treatment alternatives for dredged materials that contribute to potential environmental risk. The framework can be used by environmental managers to identify important transport and fate mechanisms and routes of potential exposure, and to illustrate the need for a comprehensive site assessment.

Examined environmental impacts associated with the release of a plume of high pH groundwater from an industrial landfill. Assisted in the development of a sampling program to demonstrate that high pH groundwater was not mobilizing naturally occurring metals in soil.

Advisory Boards

- Task Group Leader for review of American Society of Testing Materials (ASTM) standard "Guide for Determination of the Bioaccumulation of Sediment Associated Contaminants by Benthic Invertebrates." Responsible for revision and updating of standard bioaccumulation test method.

Peer Reviewer

- Environmental Toxicology and Chemistry
- Integrated Environmental Assessment and Management
- Journal of Human and Ecological Risk Assessment
- Archives of Environmental Contamination and Toxicology

Professional Affiliations

- American Chemical Society (member)
- Society of Environmental Toxicology and Chemistry (member, editorial reviewer and former member of the Board of Directors for the North American Chapter)

Exponent
3401 Market Street
Suite 300
Philadelphia, PA 19104

telephone 215-594-8800
facsimile 215-594-8899
www.exponent.com

Angelina J. Duggan, Ph.D.
Managing Scientist

Professional Profile

Dr. Angelina Duggan is a Managing Scientist in Exponent's Health Sciences practice. She is an organic chemist and toxicologist with more than 25 years experience in pharmaceutical and agrochemical product development and global regulatory affairs that includes process manufacturing chemistry and the organization and project management of multi-disciplinary technical teams. Dr. Duggan integrates toxicology, biomonitoring, exposure, physicochemical and epidemiology data to address FIFRA, TSCA, and REACH regulatory requirements and in conducting human health environmental risk assessments. She is also experienced in the application of Structure Activity Relationships (SAR) and cluster analysis and provides regulatory support for FDA bulk pharmaceuticals and biocompatibility for medical devices.

Dr. Duggan has successfully addressed intellectual property and patent infringement for chemical and pharmaceutical manufacturing and applied technology. She has also provided project management, work plans, and timelines and negotiated intellectual property agreements for university and industrial partner R&D contracts that included chemical and biotechnology discovery research and applied pharmaceutical uses of agrochemicals. Dr. Duggan is also experienced in providing services related to data compensation, and due diligence evaluations of toxicology and product chemistry databases.

Before joining Exponent, Dr. Duggan provided scientific guidance for Washington DC trade associations, pesticide and chemical manufacturers and formulators, regarding EPA and State regulations and human health science and policy. EPA also appointed her to provide science and policy expertise for endocrine disruption and children's health, in serving on advisory committees, the Endocrine Disruption Screening and Testing Advisory Committee (EDSTAC) and the Children's Health Protection Advisory Committees. She has also provided technical leadership for task forces, and project teams to address endocrine disruption, cancer risk assessment, farm family risk, worker exposure, pesticide human testing, and chemical surfactant tolerance reassessment.

Dr. Duggan can effectively communicate risk assessment issues and policy to scientists and non-scientists and is highly accomplished in addressing media relations, including providing effective interviews to the trade and popular press. She has presented and provided written public comments at EPA workshops and to Science Advisory Panels and Boards. Dr. Duggan has also authored and organized the submission of numerous technical and regulatory science policy papers to EPA's Public Docket. Her project management experience includes multi-disciplinary litigation teams, discovery Research and Development, process chemistry, regulatory affairs, global product safety and stewardship. She has also presented safety product profiles to EPA, Latin American, European, and Asian regulators and provided guidance for the development and implementation of biotechnology and discovery strategic plans.

ANNEX 158

Academic Credentials and Professional Honors

N.I.H Postdoctoral Fellow: Natural Products Synthesis, Isolation and Structure Elucidation, Cornell University, 1976
Ph.D., Marine Natural Products, Synthetic Organic Chemistry, Rutgers University, 1974
N.I.H. Predoctoral Fellow, Rutgers University, 1972–1974
M.S., Organic Chemistry, Rutgers University, 1972
B.A., Biology and Chemistry Rutgers University (with honors), 1967

Patents

Duggan AJ, Engel JF, Lutomski KA. Benzoheterocyclyl ketone hydrazone insecticides. U.S. Patent No. 4,895,871, 1989.

Duggan AJ. Pyrazoline insecticides. U.S. Patent No. 4,767,779, 1988.

Duggan AJ. Vinyl Phenylthiocarbonate. U.S. Patent No. 4,622,408, 1986.

Duggan AJ, Webb RL. New process for preparing hydroxyphenylpyridazinones. U.S. Patent No. 4,272,440, 1978

Publications

Duggan A, Snedeker S, Zambrone F. Sessions on the toxicology of agricultural exposures and cancer. Scandinavian J Work Environ Health 2005; 31:119.

Charnley G, Chukwudebe A, Chen W, Duggan A, Hawk R, Krieger RI, Ross J, Yarborough C. Di-alkyl phosphate biomonitoring data: Assessing cumulative exposure to organophosphate pesticides. Regul Toxicol Pharmacol 2003; 37:382.

Cardona R, Duggan A, Gordon E, Stevens E, Tobia A. ACPA perspective on EPA's cancer risk assessment policy in light of the proposed 1996 guidelines for carcinogen risk assessment. Risk Policy Report, September 22, 2000.

Hughes PR, Wood HA, Breen JP, Simpson SF, Duggan AJ, Dybas JA. Enhanced bioactivity of recombinant baculovirus expressing insect-specific spider toxins in lepidopteran crop pests. J Invertebrate Pathol 1997; 69:112.

Duggan AJ, Grabowski EJJ, and Russ WK Jr. Phase—Transfer mediated heteroaromatic nucleophilic substitution: introduction of a beta-adrenergic blocking moiety. Synthesis 1981; 573.

Adams MA, Duggan AJ, Smolanoff J, Meinwald J. The total synthesis of (+/-) pederamide. J Am Chem Soc 1979; 101:5374.

Duggan AJ, Roberts FE. A facile preparation of a VOC reagent, vinyl phenylthiocarbonate. Tetrahedron Lett 1979; 595.

Adams MA, Duggan AJ, Meinwald J. Synthesis of ethyl 1 ,3,6-trioxaspiro-(4.5) decane-4-carboxylate derivatives from *delta* - lactones (preparation of 2-methoxy-2- glycolamide-tetrahydro-2H-pyran; elaboration of pederamide side chain). Tetrahedron Lett 1978; 4327.

Adams MA, Brynes PJ, Duggan AJ, Meinwald J. Reaction of enolate anions with lactones. Tetrahedron Lett 1978; 4323.

Duggan AJ, Hall SS, Weber GF. Relative reactivity of substituted 2-alkoxy and 2-phenoxy-3,4-dihydro-2H-pyrans with tert-butyl hypochlorite: Effect of substituents on reactivity and products. J Org Chem 1978; 43:667.

Duggan AJ, Hall SS. Addition of tert-butyl hypohalites to 3,4-dihydro-2H-pyran and its 2-alkoxy 6-methyl derivatives in hydroxylic solvents. J Org Chem 1977; 42:1057.

Duggan AJ, Eisner T, Kinnel R, Meinwald J, Miura I. Panacene: An aromatic bromoallene from a sea hare *(Aplysia brasiliana).* Tetrahedron Lett 1977; 3913.

Adams MA, Duggan AJ, Meinwald J. An adventitious synthesis of pederolactone. Heterocycles 1977; 7:989.

Duggan AJ, Hall SS. 3-Alkoxy-2-oxanorcarenes: synthesis of cyclopropanes from labile olefins using an improved lithium ammonia reduction procedure on the dichlorocarbene adducts. J Org Chem 1975; 40:2238.

Duggan AJ, Hall SS. The chemistry of 2-alkoxy-3 ,4-dihydro-2H-pyrans III: synthesis and solvolysis of the dichiorocarbene adducts 3-alkoxy-2-oxa-7,7-dichloro-norcaranes. J Organ Chem 1975; 40:2234.

Duggan AJ, Hall SS. The Chemistry of 2-aIkoxy~3,4-dihydro-2H-pyrans II: addition of dimethyl acetylenedicarboxylate. J Org Chem 1974; 39:3432.

Borer R, Duggan AJ, Muller R, Rosenberger M, Saucy G. Steroid total synthesis part 8; (+/-) - Estr4-ene-3,17-dione. Helvetica Chemica Acta 1972; 55:2663.

Duggan AJ, Rosenberger M, Saucy G. Steroid total synthesis part 7; **(+/-)** -Estr-4-ene-3, 17-dione and (j) 1 3-ethyl-gon-4-ene-3, 1 7-dione. Helvetica Chemica Acta 1972; 55:1333.

Rosenberger M, Andrews D, DiMaria F, Duggan AJ, Saucy G. Synthesis of delta-lactones from gluteraldehyde. Helvetica Chemica Acta 1972; 55:249.

Book Chapters

Duggan A. Putting the toxicology and risk assessment of approved organic pesticides in perspective. American Chemical Society Symposium Series 947: Crop Protection Products for Organic Agriculture, Environmental Health and Efficacy Assessment, 2006.

Duggan AJ. Endocrine issues update: pesticide formulations and application systems. 18th Volume, ASTM STP 1347, Monograph of the proceedings American Society for Testing and Materials, Pesticide Formulations and Application Systems San Diego, CA, October 1997.

Selected Published Abstracts

Duggan A. Regulatory science and risk assessment of endocrine-active substances. Presented at the IUPAC–KSPS International Workshop on Pesticides 2003, Seoul, Korea, October 2003.

Duggan A. Putting the toxicology and risk assessment of approved organic pesticides in perspective. American Chemical Society National Meeting, New Orleans, LA, March 2003.

Duggan, A. To what extent have we known about endocrine disruption chemicals? 3rd International Symposium on Environmental Endocrine Disrupters co-sponsored by the Japan Society of Endocrine Disrupter Research (JSEDR) and the Japan Environment Agency (JEA) Yokohama, Japan, December, 2000.

Selected Presentations

Duggan A. Biocompatibility: Risk analysis and safety evaluations, a risk assessor's perspective. Drexel University, Philadelphia, PA, May 2008.

Duggan A. Historical perspective of the endocrine disruption issue, EDSTAC and validation. Chair Session One: Background on the Endocrine Screening (EPA's EDSP Tier I), International Society of Regulatory Toxicology and Pharmacology, NIH Bethesda, MD, February 2008.

Duggan A. Consortia/Task Forces/SIEFS: Challenges in participation and organization. Personal Care Products Council REACH Symposium, Washington, DC, February 2008.

Duggan A. Interpreting biomonitoring in the context of risk assessment and liability. NJ Chapter of Society of Woman Environmental Professionals, Newark, NJ, January 2008.

Duggan A. Biocompatibility: Risk analysis and safety evaluations, a risk assessor's perspective. Drexel University, Philadelphia, PA, June 2007.

Duggan A. Interpreting biomonitoring in the context of risk assessment, introductory remarks. Presented at Society of Risk Analysis, Baltimore, MD, December 2006.

Duggan A. Regulatory science and risk assessment of endocrine-active substances. Presented at the IUPAC –KSPS International Workshop on Pesticides 2003, Seoul, Korea, October 2003.

Duggan A. Putting the toxicology and risk assessment of approved organic pesticides in perspective. Presented at the American Chemical Society National Meeting, New Orleans, LA, March 2003.

Duggan A. Toxicology rappateur. International Symposium on Agricultural Exposures and Cancer. Presented at Oxford University, Oxford, UK, November 2002.

Duggan A. The value of human data in conducting safety assessments. Presented at Chemicals Manufacturers and Distributor Association (CPDA) Annual Meeting, Washington, D.C., February 2001.

Duggan A. What are the actual risks to children and EPA regulation of pesticides. Presented and moderated expert panel discussion on children's health issues at the Responsible Industry for a Sound Environment (RISE) Annual Meeting, Palm Springs, FL, September 2001.

Duggan A. FQPA science and policy implications. Presented to the Agricultural Company and Banana Company Task Force, San Jose, Costa Rica, May 2000.

Duggan A. Industry perspective: to what extent have we known about endocrine disruption chemicals? Presented and participated on panel discussion, 3rd International Symposium on Environmental Endocrine Disrupters, co-sponsored by the Japan Society of Endocrine Disrupter Research (JSEDR) and the Japan Environment Agency (JEA), Yokohama, Japan, December, 2000.

Duggan A. US and EU endocrine disruption policy—Implications for Japan and Children's health initiatives: Potential emerging global policy issue. Presented to the Japanese Chemical Industry Association (JCIA) Tokyo, Japan, December 2000.

Duggan A. Endocrine Disruption Screening and Testing Committee (EDSTAC) update on priority setting. Presented at Chemical Manufacturers Association (now known as the American Chemistry Council, ACC) Endocrine Issues Science Forum, November 1999.

Duggan A. Evaluation of the endocrine disruption theory. Presented at University of Hawaii, Honolulu, Hawaii, July 1998.

Duggan A. Evaluation of the endocrine disruption theory. Presented Rutgers University New Brunswick, NJ, April 1998.

Duggan A. Progress report on the Endocrine Disruption Screening and Testing Committee (EDSTAC). Presented to Illinois EPA and Illinois Chemical Manufacturers Association, Chicago, IL, June 1997.

Duggan AJ. Endocrine issues update: pesticide formulations and application systems. Presented at American Society for Testing and Materials, Pesticide Formulations and Application Systems, San Diego, CA., October 1997.

Duggan A. Industry perspective on the endocrine disruption theory. Presented and participated in a panel discussion at the Responsible Industry for a Sound Environment (RISE) Annual Meeting, Washington, D.C., September, 1997.

Duggan, A. Endocrine disruption screening and testing advisory committee update. Presented at he American Crop Protection Association (now known as CropLife America, CLA) Spring Conference, May 1997.

Academic Appointments

- Adjunct Chemistry Lecturer, Rutgers University Newark, NJ, 1974

Consulting and Advisory Appointments

- International Society of Regulatory Toxicology and Pharmacology Board Councilor (Since 2005)
- ILSI International Biomonitoring Symposium (2004)
- International Life Sciences (ILSI) CARES Steering Committee (2004–2005)
- Children's Health Protection Advisory Committee (2001–2005)
- Harvard Center for Risk Analysis Advisory Committee (2002)
- American Crop Protection Association (now CropLife America) Biotechnology Steering Committee (1997)
- EPA Endocrine Disruption Screening and Testing Advisory Committee (1996–1998)

Peer Reviewer

- Journal of Organic Chemistry
- International Society of Exposure Assessment
- Regulatory Toxicology and Pharmacology
- Synthesis

Professional Affiliations

- American Chemical Society
- American College of Toxicology
- American Public Health Association (2004–2005)
- International Society of Regulatory Toxicology and Pharmacology
- CropLife America
- International Union of Pure and Applied Chemistry
- Phi Beta Kappa
- Sigma Xi
- Society of Risk Analysis
- Society of Toxicology
- Synthetic Organic Chemistry Manufacturers Association

Project Experience

Currently serving as Technical Project Manager for the Joints Inerts Task Force that required organizing 30 companies, registrants and suppliers in supporting more than 300 pesticide inerts surfactants to address Food Quality Protection Act EPA tolerance reassessment requirements.

Experienced in developing chemical cluster groups and structure to activity analyses to support data development plans for FIFRA, TSCA and REACH regulatory applications.

Provided intellectual property technology assessment evaluations and written expert declarations for pharmaceutical and chemical process chemistry and manufacturing patents that resulted in either successful defenses and or appeals.

Evaluated human health issues related to performance and biocompatibility of various medical devices.

Serving on Exponent Institutional Review Board to evaluate protocols, ethical (informed consent and questionnaires), and safety considerations, for observational studies involving human participants.

Experienced in the preparation and issues management of chemical and pesticide registration applications to gain approvals from EPA and international regulatory authorities. This has included EPA Pre-manufacture Notices (PMNs) and application of Read Across strategy to High Production Volume (HPV) testing.

Developed strategies and work plans to address regulatory issues for Toxic Substances Control Act (TSCA) 5e PMN from EPA Office of Pollution Prevention and Toxics (OPPT).

Experienced in conducing FIFRA and TSCA regulatory support and human health risk assessments for pesticide, industrial chemicals and fragrance chemical ingredients.

Experienced in preparing FDA applications to manufacture pesticide products as bulk pharmaceuticals, and UK Veterinary Medicines Directorate (VMD) applications for animal health use.

Provided Federal Insecticide and Fungicide and Rodenticide Act (FIFRA) human health risk assessment science and policy guidance for Washington DC trade pesticide association comprised of more than 50 member companies (basic and generic manufacturers), formulators, and distributors regarding crop and non-crop uses of pesticide products at both the Federal and State level.

Developed risk communications strategies and prepared documents on a broad array of EPA science and risk assessment regulations and policy: Food Quality Protection Act; human testing; cancer risk assessment,; endocrine issues; developmental neurotoxicity testing (DNT); environmental exposure and disease links; children's health; and farm family exposure issues.

Experienced in media relations including interviews to trade publications and the popular press.

Managed science and regulatory projects related to human testing and cancer risk of chemicals and pesticides.

Conducted due diligence for toxicology and product chemistry regulatory studies.

Provided chemical assessment expertise to support environmental forensics for 1,2,3 - trichloropropane.

Provided technical support to prepare pharmaceutical/agrochemical discovery and process chemistry patents.

Authored and organized numerous science policy and technical papers for US EPA Public Docket relating to the use of human data in risk assessment, FQPA 99.9 percentile of regulation, FQPA aggregate and cumulative risk assessment, children's health, EPA's aging initiative, endocrine disruption (priority setting, screening and validation), biomonitoring, and cancer risk assessment.

Experienced in developing and optimizing new chemical processes for pilot plant and production manufacturing.

Experienced in pesticide data compensation regulations and registrations support including the development of summary spreadsheets and costing of studies.

Managed Agency negotiations to address EPA Developmental Neurotoxicity Testing Data Call-in for more than 30 organophosphate insecticides.

Completed MBA course work and provided technical regulatory and business management support for agrochemical supplier and distributor contracts.

Presented oral and written public comments on EPA regulatory science and policy to the FIFRA Science Advisory Panel, Federal Advisory Committees, EPA Science Advisory Board, and at EPA technical briefings and workshops.

Represented pesticide and chemical industries, and provided presentations, at international symposiums for endocrine disruption, children's health, agrochemical cancer epidemiology and biomonitoring.

Project manager for development of multi-million dollar FQPA risk assessment software, the Cumulative Aggregate Risk Evaluation System (CARES).

Participated in global pesticide product stewardship and safety audits. Met with international regulators to remediate product specific human health and environmental safety concerns. Also authored the activity/conditions assessment checklist and criteria to audit US and international formulation/manufacturing plants and product supply/distributor business partners.

Provided project management for global regulatory affairs, product safety and development, including FIFRA 6(A)(2) and international conventions such as FAO Code of Conduct, Prior Informed Consent (PIC) Persistent Organic Pollutants (POPs) and CODEX.

Provided product-specific presentations and written communications to US EPA and international government authorities in Australia, Canada, Latin America (Brazil, Costa Rica, Guatemala, and Mexico), EU countries, and throughout Asia (including Korea, North Vietnam, India, China, Pakistan, Philippines, Indonesia, and Thailand) that saved multi-million dollar product registrations.

Provided project management, work plans, and timelines and negotiated intellectual property agreements for university and industrial partner R&D contracts that included discovery research and pharmaceutical uses of agrochemicals.

Managed strategic planning and implementation of agrochemical biotechnology and R&D discovery screening projects for natural products and synthetic chemicals.

Collaborated with laboratory and field biologists, toxicologists, metabolism and environmental scientists and business development staff to address field efficacy, toxicology and environmental safety issues and the economic viability of insecticide, fungicide and herbicide development candidates.

Secured and managed major contracts to acquire large blocks of chemicals from universities, small companies and major pharmaceutical and agrochemical companies to support automated high throughput screening laboratory.

Project manager for two $3 million dollar biotechnology discovery contracts, evaluating spider venoms and fermentation broths. Directed research of multi-disciplinary teams of company and external scientists, which resulted in patentable new leads and genetically engineered (baculovirus) product candidates.

Managed and prepared budgets for more than two dozen scientists, involved in all phases of agrochemical discovery research and product development, that included responsibility for external research programs and robotic high throughput screening, microbiology, NMR, HPLC analysis and chemical synthesis laboratories.

Experienced in the synthesis, isolation/structure elucidation and pharmaceutical and agrochemical screening of natural products derived from marine plants and animals (venoms) and microbial fermentation broths and plants (pharmacognosy).

Prior Experience

Human Health Science and Policy Leader and Director Science Policy, CropLife America (formerly America Crop Protection Association), 1999–2005
Global R&D Development and Regulatory Affairs Manager, FMC Corporation Agricultural Products Group, 1994–1999

Discovery Manager External Resources and Screening, FMC Corporation Agricultural Products Group, 1991–1994
New Leads Discovery Manager, FMC Corporation Agricultural Products Group, 1988–1991
Synthesis Manager, Insecticides, FMC Corporation Agricultural Products Group, 1985–1988
Senior Discovery Research Chemist, FMC Corporation Agricultural Products Group, 1983–1985
Process Research Senior Chemist, Merck, 1977–1983
Process and Medicinal Research Senior Chemist, Smith Kline French/Beecham, 1976–1977
Associate Chemist, Hoffmann-La Roche, 1967–1972

Exponent
149 Commonwealth Drive
Menlo Park, CA 94025

telephone 650-326-9400
facsimile 650-326-8072
www.exponent.com

Charlotte H. Edinboro, D.V.M., Ph.D.
Senior Scientist

Professional Profile

Dr. Charlene Edinboro is a Senior Scientist in Exponent's Health Sciences Center for Public Health and Industrial Hygiene. Dr. Edinboro has a diverse background in several disciplines including epidemiology, veterinary medicine, and aerospace engineering.

Dr. Edinboro's experience in epidemiology includes cancer epidemiology, nutritional epidemiology, exposure assessment, and pharmacoepidemiology. At Exponent, Dr. Edinboro has reviewed medical, epidemiologic, and toxicologic literature on numerous subjects, and provided estimates of incidence or prevalence of specific diseases for epidemiologic evaluations of environmental and occupational exposures. Dr. Edinboro has prepared state-of-the-art reviews for reports and manuscripts on environmental perchlorate exposures and thyroid function, as well as smoking, cardiovascular disease, and magnetic field exposure. Projects have included an analysis of newborn screening data and potential perchlorate exposure in drinking water, technical support to an expert panel and a manufacturer evaluating applicability of a screening test for occupational beryllium exposure, and research support for a project evaluating dietary supplements and potential adverse health outcomes. Dr. Edinboro reviewed evidence in a case alleging PCB exposure associated with neonatal foal morbidity and mortality. She used all facets of her education and experience in a dairy inspection where use of robotic milking machines was associated with reportedly higher rates of mastitis than before their use. Dr. Edinboro has participated in a safety evaluation of dog treat ingredients, in human food-borne outbreak investigations, and in projects related to animal disease potentially due to feeds or environmental exposures. Dr. Edinboro has provided a review of literature for potential health effects of fiducial marker use in several new applications, and has participated in other medical device projects. Her research has included studies of dietary and environmental risk factors for feline hyperthyroidism, clinical trials of vaccines in dogs and cats at humane shelters to evaluate effectiveness, and evaluation of the impact of repeated vaccination on the immune status of Great Danes. Her research interests include potential impacts of dietary and environmental exposures on the thyroid, small animal population disease control, and companion animals as sentinels for human health. Dr. Edinboro is a member of the American Thyroid Association's Public Health Committee (2007–2010).

Dr. Edinboro holds an active California veterinary license. As a small animal veterinarian, she has performed routine physical examinations and treatment, preventive care, routine surgeries, emergency medicine, and shelter animal medicine, including population disease control, forensics, zoonosis identification, and wildlife medicine. Dr. Edinboro is active with the Peninsula Veterinary Medical Association, serving as the 2008 president, and she has been a liaison with a local animal rescue group, a large humane society, and the local county health department. She volunteers as a feral cat spay/neuter clinic veterinarian.

Dr. Edinboro has over 20 years of experience in aerospace engineering. She worked in spacecraft control systems analysis, simulation software design and implementation, and

systems engineering, including requirements analysis, implementation, integration and test, documentation development, and on-site customer support for a variety of applications. As a team member, team leader, and coordinator of teams from diverse subcontractors, Dr. Edinboro has worked on several spacecraft programs and systems.

Academic Credentials and Professional Honors

Ph.D., Comparative Epidemiology, Purdue University, 2002
D.V.M., Veterinary Medicine, University of California, Davis, 1990
M.S., Aeronautics and Astronautics, Purdue University, 1976
B.S., Aeronautical and Astronautical Engineering, Purdue University, 1975

Veterinarian, California Veterinary Medical Board

Oxford Laboratories Award for Excellence in Advancing Knowledge of Small Animal Endocrinology, Society for Comparative Endocrinology, 2005; Recipient of Kenneth Scott Fellowship in Epidemiology and Animal Welfare, Purdue University, 1997–2001; Phi Zeta Veterinary Medicine Honor Society; Who's Who of American Women, 20th Edition, 1997–1998; Outstanding Young Women of America, 1986; TRW Certificate of Appreciation for the IUS Avionics Software Project; NASA Group Achievement Award for Voyager Spacecraft System Design and Development; NASA Group Achievement Award for Voyager Flight Operations; American Institute of Aeronautics and Astronautics Outstanding Student Branch Member, Purdue University, 1975–1976; Sigma Gamma Tau Aerospace Engineering Honor Society; Purdue University Special Merit and Alumni Association Scholarships

Prior Experience

Epidemiology
Post-Doctoral Research Assistant, Purdue University, School of Veterinary Medicine, Department of Veterinary Pathobiology, 2001–2002
Teaching Assistant, Purdue University, School of Veterinary Medicine, Department of Veterinary Pathobiology, 1999
Graduate Research Assistant, Purdue University, School of Veterinary Medicine, Department of Veterinary Pathobiology, 1997–2001

Veterinary Medicine
Small animal part-time and relief veterinarian at private practices and one large humane shelter in the San Francisco Bay Area, 1990–1997

Aerospace Engineering
Systems Engineer, Scitor Corporation, 1984–1986, summers 1987, 1988, 1989, 1990–1997
Staff Engineer, Ultrasystems Defense and Space Systems, Inc., 1982–1984
Member of the Technical Staff, TRW Defense Systems Group, 1979–1982
Engineer R&D, Ford Aerospace and Communications Corporation, 1979
Engineer II, III, Computing Analyst III, Jet Propulsion Laboratory, California Institute of Technology, 1976–1979

Publications

Edinboro CH, Kelsh MA, Lau EC. Demographic comparisons of two- v. one-stage testing results for primary congenital hypothyroidism screening in California, 1997–1998. (Abstract) Thyroid 2008; 18(s1):S-53-S-54.

Goldkamp CE, Levy JK, Edinboro CH, Lachtara JL. Seroprevalences of feline leukemia virus and feline immunodeficiency virus in cats with abscesses or bite wounds and rate of veterinarian compliance with current guidelines for retrovirus testing. J Am Vet Med Assoc 2008; 232(8): 1152–1158.

Levy JK, Edinboro CH, Glotfelty CS, Dingman, PA, West AL, Kirkland-Cady KD. Seroprevalence of *Dirofilaria immitis*, feline leukemia virus, and feline immunodeficiency virus in dogs and cats rescued from the 2005 Gulf Coast hurricane disaster. J Am Vet Med Assoc 2007; 231(2):218–225.

Edinboro CH. Companion animals may serve as sentinels of health risk—A review of thyroid diseases in three non-human species. (Abstract) Thyroid 2006; 16(9):908–909.

Buffler PA, Kelsh MA, Lau EC, Edinboro CH, Barnard JC, Rutherford GW, Daaboul JJ, Palmer L, Lorey FW. Thyroid function and perchlorate in drinking water: An evaluation among California newborns, 1998. Environ Health Perspect 2006; 114(5):798–804.

Mezei G, Cher D, Kelsh M, Edinboro C, Chapman P, Kavet R. Occupational magnetic field exposure, cardiovascular disease: mortality, and potential confounding by smoking. Ann Epidemiol 2005; 15(8):622–629.

Edinboro CH, Scott-Moncrieff JC, Glickman LT. Review of iodine recommendations for commercial cat foods and potential impacts of proposed changes. (Abstract) Thyroid 2004; 14(9):722.

Edinboro CH, Scott-Moncrieff JC, Glickman LT. Environmental risk factors for feline hyperthyroidism: Pet cats as potential sentinels for public health. (Abstract) Thyroid 2004; 14(9):759.

Edinboro CH, Scott-Moncrieff JC, Janovitz EB, Thacker HL, Glickman LT. Epidemiologic study of the relationships between commercial canned food consumption and the risk of hyperthyroidism in cats. J Am Vet Med Assoc 2004; 224(6):879–886.

Edinboro CH, Ward MP, Glickman LT. A placebo-controlled trial of two intranasal vaccines to prevent tracheobronchitis (kennel cough) in dogs entering a humane shelter. Prevent Vet Med 2004; 62(2):89–99.

Edinboro CH, Scott-Moncrieff JC, Tetrick M, Glickman LT. Dietary and environmental risk factors for clinical hyperthyroidism in pet cats. Abstract, Ann Epidemiol 2002; 12(7):509.

Edinboro CH. Dietary and environmental risk factors for feline hyperthyroidism. Dissertation. Department of Veterinary Pathobiology, Purdue University, 2002.

Edinboro CH, Janowitz LK, Guptill-Yoran L, Glickman LT. A clinical trial of intranasal and subcutaneous vaccines to prevent upper respiratory infection in cats at an animal shelter. Feline Practice 1999; 27(6):7–11, 13.

Book Chapter

Edinboro CH. Veterinary epidemiology. In: Encyclopedia of Epidemiology. Boslaugh S (ed), Thousand Oaks, CA: Sage Publications, pp. 1079–1083, 2007.

Presentations

Edinboro CH, Kelsh MA, Lau EC. Demographic comparisons of two- v. one-stage testing results for primary congenital hypothyroidism screening in California, 1997-1998. Poster, American Thyroid Association 79th Annual Meeting, Chicago, IL, October 2008.

Edinboro CH. Prevalence of feline leukemia and immunodeficiency viruses in feral cats on the San Francisco peninsula. Epidemiology Graduate Seminar, University of California, Davis, CA, November 2006.

Edinboro CH. Companion animals may serve as sentinels of health risk—A review of thyroid diseases in three non-human species. Poster, American Thyroid Association 77th Annual Meeting, Phoenix, AZ, October 2006.

Edinboro CH. Prevalence of feline leukemia and immunodeficiency viruses in feral cats on the San Francisco peninsula. Poster, 8th International Feline Retrovirus Research Symposium, Washington, DC, October 2006.

Edinboro CH. Prevalence of feline leukemia and immunodeficiency viruses in feral cats in San Francisco Bay Area. 11th International Symposium for Veterinary Epidemiology and Economics, Cairns, Queensland, Australia, August 2006.

Edinboro CH. Prevalence of obesity in dogs and obesity and asthma in cats presented to North American veterinary school hospitals. Poster, 11th International Symposium for Veterinary Epidemiology and Economics, Cairns, Queensland, Australia, August 2006.

Edinboro CH. Clinical trials of intranasal vaccines to prevent respiratory diseases in animal shelters. Epidemiology Graduate Seminar, University of California, Davis, CA, May 2005.

Edinboro CH, Scott-Moncrieff JC, Glickman LT. Review of iodine recommendations for commercial cat foods and potential impacts of proposed changes. Poster, American Thyroid Association 76th Annual Meeting, Vancouver, BC, Canada, September-October 2004.

Edinboro CH, Scott-Moncrieff JC, Glickman LT. Environmental risk factors for feline hyperthyroidism: Pet cats as potential sentinels for public health. Poster, American Thyroid Association 76th Annual Meeting, Vancouver, BC, Canada, September–October 2004.

Edinboro CH. Dietary and environmental risk factors for feline hyperthyroidism, or "there and back again." Peninsula Veterinary Medical Association, Belmont, CA, March 2004.

Mezei G, Cher D, Kelsh M, Chapman P, Edinboro C, Kavet R. Cardiovascular deaths and occupational exposure to magnetic fields in the national mortality followback survey. Poster, Bioelectromagnetics Society Annual Meeting, Wailea, Maui, HI, June 2003.

Edinboro CH, Scott-Moncrieff JC, Tetrick M, Glickman LT: Dietary and environmental risk factors for clinical hyperthyroidism in pet cats. Poster, American College of Epidemiology Annual Meeting, Albuquerque, NM, September 2002.

Edinboro CH. Do endocrine disrupters in canned food linings cause hyperthyroidism? Epidemiologic evidence from an animal model. Interdepartmental Nutrition Program Seminar Series, Purdue University, September 2002.

Edinboro CH. Disease recognition, prevention, and shelter programming for animal health. Indiana Association of Animal Control Personnel Conference, Indianapolis, IN, October 1999.

Academic Appointments

- Affiliate, University of Florida Maddie's® Shelter Medicine Program

Teaching Experience

- Teaching Assistant, Small Animal Epidemiology for third-year veterinary students, Purdue University, School of Veterinary Medicine, Department of Veterinary Pathobiology (8–10/99)

Research Experience

- Post-Doctoral Research Assistant, Great Dane Health and Vaccine Study, Purdue University, School of Veterinary Medicine, Department of Veterinary Pathobiology (11/01–10/02)
- Graduate Research Assistant, Purdue University, School of Veterinary Medicine, Department of Veterinary Pathobiology (8/97–11/01)
  - –Designed and conducted a controlled clinical trial to evaluate the efficacy of two intranasal vaccines for the prevention of upper respiratory disease (Kennel Cough) in dogs at a humane shelter
  - –Conducted case-control and cross-sectional studies to identify dietary and environmental risk factors for feline hyperthyroidism (PhD Research)

Peer Reviewer

- Journal of the American Animal Hospital Association – Section Editor for Study Design and Epidemiology
- American Journal of Veterinary Research
- Preventive Veterinary Medicine
- Toxicological Sciences

Professional Affiliations

- American Veterinary Medical Association
- American Thyroid Association
  – Public Health Committee Member, 2007–2010
- Association of Shelter Veterinarians
- American Association of Feline Practitioners
- Association for Veterinary Epidemiology and Preventive Medicine
- Society for Epidemiologic Research
- Peninsula Veterinary Medical Association (member, all executive offices held)
  – President, 2008 (second occasion)
- San Mateo County Animal Population Trust Fund Committee
- Center for Animal Protection and Education, Santa Cruz, CA (Advisory Board Member, former Board Member)
- Homeless Cat Network, San Carlos, CA (Veterinary Advisory Board Member)
- Peninsula Fix Our Ferals (Volunteer Veterinarian)

Exponent
15375 SE 30th Place
Suite 250
Bellevue, WA 98007

telephone 425-519-8700
facsimile 425-519-8799
www.exponent.com

Anne Fairbrother, D.V.M., Ph.D.
Senior Managing Scientist

Professional Profile

Dr. Anne Fairbrother is a Senior Managing Scientist in Exponent's EcoSciences practice, with more than 30 years of experience in ecotoxicology, wildlife toxicology, contaminated site assessment, and regulatory science for existing and emerging chemicals in the U.S. and Europe. She recently served on a Science Advisory Panel to the state of Utah and as a consultant to the British Columbia (BC) Ministry of Environment to set site-specific water quality standards for selenium that protect fish and wildlife. She has conducted large-area (>100 sq mile) risk assessments at mines in tropical, desert, and mountain ecosystems, determining risk thresholds for plants and wildlife. She provided consultation on future development of mine pit lakes, assessed the risk to livestock from use of wastewater on irrigated pasture during mine closure operations, and conducted an assessment of risk to terrestrial and aquatic organisms from an abandoned mercury mine. Dr. Fairbrother conducted an assessment of the potential ecological risks to aquatic life in San Francisco Bay and coastal southern California posed by use of copper pipes. She also assessed risks to wildlife at sites contaminated with organic chemicals, including DDT, PCBs, dioxins, and petroleum hydrocarbons in Delaware, Texas, Oregon, and California, integrating ecological risks with human health risk assessments.

As a consultant, Dr. Fairbrother has supported various chemical industry groups in compiling and reviewing data from the literature in support of both U.S. and European regulatory processes. Historically, this included preparation of screening information data sets (SIDs) for submission through EPA to the OECD's High Production Volume (HPV) data call-in program. More recently, she also has input the data into the IUCLID database for Europe-wide risk assessments and the REACH chemical registration program.

Dr. Fairbrother has participated in or led the development of guidance documents for ecological risk assessments. For example, she was co-author of the EPA's *Framework for Metals Risk Assessment* and for BC Ministry of Environment guidance for implementing Tier 1 ecological risk assessments of contaminated sites and for setting soil clean-up values, and participated in the development of Ecological Soil Screening Levels (Eco-SSLs) for EPA.

While a scientist at the EPA, Dr. Fairbrother led research into the ecological risks of bioengineered crops, methods for assessing risks of nanomaterials, and some of the early guidance for field assessments of Superfund sites and effects of pesticides on birds. She researched and developed methods for assessment of chemical effects on bird immune and endocrine systems.

Dr. Fairbrother has published more than 80 peer-reviewed articles and book chapters that reflect her expertise in wildlife toxicology, immunotoxicology, endocrine-disrupting chemicals, and ecological risk assessment. She serves on numerous scientific boards, expert panels, and

editorial boards in support of scientific and regulator y issues. A veterinarian and Certified Wildlife Biologist, Dr. Fairbrother served as President of the Society of Environmental Toxicology and Chemistry, American Association of Wildlife Veterinarians, and Wildlife Disease Association (WDA). She is the recipient of the WDA Distinguished Service Award (2002), and a gold medal for Commendable Service from EPA. Dr. Fairbrother holds an adjunct professorship at Oregon State University, Department of Environmental and Molecular Toxicology.

Academic Credentials and Professional Honors

Ph.D., Veterinary Science, University of Wisconsin, Madison, 1985
M.S., Veterinary Science, University of Wisconsin, Madison, 1982
D.V.M., Veterinary Medicine, University of California, Davis, 1980
B.S., Wildlife and Fisheries Biology, University of California, Davis, 1976

Distinguished Service Award, Wildlife Disease Association, 2002
Gold Medal for Commendable Service, EPA, 2005
Bronze Medal for Commendable Service, EPA, 2006, 2008

Licenses and Certifications

Certified Wildlife Biologist, The Wildlife Society, 1995
40-hour Hazwoper Training and Certification

Publications

Fairbrother A, Wentsel R, Sappington K, Wood W. Framework for metals risk assessment. Ecotox Environ Saf 2007; 68:145–227.

Nagy LR, Fairbrother A, Orme-Zavaleta J, Etterson M. The intersection of independent lies in ecological risk assessment. Hum Ecol Risk Assess 2007; 13:355–369.

Gallagher K, Benson WH, Brody M, Fairbrother A, Hasan J, Klaper R, Lattier D, Lundquist S, McCarroll N, Miller G, Preston J, Sayre P, Seed J, Smith B, Street A, Troast R, Vu V, Reiter L, Farland W, Dearfield K. Genomics: Applications, challenges and opportunities for the U.S. EPA. Hum Ecol Risk Assess 2006; 12(3):572–590.

Suter II GW, Norton SB, Fairbrother A. Individuals versus organisms versus populations in the definition of ecological assessment endpoints. Integrated Environ Assess Mgmt 2005; 1:397–400.

Fairbrother A, Turnley JG. Predicting risks of uncharacteristic wildfires: Application of the risk assessment process. Forest Ecol Mgmt 2005; 211:28–35.

Bennett RS, Dewhurst I, Fairbrother A, Hart ADM, Hooper M, Leopold A, Mineau P, Mortensen S, Shore RF, Springer TA. A new interpretation of avian and mammalian reproduction toxicity test data in ecological risk assessment. Ecotoxicol 2005; 14(8):1–15.

Shore RF, Crocker DR, Akcakaya HR, Bennett RS, Chapman PF, Clook M, Crane M, Dewhurst IC, Edwards PJ, Fairbrother A, Ferson S, Fischer D, Hart ADM, Holmes M, Hooper MJ, Lavine M, Leopold A, Luttik R, Mineau P, Moore DRJ, Mortenson SR, Noble DG, O'Connor RJ, Roelofs W, Sibly RM, Smith GC, Spendiff M, Springer TA, Thompson HM, Topping C. Case Study Part 1: How to calculate appropriate deterministic long-term toxicity to exposure ratios (TERs) for birds and mammals. Ecotoxicol 2005; 14(8):1–17.

Roelofs W, Crocker DR, Shore RF, Moore DRJ, Smith GC, Akcakaya HR, Bennett RS, Chapman PF, Clook M, Crane M, Dewhurst I, Edwards PJ, Fairbrother A, Ferson S, Fischer D, Hart ADM, Holmes M, Hooper MJ, Lavine M, Leopold A, Luttik R, Mineau P, Mortenson SR, Noble DG, O'Connor RJ, Sibly RM, Spendiff M, Springer TA, Thompson HM, Topping C. Case Study Part 2: Probabilistic modelling of long-term effects of pesticides on individual breeding success in birds and mammals. Ecotoxicol 2005; 14(8):1–29.

Clark J, Oretgo L, Fairbrother A. Sources of variability in plant toxicity testing. Chemosphere: Environ Toxicol Risk Assess 2004; 57:1599–1612.

Watrud LS, Lee Eh, Fairbrother A, Burdick C, Reichman JR, Bollman M, Storm M, King G, Van de Water PK. Evidence for landscape-level, pollen-mediated gene flow from genetically modified creeping bentgrass with CP4 EPSPS as a marker. Proc Natl Acad Sci 2004; 101(40):14533–14538.

Fairbrother A, Smits J, Grasman K. Avian immunotoxicology. J Toxicol Environ Health, Part B 2004; 7:105–137.

Fairbrother A. Lines of evidence in ecological risk assessment. Human Ecol Risk Assess 2003; 9:1475–1491.

Sappington K, Fairbrother A, Wentsel R, Wood W. Development of a framework for risk assessment of metals. J Environ Mgmt 2003; 5:122–132.

Brewer L, Fairbrother A, Clark J, Amick D. Acute toxicity of lead, steel, and an iron-tungsten-nickel shot to mallard ducks (Anas platyrhynchos). J Wildl Dis 2003; 39(3):638–648.

Adams WA, Brix KV, Edwards M, Tear LM, DeForest DK, Fairbrother A. Analysis of field and laboratory data to derive selenium toxicity thresholds for birds. Environ Toxicol Chem 2003; 22(9):2020–2029.

Phipps T, Tank SL, Brewer L, Wirtz J, Coyner A, Ortego LS, Fairbrother A. Essentiality of nickel and homeostatic mechanisms for its regulation in terrestrial organisms. Environ Rev./Dossiers Environ 2002; 10(4):209–261.

Stroo HF, Jensen R, Loehr RC, Nakles DV, Fairbrother A, Liban CB. Environmentally acceptable endpoints for PAHs at a manufactured gas plant site. Environ Sci Technol 2000; 34(18):3831–3836.

Fairbrother A. Comparative aspects of estrogen functions and measurements in oviparous and viviparous vertebrates. Human Ecol Risk Assess 2000; 6:73–102.

Fairbrother A, Brix KV, DeForest DK, Adams WJ. Egg selenium thresholds for birds: A response to J. Skorupa's critique of Fairbrother et al., 1999. Human Ecol Risk Assess 2000; 6:203–212.

Fairbrother A, Brix KV, Toll JE, McKay S, Adams WJ. Egg selenium concentrations as predictors of avian toxicity. Human Ecol Risk Assess 1999; 5:1229–1253.

Fairbrother A, Bennett RS. Ecological risk assessment and the precautionary principal. Human Ecol Risk Assess 1999; 5:943-950.

Glicken J, Fairbrother A. Environment and social values. Human Ecol Risk Assess 1998; 4:779–786.

Ozman M, Dominguez SE, Fairbrother A. Effects of dietary azinphos methyl on selected plasma and tissue biomarkers of the gray-tailed vole. Bulletin of Environ Contam Toxicol 1998; 60:194–201.

Fairbrother A, Landis WG, Dominguez S, Shiroyama T, Buchholz P, Roze MJ, Matthews GB. A novel nonmetric multivariate approach to the evaluation of biomarkers in terrestrial field studies. EcoToxicol 1998; 7:1–10.

Chapman, P. M., Fairbrother A, Brown D. A critical evaluation of safety (uncertainty) factors for ecological risk assessment. Environ Toxicol Chem 1998; 17(1):99–108.

Fowles JR, Fairbrother A, Kerkvliet NI. Effects of induced hypo and hyperthyroidism on immune function and plasma biochemistry in mallards (Anas platyrhynchos). Comp BioChem Physiol 1997; 118C:213–220.

Fowles JR, Fairbrother A, Trust KA, Kerkvliet NI. Effects of Aroclor-1254 on the thyroid gland, immune function, and hepatic cytochrome P-450 activity in mallards. Environ Research 1997; 75:119–129.

Fairbrother A, Kapustka LA, Williams BA, Bennett RS. Effects-initiated assessments are not risk assessments. Human Ecol Risk Assess 1997; 3:119–124.

Kapustka LA, Williams BA, Fairbrother A. Evaluating risk predictions at population and community levels in pesticide registration--hypotheses to be tested. Environ Toxicol Chem 1996; 15:427–431.

Larson OR, Schwab RG, Fairbrother A. Seasonal occurrence of fleas (Siphonaptera) on deer mice (Peromyscus maniculatus) in Northern California. J Vector Ecol 1996; 21:31–36.

Fairbrother A, Kapustka LA, Williams BA, Glicken J. Risk assessment in practice: Success and failure. Human Ecol Risk Assess 1995; 1:367–375.

Fowles J, Fairbrother A, Baecher-Steppan L, Kerkvliet NI. Immunologic and endocrine effects of the flame-retardant pentabromodiphenyl ether (DE-71) in C57B1/6J mice. Toxicol 1994; 86:49-61.

Marden B, Fairbrother A, Bennett J. Interlaboratory comparison of cholinesterase assay. Environ Toxicol Chem 1994; 13:1761–1768.

Trust KA, Fowles JR, Hooper MJ, Fairbrother A. Cyclophosphamide effects on immune function of European starlings. J Wildl Dis 1994; 30:328–334.

Fairbrother A, Fix M, O'Hara T, Ribic CA. Impairment of growth and immune function of avocet chicks from sites with elevated selenium, arsenic, and boron. J Wildl Dis 1994; 30:222–233.

Trust KA, Fairbrother A, Hooper MJ. Effects of 7,12-dimethylbenz[a]anthracene on immune function and mixed-function oxygenase activity in the European starling. Environ Toxicol Chem 1994; 13:821–830.

Fowles JR, Kerkvliet N, Fix M, Fairbrother A. Glucocorticoid effects on natural killer cell activity, antibody response, and plasma chemistry in mallards. Comp Develop Immunol 1993; 17:165–177.

Dominguez SE, Mnkel JL, Fairbrother A, Williams BA, Tanner RW. Effect of 2,4-dinitrophenol on metabolic rate of bobwhite quail. J Appl Toxicol Pharmacol 1993; 123:226–233.

Buchholz P, Fairbrother A. Pathogenicity of Salmonella pullorum in northern bobwhite quail and mallard ducks. Avian Dis 1992; 36:304–312.

Marden BT, Fowles JR, Fairbrother A. [3H]Nmethylscopolamine binding to heart atrium and four brain regions from the mallard. Comp. BioChem and Physiol 1992; 103:115–120.

Fairbrother A, Fowles J. Subchronic effects of sodium selenite and selenomethionine on immune functions of the mallard. Arch Environ Contam Toxicol Chem 1990; 19:836–844.

Fairbrother A, O'Loughlin D. Hematological values of the mallard (Anas platyrhynchos) during different reproductive states. J Wildl Dis 1990; 26:78–82.

Fairbrother A, Craig MA, Walker K, O'Loughlin D. Changes in mallard (Anas platyrhynchos) serum chemistries due to age, sex, or reproductive condition. J Wildl Dis 1990; 26:67–77.

Fairbrother A, Wagner SL, Welch S, Smith BB. Influence of menstrual cycle on serum cholinesterase. Environ Health 1989; 49:181–189.

Fairbrother A, Bennett JK. The usefulness of cholinesterase measurements. J Wildl Dis 1988; 24(3):587–590.

Fairbrother A, Bennett RS, Bennett JK. Sequential sampling of plasma cholinesterase (ChE) in mallards (Anas platyrhynchos). Environ Toxicol Chem 1987; 8:117–122.

Fairbrother A, Bennett RS. Changes in mallard hen behaviors in response to methyl parathion-induced illness of ducklings. Environ Toxicol Contam 1987; 7:499–503.

Crawford JA, Cole PJ, Kilbride KM, Fairbrother A. Atypical plumage of a female California quail. Cal Fish Game 1987; 73:244–247.

Knittel MD, Fairbrother A. Effect of either above optimum temperature or low pH on survival of free virus of Autographa californica nuclear polyhedrosis virus. Appl Environ Microbiol 1987; 53: 2771–2773.

Fairbrother A, Yuill TM. Experimental infection and horizontal transmission of Modoc virus in deer mice (Peromyscus maniculatus). J Wildl Dis 1987; 23:179–185.

Fairbrother A, Yuill TM, Olson LJ. Effects of three plant growth regulators on the immune response of young and aged deer mice (Peromyscus maniculatus). Arch Environ Contam Toxicol 1986; 15:265–275.

Paull JA, Fairbrother A. Vaginal lavage for pregnancy diagnosis in deer mice, Peromyscus maniculatus. J Exp Zool 1985; 233:143–149.

Fairbrother A, Yuill TM. Experimental viral infections of deer mice (Peromyscus maniculatus). J. Mammal. 1984; 65:499–503.

Fairbrother A, Yuill TM, Olson LJ. Effects of ingestion of chlorocholine chloride and cyclophosphamide on Venezuelan equine encephalitis virus infections in deer mice (Peromyscus maniculatus). Toxicol 1984; 31:67–71.

Porter WP, Hinsdill RD, Fairbrother A, Olson LJ, Jaeger J, Yuill TM, Bisgaard S, Hunter WG, Nolan K. Toxicant-disease-environment interactions associated with suppression of immune system, growth and reproduction. Science 1984; 224:1014–1017.

Glicken (Fairbrother) A, Schwab RG. Modes of ectoparasite reinfestations of deer mice (Peromyscus maniculatus). J Wildl Dis 1980; 16:577–586.

Glicken (Fairbrother) A, Kendrick JW. Hoof overgrowth in Holstein Frisian dairy cattle. J Heredity 1977; 68:386–390.

Books

Clark J, Fairbrother A, Kapustka LA. Adaptation and acclimation of terrestrial organisms to metals in soil. International Copper Association Special Publication, SETAC Press, Pensacola, FL, 2001.

Fairbrother A. Seminars in Avian and Exotic Pet Medicine—Toxicology. Guest Editor and Introduction for Volume 8(1). WB Saunders Company, Philadelphia, PA, 1999.

Fairbrother A, Kapustka LA. Hazard classification of inorganic substances in terrestrial systems. International Council on Metals and the Environment, Ottowa, Canada, 1997.

Glickman L, Fairbrother AA, Guarino M, Bergman HL, Buck WB, Cork LC, Hayes HM, Legator SM, McConnell EE, Mcnelis DN, Temple SA. The use of animals as sentinels of environmental health hazards. National Academy Press, Washington, DC, 1991.

Book Chapters

Fairbother A. Risk management safety factors. In: Encyclopedia of Ecology. Jorgensen SE (ed), Elsevier: Oxford, 2008.

Lewis MA, Fairbrother A, Menzer RE. Methods in environmental toxicology. In: Principles and Methods of Toxicology, Fifth Edition. Hayes AW (ed), Taylor and Francis: Philadelphia, PA, 2007.

Fairbrother A, Hope B. Terrestrial ecotoxicology. pp. 138–142. In: Encyclopedia of Toxicology, Second Edition. Wexler, P. (ed), Elsevier: Oxford, 2005.

Mount DR, Ankley GT, Brix KV, Clements WH, Dixon DG, Fairbrother A, Hickey CW, Lanno RP, Lee CM, Munns WR, Ringer RK, Staveley JP, Wood CM, Erickson RJ, Hodson PV. Effects assessment. pp. 53–118. In: Reevaluation of the State of the Science for Water-Quality Criteria Development. Reiley MC, et al. (eds), SETAC Press: Pensacola, FL, 2003.

Fairbrother A, Kapustka LA. A historical perspective of environmental concerns to frame the issues. pp. 1–17. In: High-Potency Herbicides Impact on Nontarget Plants. Ferenc SA (ed), SETAC Press: Pensacola, FL, 2001.

Fairbrother A. Putting the impacts of environmental contamination in perspective. pp. 671–689. In: Ecotoxicology of Wild Mammals. Shore RE, Rattner BA (eds), Ecological and Environmental Toxicology Series, John Wiley and Sons: Chichester, UK, 2001.

Fairbrother A, Lewis MA, Menzer RE. Methods in environmental toxicology. In: Principals and Methods of Toxicology, Fourth Edition. Hayes AW (ed), Taylor and Francis: Philadelphia, PA, 2000.

Fairbrother A, Bennett RS. Multivariate statistical applications for addressing multiple stresses in ecological risk assessments. pp. 69–115. In: Multiple Stressors in Ecological Risk and Impact Assessment: Approaches in Risk Estimation. Ferenc SA, Foran JA (eds), SETAC Press: Pensacola, FL, 2000.

Fairbrother A, Ankley GT, Birnbaum LS, Bradbury SP, Francis B, Gray LE, Hinton D, Johnson LL, Peterson RE, Van Derkraak G. Reproductive and developmental toxicology of contaminants in oviparous animals. pp 283–362. In: Reproductive and Developmental Effects

of Contaminants in Oviparous Vertebrates. In: DiGiulio RT, Tillit DE (eds), SETAC Press: Pensacola, FL, 1999.

Klump JU, Adams WJ, Cardwell R, Fairbrother A, Harris HJ, Ingersoll CG, Power M, Reid LM. Conceptual approaches to identify and assess multiple stressors. pp. 1–26. In: Multiple Stressors in Ecological Risk and Impact Assessment. Foran JA, Ference SA (eds), SETAC Press: Pensacola, FL, 1999.

Kelsch T, Powell RL, Dixon KR, Fairbrother A, Helgen JC, Klaine SJ, Mayer FL, Pascoe GA, Shaw SL, Theriot RF. Regulatory issues and risk assessment. pp. 275–314. In: Ecotoxicology and Risk Assessment for Wetlands. Lewis MA, Mayer FL, Powell RL, Nelson MK, Klaine SJ, Henry MG, Dickson GW (eds), SETAC Press: Pensacola, FL, 1999.

Peakall DB, Fairbrother A. Biomarkers for monitoring and measuring effects. pp. 351–376. In: Pollution Risk Assessment and Management. Douben PET (ed), John Wiley and Sons: Chichester, UK, 1998.

Fairbrother A. Establishing the health of ecosystems. pp. 101–108. In: Multiple Stresses on Ecosystems. Cech JJ, Wilson BA, Crosby DG (eds), Lewis Publishers: Boca Raton, FL, 1998.

Fairbrother A. Ecotoxicological principles for avian field studies. pp. 11–16. In: Radiotelemetry for Avian Field Studies. Brewer LW, Fagerstone KA (eds), SETAC Press: Pensacola, FL, 1998.

Kapustka LA, Fairbrother A, Williams BA, Glicken J, Bennett RS. Environmental risk assessment for sustainable cities. Technical Publication Series [3], UNEP International Environmental Technology Centre, Osaka, Japan, 1996. ISBN 92-807-1505-4.

Fairbrother A. Cholinesterase inhibitors. In: Non-Infectious Diseases of Wildlife, Second Edition. Fairbrother A, Locke L, Hoff GL (eds), Iowa State University Press, Ames, IA, 1996.

Fairbrother A, Knapp CM. Ecological aspects of land spreading sewage sludge. pp. 75–80. In: Sewage Sludge: Land Utilization and the Environment. Clapp CE (ed), ASA-CSSA-SSSA, Madison, WI, 1994.

Menzer RE, Lewis MA, Fairbrother A. Methods in environmental toxicology. pp. 1391–1418. In: Principles and Methods of Toxicology, Third Edition. Hayes AW (ed), Raven Press, New York, NY, 1994.

Fairbrother A. Clinical enzymology. pp. 63–92. In: Nondestructive Biomarkers in Vertebrates. Fosi C, Leonzio C (eds), Lewis Publishers: Boca Raton, FL, 1993.

Fairbrother A. Immunotoxicology of captive and wild birds. pp. 251–262. In: Wildlife Toxicology and Population Modeling: Integrated Studies of Agroecosystems. Kendall R, Lacher TE (eds), Lewis Publishers: Boca Raton, FL, 1993.

Weeks BA, Anderson DP, DuFour AP, Fairbrother A, Goven AJ, Lahvis GP, Peters G. Immunological biomarkers to assess environmental stress. pp. 212–234. In: Biomarkers: Biochemical, Physiological, and Histological Markers of Anthropogenic Stress. Huggett RJ, Kimerle RA, Mehrle PM, Bergman HL (eds), Lewis Publishers: Boca Raton, FL, 1992.

Fairbrother A. Decontamination and mitigation of baculoviruses. pp. 843–850. In: Microbial Ecology: Principles, Methods, and Application to Environmental Biotechnology. Levin M, Seidler R, Rogul M (eds), McGraw Hill: New York, NY, 1991.

Rattner BA, Fairbrother A. Sources of variability in cholinesterase measurements. pp. 89–108. In: Cholinesterase-Inhibiting Insecticides—Their Impact on Wildlife and the Environment. Mineau P (ed), Elsevier Science Publishers B.V., Amsterdam, Holland, 1990.

Fairbrother A, Bennett JK, Marden B, Hooper NJ. Methods of cholinesterase analysis, A United States perspective. pp. 35–72. In: Cholinesterase-Inhibiting Insecticides—Their Impact on Wildlife and the Environment. Mineau P (ed), Elsevier Science Publishers B. V., Amsterdam, Holland, 1990.

Books Edited

Fairbrother A (ed). Test Methods for Hazard Determination of Metals and Sparingly Soluble Metal Compounds in Soils. SETAC Press: Pensacola, FL, 2002.

Fairbrother A, Locke L, Hoff, GL (eds). Non-Infectious Diseases of Wildlife, Second Edition. Iowa State University Press: Ames, IA, 1996.

Selected Published Abstracts

International

Fairbrother A, Wentsel R, Wood W, Sappington K, Noyes P. Framework for inorganic metals risk assessment. Presented at Society of Environmental Toxicology and Chemistry Annual Meeting, Montreal, Canada, November 2006.

Gallagher K, Morris J Willis, J., Alwood A, Bauer D, Boethling R, Brody M, Burgin D, Chow F, Dreher K, Fairbrother A, Henry T, Karn B, Libelo L, Lingle S, Nabholz J, Prothero S, Savage N, Sayre P, Scalera J, Schoepf W, Street A, Utterback D, Williamson T, Zepp R. Nanotechnology: environmental opportunities and challenges. Presented at Society of Environmental Toxicology and Chemistry Annual Meeting, Montreal, Canada, November 2006; and Society for Risk Analysis Meeting, Baltimore, MD, December 2006.

Schumaker N, Nagy L, Fairbrother A. PATCH: A spatically explicit wildlife population model for assessing risks of pesticides to songbirds. Presented at the Wildlife Disease Association World Congress, Cairns, Australia, June 2005.

Fairbrother A, Wentsel R. Framework for inorganic metals risk assessment. Presented at Society of Environmental Toxicology and Chemistry, European Annual Meeting, Lille, France, May 2005.

Fairbrother A. Communicating probabilistic risk outcomes to risk managers. Presented at Society of Environmental Toxicology and Chemistry, European Annual Meeting, Hamburg, Germany, April 2003.

Clark J, Fairbrother A, Brewer L, Bennett RS. Effects of exogenous estrogen on mate selection of house finches. Presented at Society of Environmental Toxicology and Chemistry, European Annual Meeting, Vienna, Austria, May 2002.

Blanton ML, Driver CJ, Fairbrother A, Touart L. Detailed review paper for an avian two-generation and partial life-cycle reproductive and developmental toxicity test. Presented at Society of Environmental Toxicology and Chemistry, European Annual Meeting, Vienna, Austria, May 2002.

Trust KA, Fairbrother A, Hooper MJ. Effects of 7,12-dimethylbenz[a]anthracene on immune function and mixed-function oxygenase activity in the European starling. Society of Toxicology Annual Meeting, New Orleans, LA, March 1993; and Wildlife Disease Association Annual Meeting, Guelph, Canada, August 1993.

Fairbrother A. Biomarkers in wildlife. Society of Environmental Toxicology and Chemistry Annual Meeting, Toronto, Canada, November, 1989.

Fairbrother A. Immunotoxicology of wild and laboratory birds. Wildlife Disease Association 6th International Meeting, East Berlin, GDR, August, 1990.

Yuill TM, Hinsdill RD, Porter WJ, Fairbrother A. The hidden challenge: determining sublethal effects of wildlife diseases. Wildlife Disease Association 6th International Meeting, East Berlin, GDR, August, 1990.

National

Fairbrother A, Dohmen P, Marchand M, McCarty LS, Solomon K. Use of (Eco) toxicity data as screening criteria for the identification and classification of PBT / POP compounds. Presented at the Society of Environmental Toxicology and Chemistry Annual Conference, Tampa, FL, November 2007.

DeForest D, Fairbrother A, Adams BA. Selenium hormesis in birds—Implications for developing dietary and egg-based toxicity thresholds. Presented at the Society of Environmental Toxicology and Chemistry Annual Conference, Tampa, FL, November 2007.

Grim KC, Fairbrother A, Monfort S, Tan S, Rattner B, Gerould S, Beasley V, Aguirre A, Rowles T. Results of a wildlife toxicology workshop held by the Smithsonian Institution—Identification and prioritization of problem statements. National Presented at the Society of

Environmental Toxicology and Chemistry Annual Conference, Milwaukee, WI, November 2007.

Hope B, Allard P, Fairbrother A, Hull R, Johnson MS, Kapustka LA, McDonald B, Sample BE. Representation and consequences of uncertainty in the toxicity reference value. Presented at the Society of Environmental Toxicology and Chemistry Annual Conference, Milwaukee, WI, November 2007.

Allard P, Hill R, Mann G, Mackintosh C, Hull R, Kapustka LA, Mcdonald B, Hope B, Sample BE, Fairbrother A, Johnson MS. Using dose-response relationships for wildlife TRVs. Presented at the Society for Risk Analysis Annual Conference, Milwaukee, WI, November 2007.

Kapustka L, Fairbrother A, Sample BE. Linking assessment endpoints and wildlife TRVs. Presented at the Society for Risk Analysis Annual Conference, Milwaukee, WI, November 2007.

Hull RN, Allard P, Fairbrother A, Hope B, Johnson MS, Kapustka LA, McDonald B, Sample BE. Summary of recommendations for wildlife TRV development and use. Presented at the Society of Environmental Toxicology and Chemistry Annual Conference, Milwaukee, WI, November 2007.

Fairbrother A. Environmental immunotoxicants: Human-wildlife relationships. Presented at the Society of Environmental Toxicology and Chemistry Annual Conference, Milwaukee, WI, November 2007.

Fairbrother A, Sappington K, Wentsel R, Menzie C, Bottimore D, Downey P, Haber L, Harding-Barlow I, Nelson M, Thornton K. Principles for Metals Risk Assessment USEPA Framework. Presented at the Society for Risk Analysis Annual Conference, Baltimore, MD, December 2006.

Fairbrother A, Wentsel R, Sappington K, Wood W, P. Noyes. Framework for inorganic metals risk assessment. Presented at Society of Environmental Toxicology and Chemistry Annual Meeting, Montreal, Canada, November 2006.

Morzillo AT, Fairbrother A. Effects of human activities on resident mammals within urban ecosystems. Presented at the 86th Annual Meeting of the American Society of Mammalogists meeting, Amherst, MA, June 2006.

Smith C, Stubblefield W, Clark J, Fairbrother A, Allen H, Schoeters I, Dwyer R. Distribution of soil bioavailability parameters throughout Europe and development of metalloregions. Major Scientific/Technical Contributions. Presented at Society of Environmental Toxicology and Chemistry Annual Meeting, Portland, OR, November 2004.

Wentsel R, Fairbrother A. Overview of the development of the Framework for Metals Risk Assessment. Presented at Society of Environmental Toxicology and Chemistry Annual Meeting, Portland, OR, November 2004.

Fairbrother A. Comparison of European and United States approaches to new and existing substances regulation. Presented at Society of Environmental Toxicology and Chemistry Annual Meeting, Portland, OR, November 2004.

Adams W, Brix K, DeForest D, Toll J, Fairbrother A, Kapustka L. Ecological risk assessment at a copper smelter. Presented at Society of Environmental Toxicology and Chemistry Annual Meeting, Portland, OR, November 2004.

Suter II GW, Fairbrother A, Munns Jr WR, Norton SB, Wentsel R, Kravitz MJ. Individuals versus organisms versus populations in the definition of ecological assessment endpoints. Presented at Society of Environmental Toxicology and Chemistry Annual Meeting, Portland, OR, November 2004.

Smolders E, Fairbrother A, Hale B, Lombi E, McGrath S, McLaughlin M, Rutgers M, Van der Vliet L. Hazard assessment of metals and metal compounds in terrestrial systems. Presented at Society of Environmental Toxicology and Chemistry Annual Meeting, Austin, TX, November 2003.

Adams WJ, Tear LM, Edwards M, Fairbrother A, Brix KV. Re-analysis of field data used to derive selenium toxicity thresholds for birds. Presented at Society of Environmental Toxicology and Chemistry Annual Meeting, Nashville, TN, November 2000.

Fairbrother A. Values of constructed and natural ecosystems: Are they equivalent? Presented at Society for Risk Analysis Annual Meeting, Arlington, VA, December 2000.

Fairbrother A, Tear L, Toll J. Probabilistic risk assessment of methiocarb in terrestrial agroecosystems. Presented at Society of Environmental Toxicology and Chemistry Annual Meeting, Nashville, TN, November 2000.

McQuillen H, Brewer L, Fairbrother A, Clark J, Bennett RS, Fry DM. Field deployable techniques to monitor exposure to environmental estrogens throughout the reproductive cycle of wild birds. Presented at Society of Environmental Toxicology and Chemistry Annual Meeting, Nashville, TN, November 2000.

Fairbrother A. A critical review of avian test methods for endocrine disrupting activity of environmental chemicals. Presented at Society of Environmental Toxicology and Chemistry Annual Meeting, Philadelphia, PA, November 1999.

Fairbrother A, Bennett RS. Environmental risk assessment and the precautionary principle. Presented at Society of Environmental Toxicology and Chemistry Annual Meeting, Charlotte, NC, November 1998.

Fairbrother A, Bennett RS. Ecological risk assessment at the Mother Lode mercury mine, Ochoco National Forest. The 47th Annual Meeting of the Wildlife Disease Association, Madison, WI, August 1998.

O'Hara T, Franson C, Fairbrother A. Forensic investigations of wildlife: contaminants. Presented at Society of Environmental Toxicology and Chemistry Annual Meeting, San Francisco, CA, November 1997.

Clark J, Fairbrother A, Brewer L, McQuillen H, Bennett RS. Effects of exogenous estrogen on mate selection of house finches. Presented at Society of Environmental Toxicology and Chemistry Annual Meeting, Nashville, TN, November 2000.

Invited Presentations

International

Fairbrother A. Environmental effects of manufactured nanomaterials. Invited plenary presentation at SETAC World Conference, Sydney, Australia August 2008.

Fairbrother A. Ecological risk assessment and wildlife toxicology. 1st International Conference on Environmental Issues, Hanoi, Vietnam, March 2004.

Fairbrother A. Genetically modified foods: Technological breakthrough or ecological nightmare? Keynote address at SETAC Asia Pacific conference, Christchurch, New Zealand, September 2003.

Fairbrother A, Turnley JG. Communication of probabilistic risk assessments. Invited presentation in special symposium on Probabilistic Risk Assessment at SETAC Europe 13th annual conference, Hamburg, Germany, April 2003.

Clark J, Fairbrother A, Brewer L, Bennett RS. Effect of exogenous estrogen exposure on mate selection by the female house finch. Invited presentation at SETAC Europe 12th Annual Conference, Vienna, Austria, May 2002.

Robinson S, Fairbrother A. Human health risks from organotins in household products. Proceedings of the Organotin Environmental Programme Association Meeting, Sardinia, Italy, October 2000.

Fairbrother A, Brix KV, DeForest DK, Adams WJ. Critical review of tissue-based selenium toxicity thresholds for fish and birds. Presented at Mine Reclamation Symposium, Williams Lake, British Columbia, June 2000.

Fairbrother A. Fellow of the Crown Research Institute, Wellington, New Zealand. Invited lectures to scientific staff, regulators and academics (University of NZ, Christchurch), October 2000.

Fairbrother A. Keynote speaker and invited lecturer, Zoo and Wildlife Veterinary Medicine, Continuing Education. Western Plains Zoo, Dubbo, Australia. September 1999.

Fairbrother A. Tier 1 (Screening Level) risk assessments in British Columbia. Workshop sponsored by the Ministry of the Environment, Vancouver, BC, November 1998.

National

Plenary: Federal environmental legislation in the U.S. for protection of wildlife and regulation of environmental contaminants. Smithsonian Wildlife Toxicology Symposium, Washington DC March 2007.

Keynote: History of development and use of bioindicators and biomarkers in the U.S. 14th International Conference on Bioindicators. Baltimore, MD April 2006.

Lecture: RCRA and CERCLA: Environmental containment, contamination, and clean up. School of Veterinary Medicine, University of Illinois, March 2005.

Co-instructor: Introduction to Ecological Risk Assessment. Dept. of Fisheries and Wildlife *and* Dept. of Environmental and Molecular Toxicology, Oregon State University, Corvallis, OR, Winter 2003–2007.

Lectures: Risk assessment overview and introduction to TSCA and FIFRA. Presented in an upper division graduate level course on environmental studies. Department of Environmental Science, Oregon State University, Corvallis, OR, Fall 2002, Winter 2003, 2004.

Ecological Risk Assessment Guidelines in Oregon -- Case Study. Presentation at the Environmental Law Education Center, 2nd Annual Meeting on Contaminated Sites Issues, Portland, OR, March 1998.

Selenium toxicity in wetland birds. Selenium Symposium, Salt Lake City, UT, March, 1997.

Toxicity Extrapolations in Terrestrial Systems. Lead Instructor. A short-course workshop at the Society of Environmental Toxicology and Chemistry 17th Annual Meeting, Washington, DC, November, 1996.

Environmental Risk Assessment for Sustainable Development. Nevada Environmental Conference, Reno, NV, September–October, 1996.

Ecological risk assessment benefits, environmental management. Invited presentation at Ecological Risk Assessment Symposium, Corvallis, OR, November, 1994.

The biomedical paradigm applied to ecosystems. Ecosystem Health Meeting sponsored by University of California, Davis, Sacramento, CA, October, 1993.

Ecological aspects of land spreading of sewage sludge. Land Application of Sewage Sludge Symposium, Minneapolis, MN, August, 1993.

Seminar: Ecological risk assessment: from biomarkers to landscapes. Department of Environmental and Molecular Toxicology, Oregon State University, Corvallis, OR, February 2003.

Lectures: Ecological Risk Assessment. Team-taught upper division/graduate level course at Oregon State University, Corvallis, OR, Winter Quarter 2003.

Lectures: Wildlife Toxicology. Presented in an upper division graduate level course on wildlife diseases. Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR, March 1998 and 1999.

Lectures: Situational Ethics – the use of science in policy making. Oregon Junior Science and Humanities Symposium, Oregon State University, Corvallis, OR, March 1996–1999.

Invited Weisse Lecturer: Ecological Risk Assessment and Wildlife Toxicology. Department of Zoology, University of Oklahoma, Norman, OK, January 1998.

Seminar: Toxicity extrapolations in terrestrial systems. University of Nevada, Reno, NV, April 1997.

Lecture: Introduction to ecotoxicology. University of Nevada, Reno, NV, April 1997.

Lecture: Ecotoxicology and veterinary medicine. School of Veterinary Medicine, Oregon State University, Corvallis, OR, August, 1995 and 1996.

Lecture: Ecological risk assessment practices. Envirovet Program, Duluth, MN, August, 1994.

Lecture: Current and future ecological risk assessment approaches in the EPA. Envirovet Program, Duluth, MN, July, 1993.

Lecture: Environmental science and policy in the 21st century. Oregon Junior Science and Humanities Symposium, Corvallis, OR, March, 1993.

Lecture: Wildlife veterinary medicine and conservation biology. School of Veterinary Medicine, University of California, Davis, CA, February, 1992.

Seminar: Environmental toxicology: a growing concern? College of Veterinary Medicine, Oregon State University, Corvallis, OR, November, 1990.

Lecture: Career opportunities in wildlife medicine. Keynote speaker at Phi Beta chapter Annual Meeting, Oregon State University, Corvallis, OR, May, 1990.

Lecture: Wildlife immunotoxicology. Oregon State University, spring term of even years, Corvallis, OR.

Lecture: The role of the USEPA in environmental toxicology. Institute of Wildlife Toxicology and Chemistry, Western Washington University, Bellingham, WA, April, 1990.

Lecture: The Wildlife Toxicology Research Team at the USEPA Environmental Research Laboratory in Corvallis. Institute of Wildlife Toxicology and Chemistry, Western Washington University, Bellingham, WA, 1987.

Prior Experience

Sr. Consultant and Lead for Environmental Risk Assessment and Toxicology, Parametrix, Inc., 2007–2008
Associate Director for Science, U.S. EPA, National Health and Environmental Effects Research Laboratory, Western Ecology Division, 2006–2007
Chief, Risk Characterization Branch, (Supervisory Life Scientist, hired at the GS-15 level [science promotion to Grade 15, 9/02]); U.S. EPA, National Health and Environmental Effects Research Laboratory, Western Ecology Division, Corvallis, 2002–2006
Director and Senior Ecotoxicologist, Terrestrial Ecotoxicology; Parametrix, Inc., 1999–2002
Sr. Wildlife Ecotoxicologist; Ecological Planning and Toxicology, Inc.,1994–1999
Chief, Ecotoxicology Branch, (Supervisory Ecologist, detailed at the GM-15 level), USEPA Environmental Research Laboratory, 1992–1994
Research Ecologist USEPA Environmental Research Laboratory (GS12 – GS14), 1986–1992
Courtesy Associate Professor, College of Veterinary Medicine, Oregon State University, 1987–2003
Courtesy Professor, Department of Environmental and Molecular Toxicology, Oregon State University, 2003–present

Selected Project Experience

Conducted an RI/FS for 150 miles of the upper Columbia River (Canadian border to the Grand Coulee Dam) and surrounding uplands to assess potential ecological risks of smelter emissions to aquatic life, plants, and wildlife. Studied contaminated sediments to ascertain bioavailable metals, conducted food-chain analyses for fish and wildlife, and evaluated soil and uplands in depositional areas to assess risks to plants and wildlife. Work was conducted under agreement with EPA and participating parties.

Conducted a Detailed Ecological Risk Assessment of the tailings management system of the Gratzburg mine, Irian Jaya, Indonesia. This included assessing risks to plants and wildlife in jungles and estuarine mangrove ecosystems through food-chain analyses, ecological function studies, and floristic composition analyses. Performed extensive plant phytotoxicity and metal uptake studies to determine risk thresholds for tropical species. A detailed report was written estimating current and future (until mine closure in 2034) risks.

Served as an Expert Advisor to Cominco and its contractors for design and conduct of a terrestrial wide-area assessment under the Contaminated Site Regulations of British Columbia. This included development of appropriate assessment endpoints, conceptual site models, sampling and analysis plans, and final risk estimates. The area encompassed the upper Columbia River Valley and associated side valleys that had been subject to past deposition from the zinc-lead smelter plume.

Conducted an Ecological Risk Assessment for 165 square miles of property surrounding the Bingham Canyon, Utah, gold mine. Work included a survey of plants and wildlife on the site, food-chain analysis of potential metal contamination, field measurements of small-mammal populations, nesting surveys of shorebirds, and development of management options for various

portions of the site. Included a probabilistic risk assessment of effects of selenium on the local populations of wading birds.

Conducted an assessment of risk to terrestrial and aquatic organisms from an abandoned mercury mine in the Ochoco Mountains, Oregon, and determined risk-based cleanup levels. This was the first risk assessment to follow the newly published Oregon Department of Environmental Quality guidelines.

Assessed the potential for risk to livestock from use of wastewater on irrigated pasture during mine closure. Selenium and thallium were identified as contaminants of concern. Plant uptake studies were conducted to refine risk estimates for thallium, both in laboratory and field situations.

Provided expert consultations on review comments relating to potential future development of pit lakes at gold mines in Nevada. Included interpretation of information on contaminants of concern, potential for bioaccumulation, and wildlife food-chain contamination.

Conducted an assessment of the potential ecological risks posed by use of copper pipes in housing in California. Specific emphasis was on amount of copper discharged to San Francisco Bay. Other areas, such as the Southern California Bight and San Diego Bay, also were assessed. Endpoints included protection of aquatic life, achievement of water quality criteria, and methods for establishing water effect ratios for specific locations.

Conducted a screening-level and Level II ecological risk assessment as part of a cleanup of stormwater runoff from the bus yard of the Tri-Met transportation authority in Portland, Oregon. Runoff into a bioswale had contaminated a small wetland and possibly a nearby creek. Endangered species of concern included the red-legged frog. Human health risks also were assessed for final cleanup.

Developed a probabilistic risk assessment model for determining risk of pesticides to birds using agricultural fields, including both flowable and granular pesticides. The model was developed using the Analytica® decision-based software system. The model was developed for industry as part of the ECOFRAM process sponsored by the EPA. The basic model is applicable to exposure to any contaminant, and contains a fate module that allows input of degradation rates over time.

Provided technical and managerial support to the organotin industry for submission of a screening information data set (SID) of information on 27 chemicals to the OECD's High Production Volume (HPV) data call-in program. Reviewed the available literature on physical/chemical properties, environmental fate, ecotoxicity, and human health effects for all the chemicals, and entered appropriate data into the IUCLID database system. Tests were placed with contract laboratories to fill data gaps. Structure-activity relationships and chemical categories were developed to reduce the need for testing. Developed rest plans, SIARs, and dossiers for submission to the regulatory authorities.

Collated all existing toxicity reference values for wildlife, plants, and soil invertebrates into a user-friendly database. Information was accessible via an interface with Microsoft Access.

Included in the database were the endpoint, species tested, method of determining TRV/ benchmark, and jurisdiction. All values were rated on 20 criteria, and a desirability rating was provided to guide the selection of an endpoint when multiple values (i.e., jurisdictions) were available. The database is to be integrated into the Tri-Services web-based screening-level risk assessment model.

Built a database of nickel toxicity and essentiality and mechanisms for maintaining homeostasis. Retrieved and collated all available information on essentiality and toxicity of nickel to terrestrial and aquatic receptors (other than humans). Reviewed papers for data quality and entered information into a Microsoft Access database for easy retrieval (subsequently migrated to IUCLID). Literature citations were entered into ProCite.

Reviewed entire literature for effects of zinc and phthalate esters on terrestrial organisms (plants, wildlife, soil organisms). Qualified all studies for data quality and summarized the extent of the database. Provided all information in written report and electronic database of endpoints and data quality. Zinc data were used in the continent-wide ecological risk assessment conducted by the European Union (EU) and subsequently were migrated to IUCLID for use in REACH.

Wrote a Tier I assessment and supervised the conduct of toxicity and exposure studies for registration with the U.S. Fish and Wildlife Service of a new non-toxic shot for waterfowl hunting. Successfully completed the registration process under the new regulations, which allow selected testing rather than a complete battery of tests. Information also was submitted to Environment Canada for review. Shot has been registered and successfully marketed in the U.S. for several years.

Co-author of the EPA's *Framework for Metals Risk Assessment*. This guidance document provides the basic concepts for conducting human health and ecological risk assessments on inorganic metals, primarily at contaminated sites. It includes definitions and guidance for major areas, including background, bioavailability, bioaccumulation, and environmental chemistry of metals.

Wrote and produced the guidance document and checklist manual for British Columbia Ministry of Environment, Land, and Parks for implementing Tier 1 ecological risk assessments of contaminated sites. Presented the materials at training workshops in Vancouver.

Directed studies in a fully compliant GLP laboratory following FIFRA pesticide registration guideline for mallard and bobwhite quail. Included acute, subchronic, and reproduction studies with novel chemical and biological pesticides, conducted for most of the large agrichemical companies. Additional studies included tests specifically tailored to address questions of contaminant uptake from soil, potential food aversion from chemical-treated feed, and other studies to address specific aspects of exposure of wildlife to pesticides.

Conducted and published laboratory studies with the rat as a model of the pica child to determine the uptake efficiency of petroleum hydrocarbons from soils. Soil types included aged soils, treated soils, and lampblack. Information from the study can be used in exposure

equations in place of default values when estimating total uptake of PAHs from different soil types during either human or ecological risk assessments of contaminated sites.

Researched effects of estrogen supplementation in house finch breeding behavior, including mate selection, changes in plumage coloration, and reproductive output. Animals were implanted with time-release devices for continual elevation of estrogen levels, and an ELISA method for measurement of fecal/urate estrogens was adapted to the house finch to monitor changes in hormones during the breeding cycle. Used videography to assess effects on nest behaviors.

Academic Appointments

- Associate Professor (Adjunct), Department of Environmental and Molecular Toxicology, Oregon State University, 2003
- Associate Professor (Adjunct), College of Veterinary Medicine, Oregon State University, 1987–2003

Advisory Appointments

- The Institute of Environmental and Human Health, Texas Tech University, Science Advisory Board, 2005–present
- British Columbia Science Advisory Board for Contaminated Sites, 2003–present
- International Metals Consortium Ecological Technical Advisory Panel, 1995–present
- USPEA, Endocrine Disruptor Methods Validation Committee, 2004–2006
- Utah Division of Water Quality, selenium standard development, Science Advisory Panel, 2004–2008
- Novel Methods for Integrated Risk Assessment of Cumulative Stressors in the Environment (NOMIRACLE), Expert Advisory Panel, 2005–2007
- USEPA Risk Assessment Forum member, 2004–2007
- USGS BRD National Wildlife Health Center (NWHC) and Forest and Rangeland Ecology Science Center (FRESC), Peer Review Science Panel, 2005
- USEPA Office of Research and Development, Board of Scientific Counselors, 2001
- USEPA Science Advisory Panel (Pesticides), 2001
- Contaminated Soils Advisory Group, Society of Environment Toxicology and Chemistry, 1996–present
- Science Advisory Committee, US Environmental Protection Agency, Center of Excellence in Ecotoxicology, University of California, Davis, 1992–1998
- Science Advisory Panel for Soil Toxicity Criteria, British Columbia Ministry of Environment, 1996
- Peer Review Panel for Ecotoxicity Threshold Values, Superfund Program, US Environmental Protection Agency, 1995
- US Environmental Protection Agency Peer Review Panel, Ecological Risk Assessment Guidelines, 1995
- Blue Ribbon Peer Review Panel, US Fish and Wildlife Service, Patuxent Wildlife Research Center, 1990–1991

- National Research Council Committee Member, Use of Animals as Indicators of Environmental Health Hazards, 1988–1991

Editorships and Editorial Review Boards

Editorial Boards

- *Environmental Toxicology and Chemistry*, 1995–1997
- *Human and Ecological Risk Assessment*, 2004–present
- *Journal of Wildlife Diseases*, 1998–present
- *Risk Analysis*, 2001–present

Associate Editor

- *Journal of Wildlife Diseases*, 1986–1991
- *Journal of Wildlife Management*, 1995–1996
- *Chemosphere* (Risk Assessment section), 2003–2005
- *Ecotoxicology*, 1995–present

Guest Editor

- Seminars in Avian and Exotic Pet Medicine *Toxicology* Vol 8, Jan 1999
- Fact Sheets on Environmental Risk Assessment, www.icmm.org, 2001–2002
- *Ecological Applications* special issue on mercury in Clear Lake, CA, 2006–2007

Peer Reviewer

- *Archives of Environmental Contamination and Toxicology*
- *Bulletin of Environmental Contamination and Toxicology*
- *Comparative Physiology*
- *Ecological Applications*
- *Ecological Modelling*
- *Environmental Toxicology and Chemistry*
- *Human and Ecological Risk Assessment*
- *Integrated Environmental Assessment and Management*
- *Journal of Wildlife Diseases*
- *Journal of Wildlife Management*
- *Risk Analysis*

Professional Affiliations

- American Veterinary Medical Association—AVMA
  – Committee on Environmental Issues, 2001-2003 (Chair, 2002–2003)
- American Association of Wildlife Veterinarians—AAWV
  – President, 1991–1993
- Society of Environmental Toxicology and Chemistry—SETAC
  – President SETAC North America, 2002–2003
- Society for Risk Analysis—SRA
- Wildlife Disease Association—WDA
  – President, 1995–1997

ANNEX 158

Exponent
320 Goddard
Suite 200
Irvine, CA 92618

telephone 949-242-6000
facsimile 949-242-6099
www.exponent.com

Marion Joseph Fedoruk, M.D., C.I.H., D.A.B.T., FACMT
Principal Scientist

Professional Profile

Dr. Marion Joseph Fedoruk is a Principal Scientist in Exponent's Health Sciences and is an advisor to all the Health Sciences Centers. Dr. Fedoruk holds subspecialty board certification in Medical Toxicology and primary board certification in Occupational Medicine from the American Board of Preventive Medicine. There are fewer than 40 physicians in the U.S. who hold both these certifications. He is also a Diplomate of the American Board of Toxicology (DABT) and is also certified by the American Board of Industrial Hygiene as a Certified Industrial Hygienist (CIH).

Dr. Fedoruk maintains an active clinical practice and is engaged in teaching and research at the University of California, Irvine, where he is Clinical Professor of Health Sciences, and Senior Physician at the UCI Center for Occupational and Environmental Health Clinic.

Dr. Fedoruk has extensive experience in the assessment of exposure and related health effects for a broad range of chemical and biological hazards. His 25-year experience involves evaluating health significance from environmental, occupational, and product related exposures. His assessments have involved mercury, lead, arsenic, cadmium, nickel, polychlorinated biphenyl (PCBs), benzene, volatile organic hydrocarbons, isocyanates, pesticides, combustion products, talc, silica, and other dusts. He has designed, developed, and implemented medical monitoring programs for workers in several industries including hazardous waste, energy, asbestos, and electronics, and directed a course on medical surveillance. He performed an assessment of health needs for military and civilian personal involved in chemical weapons destruction in Johnson Atoll, in Micronesia. His work has involved assessment of air quality problems in homes, offices, schools, and work environments including assessments for microbial hazards.

Dr. Fedoruk has served as advisor occupational and environmental health matters to both government and industry. He served as a member of an expert panel convened by EPA and the U.S. Department of Labor to develop national priorities for educating health care providers about the adverse health effects of pesticides. Dr. Fedoruk has served as advisor to NFPA for developing medical guidelines for the Nation's firefighters. He has assisted health and fire departments in evaluating public health impacts associated with accidental chemical releases. He has also been involved in developing occupational medical programs and guidelines for several jurisdictions, including the City of New York.

Dr. Fedoruk has conducted studies and published articles in the areas of occupational and environmental medicine. He authored chapters in several books, including the World Health Organization's Encyclopedia of Occupational Safety and Health, the Encyclopedia of Toxicology, and textbooks in occupational lung diseases and thoracic oncology. He most

recently designated as a Fellow of the American College of Medical Toxicology, the society for board certified medical subspecialists.

Academic Credentials and Professional Honors

M.D., University of Alberta, Edmonton, Canada (with distinction), 1978
Biology Studies, University of Alberta, Edmonton, Canada, 1974
Premed, Selkirk College, British Columbia, Canada (honors standing), 1971

Medical Toxicology, Subspecialty, Certification in 1998 (certified by the American Board of Preventive Medicine)
Occupational Medicine, Specialty, Certification in 1984 (certified by the American Board of Preventive Medicine)
Certified Industrial Hygienist, Toxicology Aspects Certification December 1985 (certified by the American Board of Industrial Hygiene
Diplomate, American Board of Toxicology (DABT), Certification in 1987

Residency: Occupational Medicine, Department of Community and Environmental Medicine, University of California, Irvine, California, 1981–1983; Internship: Montreal General Hospital, Montreal, Canada (McGill University), mixed internship, 1978–1979

1995 Recipient of Merit in Authorship Award from the American College of Occupational and Environmental Medicine for publication, "Personal Risk Assessment Under the Americans with Disability Act: A Decision Analysis Approach," Journal of Occupational Medicine 1993, 35:1000–10

2001 Recipient of The Jean Spencer Felton Award for Excellence in Scientific Writing awarded by The Western Occupational and Environmental Medical Association

Fellow American College of Medical Toxicology, 2007

Adolph G. Kammer Merit in Authorship Award, American College of Occupational and Environmental Medicine, 1995

Publications/Abstracts

Richter RO, Kerger BD, Hoyt S, Fedoruk MJ. Influence of hydrocarbon composition on benzene vapor emissions in mixed products. Abstract selected for platform presentation at 17th International Society for Exposure Analysis Annual Meeting, Proceedings, Durham RTP, NC, October 21, 2007.

Fedoruk MJ, Kerger BD, Bronstein R, Richter RO. Airborne dust exposure assessment for automotive body shop work involving resin fillers and abrasives. Platform presentation at the Annual Meeting of the Society of Toxicology, Charlotte, NC, 2007. Toxicological Sciences 96(1):147.

Seltzer JM, Fedoruk MJ. Health effects of mold in children. Pediatr Clin North Am 2007; 54(2):309–333.

Fedoruk MJ, Smalstig T, Richter RO, Bronstein R, Kerger BD. Modeling residential exposure to xylenes and ethylbenzene from window sealant application based on laboratory mass flux measurements. Presented International Society of Exposure Analysis 15th Annual Meeting, Tucson, AZ, November 2005. Proceedings Abstract Book, p. 173.

Fedoruk MJ, Smalstig T, Tran J, Shum M, Richter RO, Bronstein R, Kerger BD. Diesel-related benzene exposures during refueling operations at two grocery distribution centers. Toxicological Sciences 84(S-1):83, Abstract #412. Presented at Society of Toxicology (SOT) 44th Annual Meeting, New Orleans, LA, April 2005.

Fedoruk M, Bronstein R, Kerger D. Ammonia exposure and hazard assessment for selected household cleaning product uses. Journal of Exposure Analysis and Environmental Epidemiology 2005; 15:534–544.

Fedoruk MJ, Bronstein R, Kerger BD. Volatile organic compound exposure assessment for government inspectors at gas stations. Toxicological Sciences 78(1-S):106(516). Presented at 43rd Society of Toxicology Annual Meeting, Baltimore, MD, March 2004.

Kerger BD, Bronstein R, Fedoruk MJ. Exposure assessment of volatile organic compounds and metals for government inspectors at auto body Repair Facilities. Toxicological Sciences 78(1–S):106-107(517). Presented at 43rd Society of Toxicology Annual Meeting, Baltimore, MD, March 2004.

Fedoruk M, Kerger B. Pitfalls of broad-based chemical screening of fire responders in California: A false alarm on cyanazine herbicide. Presented at 42nd Society of Toxicology Annual Meeting, Baltimore, MD, March 2004. Toxicology Sciences 72(S-1):241, 2003.

Fedoruk M, Bronstein R, Kerger B. Benzene exposure assessment of use of Mineral spirits-based degreaser. Applied Occupational and Environmental Hygiene 2003; 18:764–771.

Kerger B, Fedoruk M. Ammonia exposure and dose response assessment for household cleaning uses. Abstract No. 1693, Society of Toxicology Annual Meeting, Nashville, TN, March, 2002.

Fedoruk M, Kerger B. Assessment of toluene and ethyl acetate exposure from wearing a costume mask bonded with contact cement. Abstract No. 1692, Society of Toxicology Annual Meeting Nashville, TN, March 2002.

Jones P, Greaney P, Fedoruk M. A model medical surveillance program. Presented at National Institute of Occupational Health and Safety (NIOSH) symposium Best Practices in Workplace Surveillance: Identification and Tracking of Workplace Injury, Illness, Exposures, and Hazards, Cincinnati, OH, November 7–9, 2001.

Fedoruk M, Kerger B. Measurement of volatile organic compounds in vehicles. Toxicologist Suppl 2001; 1:97.

Kerger B, Fedoruk M. Benzene exposure assessment for the use of petroleum naphtha in a metal parts cleaner. Toxicologist Suppl 2000; 54(1):21.

Carmean G, Chase W, Fedoruk M. Empirical validation of New York City police officer visual acuity requirements. Abstract, 19th UOEH and 3rd IIES International Symposium, Kitakyushu, Japan, October 1999.

Fedoruk M, Carmean G. Development of job-related medical screening criteria for New York City police officers. Abstract, 19th UOEH and 3rd IIES International Symposium, Kitakyushu, Japan, October 1999.

Fedoruk M, Kerger B D. Polychlorinated biphenyls (PCBs) measured in a grade school following a fluorescent light ballast failure. Toxicologist Suppl 1999; 48(1–S):279.

Fedoruk M, Uhlman S, Baker D. Microbial contamination of a ventilation system detected by microbial volatile organic compound (MVOC) analysis. Abstract, presented at the 3rd International Conference on Bioaerosols, Fungi and Mycotoxins, Sarasota Springs, NY, September 1998.

Chester T, Fedoruk M, Langely R, Wilkinson C. The hazards of working in health care. Patient Care 1996; February 15.

Chester T, Fedoruk M, Langely R, Wilkinson C. Caution: Work can be hazardous to your health. Patient Care 1996; February 15.

Fedoruk M. ACOEM Reproductive and developmental hazard guidelines. J Occup Environ Med 1996; 38:1.

Harber P, Fedoruk M. Work placement and work fitness: Implications of the Americans with Disabilities Act for pulmonary medicine. Chest 1994; 105:1564–1571.

Harber P, Hsu P, Fedoruk M. Personal risk assessment under the Americans with Disability Act: A decision analysis approach. J Occup Med 1993; 35:1000–1010.

Harber P, Fedoruk M, Goldberg R. Accommodation of respiratory handicaps. Seminars in Respiratory Medicine 1993, 14:240–249.

Fedoruk M, Lee L. Positive pre-employment urine drug screen caused by foreign manufactured vitamin formulation. West J Med 1991; 155:663.

Sargent E, Adolph J, Clemmons M, Kird G, Pena B, Fedoruk M. The evaluation of flu-like symptoms in workers handling xanthan gum powder. J Occup Med 1990; 32:625–630.

Guidotti T, Alexander R, Fedoruk M. Epidemiologic features that may distinguish between illness due to chemical exposure and of psychogenic origin in building-associated outbreaks. J Occup Med 1987; 29:148–150.

Book Chapters

Fedoruk M, Hong S. Gastrointestinal toxicology. In: Information Resources in Toxicology, 4th Edition. Wexler P (ed), Elsevier, in press.

Fedoruk J, Miller JD. Health effects of bioaerosols. In: Field Guide for the Determination of Biological Contaminants in Environmental Samples, 2nd edition. Hung LL, Miller JD, Dillon HK (eds), American Industrial Hygiene Association, Fairfax, VA, 2005.

Fedoruk M, Guidotti T. Gastrointestinal system. In: Encyclopedia of Toxicology 2nd Edition. Wexler P, Anderson B, de Peyster A, Gad S, Hakkinen PK, Kamrin M, Locey B, Mehendale H, Pope C, Shugart L (eds), Elsevier Sciences, 2005.

Fedoruk M, Guidotti T. Skeletal system. In: Encyclopedia of toxicology 2nd Edition. Wexler P, Anderson B, de Peyster A, Gad S, Hakkinen PK, Kamrin M, Locey B, Mehendale H, Pope C, Shugart L (eds), Elsevier Sciences, 2005.

Fedoruk M, Uhlman S, Baker D, Yang H. Analysis of microbial contamination of a ventilation system detected by measurement of microbial volatile organic compounds. pp. 386–395. In: Bioaerosols, Fungi, and Mycotoxins: Health Effects, Assessment, Prevention and Control. Johanning E (ed), Boyd Printing Company, Inc., New York, NY, 1999.

Fedoruk M. Gastrointestinal system. pp. 44–50. In: Encyclopedia of Toxicology, Volume 2. Wexler P (ed), Academic Press, 1998.

Fedoruk M. Hazardous response personnel. In: Encyclopedia of Occupational Health and Safety, 4th Edition, Vol. 3. International Labour Office, World Health Organization, Geneva Switzerland, 95.19–95.21, 1997.

Hughson WG, Fedoruk MJ. Occupational and environmental causes of lung cancer and esophageal cancer. pp. 66–89. In: Comprehensive Textbook of Thoracic Oncology. Green M, Perry M, Martini N, Arriagada R (eds), Williams and Wilkins, New York, NY, 1996.

Harber P, Fedoruk M. Job demand, preplacement evaluation, and accommodation. pp. 857–867. In: Occupational and Environmental Respiratory Disease. Harber P, Schenker M, Balmes J (eds), Mosby, 1996.

Guidotti, Fedoruk MJ. The private alternative in providing occupational health care: Options, objectives, and object lessons. pp. 94–103. In: Occupational Health Services. In Canada through the Year 2000 (Proc. Conference Organized by the Canadian Occupational Health Association, Calgary, November 1986). Gibbs GW, Markham JW (eds), University Press of Canada, North York, Ontario, 1988.

Medical and Scientific Presentations

Fedoruk M. The toxicology of mold—Review of the literature. Presented at UCLA/UCI MOLD: State of the Medical and Environmental Science conference, February 27, 2008.

Fedoruk M. Health effects of bioaerosols. Presented at annual AIHce (American Industrial Hygiene Association) Professional Development Conference, Philadelphia, PA, May 5, 2007.

Fedoruk M. Building associated health problems 2007: What are the issues? Presented at Grand Rounds, Center for Occupational and Environmental Health, UCI, Irvine, CA, August 22, 2006.

Fedoruk M. Building-related health problems: The 2006 perspective. Presented at UCLA Occupational-Environmental Preventive Medicine Conference Los Angeles, CA, May 30, 2006.

Fedoruk M. Exposure assessment. Presented at the California Industrial Hygiene Council, 14th Annual Conference, Redondo Beach, CA, December 2, 2004.

Fedoruk M. Industrial toxicology. Presented at Internal Medicine Rounds, UCI Medical Center, Orange, CA, December 2004 and Veterans Administration Hospital, Long Beach, CA, December 2004.

Fedoruk M. National strategies for health care providers: Pesticide initiative. Presented at American Occupational Health Conference, Kansas City, MO, May 4, 2004.

Fedoruk M. Fungal-related health issues for the integrated waste industry. Integrated Waste Services Association (IWSA) Health and Safety Conference, Charleston, SC, April 20 2004.

Fedoruk M. Molds and mycotoxic effects. Presented at Pulmonary Medical Round, Newport Beach CA, February 2004.

Fedoruk M. Industrial hygiene and exposure assessment issues. Presented at Internal Medicine rounds, UCI Medical Center, Orange, CA, December 2003 and Veterans Administration Hospital, Long Beach, CA, December 2003.

Fedoruk M. Mold remediation: medical toxicological considerations. Presented at the American Conference of Industrial Hygienist (ACGIH) symposium entitled, "Mold Remediation: The National Quest for Uniformity Symposium," Orlando, FL, November, 2003.

Fedoruk M. Indoor health effects associated with residential mold exposure: Science versus public perception. Presented at the UCI Medical Center, Department of Medicine Grand Rounds, Orange, CA, October 29, 2002.

Fedoruk M. Home assessments: How are they done? Presented at the 60th Annual Meeting of the American College of Allergy, Asthma and Immunology, San Antonio, TX, November 16, 2002.

Fedoruk M. Fungi: Measurement and medicine. Presented at American Occupational Health Conference, American College of Occupational and Environmental Medicine, April 2001.

Fedoruk M. Fungi and mycotoxic effects. Presented at Allergy Medical Round, UCI Medical Center, Orange CA, March 2001.

Fedoruk M. Fungi: Exposure and health effects update. Presented at the 10th Annual Conference of the California Industrial Hygiene Council, Redondo Beach, CA, December 4, 2000.

Fedoruk M. Industrial hygiene and exposure assessment issues for internal medicine residents. Presented at UCI Medical Center, December 2000, and Veterans Administration Hospital, Long Beach, CA, December 2000.

Fedoruk M. Acute exposure and health issues related to Hazmat incidents. Presented at the ACOEM State of the Art Conference (SOTAC), Nashville, TN, October 28, 2000.

Fedoruk M. Industrial hygiene and environmental exposure assessment issues. Presented for the ACOEM Basic Curriculum in Occupational Medicine, Segment 3 at the State of the Art Conference (SOTAC), Nashville, TN, October 25–26, 2000.

Fedoruk M. Industrial hygiene and environmental exposure assessment issues. Presented for the ACOEM Basic Curriculum in Occupational Medicine, Segment 3, San Diego, CA, June 8–9, 2000.

Fedoruk M. Industrial toxicology. Presented to Residents in Internal Medicine at weekly rounds at UC Irvine Medical Center and Long Beach Veterans Administration Hospital, CA, January 1999.

Fedoruk M. Tuberculosis in workplace. Presented at UMA Pacific Section, American Industrial Hygiene Association, San Diego, CA, January 27, 1997.

Fedoruk M. Bioaerosol update. Presented at the University of California, Irvine, Center for Occupational and Environmental Health, January 1997.

Fedoruk M. Occupational lead toxicity: ethical aspects. Presented at the 39th Western Occupational Health Conference, Monterey CA, April 15, 1995.

Fedoruk M. Medical surveillance for reproductive hazards. Presented at American Occupational Health Conference, American College of Occupational and Environmental Medicine, Chicago, IL, May 7, 1994.

Fedoruk M. Biological monitoring methods for industrial chemical exposure. Presented at Orange County Section of the Industrial Hygiene Association Annual Conference, Norwalk CA, October 12, 1993.

Fedoruk M. Sick building syndrome: An update. 36th Annual Western Occupational Health Conference, San Diego, IL, October 25, 1992.

Fedoruk M. Environmental assessment. 58th Annual Scientific Assembly, American College of Chest Physicians, Chicago, IL, October 25, 1992.

Fedoruk M. Hazardous waste workers. American Occupational Health Conference, American College of Occupational and Environmental Medicine, Washington, DC, May 7, 1992.

Fedoruk M. Building-related illnesses. Presented at Occupational Medicine Rounds, University of California, Irvine, November, 1991.

Fedoruk M. The fire department medical program. Presented at the Symposium on the Occupational Health and Hazards of the Fire Service, International Association of Firefighters, 20th John P. Redmond Foundation Conference, Las Vegas, NV, September 20, 1991.

Fedoruk M. Environmental medicine: Consulting. Presented at the American Occupational Health Conference at the American College of Occupational Medicine, San Francisco, CA, May 3, 1991.

Fedoruk M. Sick building syndrome: Health effects. Presented at University of California, San Diego, California, School of Medicine, Pulmonary Rounds, California, March 17, 1991.

Fedoruk M. Sick building syndrome perceived risks and case studies. Presented at UCLA Occupational Medicine Rounds, Los Angeles, CA, February 27, 1991.

Fedoruk M, Levine S. Hazardous waste workers. Presented at the American College of Occupational Medicine Annual State of the Art Conference on Fitness for Work, Pittsburgh, PA, October 8, 1990.

Fedoruk M. Occupational/environmental concerns associated with use of Ribaviron and Pentamidine. Presented at the American Lung Association of Orange County meeting entitled Issues In Neonatal And Pediatric Pulmonary Care, Orange, CA, May 5, 1990.

Fedoruk M. Man-made mineral fibers. Presented at the 21st Annual Technical Symposium, American Industrial Hygiene Association-Southern California Section, Long Beach, CA, November 16, 1989.

Fedoruk M. Indoor air pollution. Presented at Occupational Medicine Symposium, AMI Tarzana Regional Medical Center, Tarzana, CA, June 6, 1989.

Fedoruk M. Occupational medicine in the hazardous waste industry: Regulatory aspects. Presented at American Occupational Health Conference, Boston, MA, May 1989.

Fedoruk M. Toxicologic risk assessment, a mechanism for establishing environmental standards. Presented at 32nd Annual Western Occupational Health Conference, Irvine, CA, October 1988.

Fedoruk M, Thorne D, and Yang M. Toxicology and health effects of asbestos fibre exposure. Proc. Third Annual Hazardous Material Management Conference—West, Long Beach, CA, December 1987.

Yang M, Thorne D, Fedoruk M, and Turl E. Assessment of exposure and public health risks during the excavation of a refinery waste contaminated site. Presented at the Air Pollution Control Association meeting, New York, NY, June 1987.

Fedoruk M. Asbestos—Perceived risks and interactive effects. Presented at the 6thUniversity of California, Irvine, Symposium on Environmental Psychology, May 14–15, 1987.

Fedoruk M. Walk-through assessment. Rohm and Haas, Corporate Occupational Health Conference, Philadelphia, PA, April, 1987.

Fedoruk M. Medical surveillance for hazardous waste workers. Presented at Occupational Medicine, Grand Rounds, School of Medicine, University of California, Irvine, March, 1987.

Fedoruk M. Lead and mercury—hazardous exposures. Occupational Health and Preventive Medicine Seminar, Naval Medical Clinic, San Diego, CA, April 6, 1986.

Fedoruk M. Health hazards and toxicology. Presented at 9th Annual Pacific Southwest Safety and Health Workshop/Seminar, San Diego, CA, April 16, 1986.

Fedoruk M. Worker "Right to Know Laws" health hazard training and industrial hygiene practice. Presented at the Occupational Medicine and Health Symposium, American Lung Association, San Diego, CA, March, 1986.

Fedoruk M. Heavy metal toxicology. Presented at the course: Industrial Toxicology Workers Right to Know, University of California, Irvine, CA, August 15, 1985.

Fedoruk M. Chemical exposures in the work place. Presented at St. Joseph's Medical Center, Burbank, CA, August 6, 1985.

Fedoruk M. Reproductive issues in the hospital setting. Presented at the Annual Conference Meeting of the Association of Hospital Employee Health Professional, San Diego, CA, October 17, 1984.

Fedoruk M. Asbestos diseases: An epidemic? Mercy Hospital and Medical Center, Medical Grand Rounds, San Diego, CA, August 9, 1983.

Academic Appointments

- Clinical Professor of Medicine, Department of Medicine, University of California, Irvine, School of Medicine, 2002–current
- Associate Clinical Professor of Medicine, Department of Medicine, University of California, Irvine, School of Medicine, 1998–2002
- Assistant Clinical Professor of Medicine, Department of Community and Environmental Medicine, University of California, Irvine, School of Medicine, 1985–1991; Department of Medicine 1991–1997
- Assistant Clinical Professor of Medicine, Pulmonary Division, Department of Medicine, University of California, San Diego, School of Medicine, July 1991–January 2000
- Lecturer, Graduate School of Public Health, Division of Public Health, Division of Occupational and Environmental Health, San Diego State University, 1983–1988
- Clinical Instructor of Medicine, Department of Medicine, University of California, San Diego, School of Medicine, 1985–1986

Teaching Experience

Graduate of Public Health, Division of Occupational and Environmental Health, San Diego State University. Primary instructor for two courses:

- "Occupational Medicine"—Core 3-unit course for MPH students specializing in occupational health, 1984–1987
- "Occupational Health Management"—3-unit course for MPH students specializing in occupational health, 1985

University of Southern California, Institute of Safety Systems and Management, Los Angeles, California:

- Instructor for several USC-sponsored extension programs and lecturer on several subjects including industrial hygiene, toxicology, occupational disease and carcinogens.
- Developed and presented a one and one half day course regarding the development and management of medical surveillance programs. This course was given in September 1985, and has been presented biannually through 1990.

Department of Health Services Division of Toxics, State of California, 1987–1988:

- Instructed portions of a course entitled "Introduction to Toxicology" for State of California, D.H.S. employees engaged in Hazardous Waste Operations. (Los Angeles, Berkeley) Sacramento.

University of California, Irvine. Instructor for courses entitled:

- "Air Pollutants and Toxic Chemicals," Social Ecology; 498.3; 1988–1991
- "Managing Indoor Air Quality Episodes," Social Ecology; February 12, 1991

University of California, Berkeley/Northern Occupational Health Center:

- Instructor for a course entitled “Pesticide Contaminated Hazardous Waste Sites” and taught section on pesticide toxicology and medical surveillance, 1989

Committees

American Lung Association, Committee on Environmental and Occupational Health, San Diego, California, 1983–1987.

County of San Diego, Subcommittee Advisory Panel, Hazardous Materials Management Team. Designated representative of County of San Diego Medical Society. The subcommittee advises County Government about the applicability, enforcement, and technical aspects of County Ordinances dealing with hazardous materials management, 1984–1987.

Agricultural/Urban Pesticide Issues Task Force. Task force member of a committee appointed by the County Board of Supervisors to review pesticide usage and determine how it impacts on both urban and agricultural concerns, January 1986–November 1986.

NIOSH/Northern and Southern California Educational Resource Centers. Served on the Advisory Committee on pesticide related hazardous waste training for health and safety professionals, 1989–1990.

National Fire Protection Association. Subcommittee member on the 1001 and 1500 committees concerning medical and physical fitness criteria for structural firefighters, 1989–present.

American College of Occupational and Environmental Medicine. Planning committee member for 1990 State of the Art Conference on Fitness for Work. Pittsburgh, Pennsylvania, October 8–12, 1990.

American College of Occupational and Environmental Medicine. Member of Occupational and Clinical Toxicology committee, 1991–2000, appointed chairman, May 1992.

American College of Occupational and Environmental Medicine. Member of Committee on Scientific Affairs, May, 1992–2000.

American College of Occupational and Environmental Medicine. Member of Committee on Medical Surveillance May, 1993–2000.

Toxicology Excellence for Risk Assessments, Cincinnati, Ohio. Member of Peer Review Committee sponsored by EPA, Health Canada and Metal Finishing Association of Southern California, concerning a risk assessment on the carcinogenicity and toxicity of soluble nickel salts.

U.S. Environmental Protection Agency. Member of expert panel concerning the development of a strategy for educating the nation’s health care providers on pesticide-related health matters.

Proceedings published in Pesticides and National Strategy for Health Care Providers, July 1998 (EPA 735-R-98-001).

Special Projects

American College of Occupational Medicine, Chicago, IL. Developed questions for the national Medical Self-Assessment Program 2 for physicians to test their knowledge base in occupational medicine.

American Lung Association. Prepared "Solvents in the Workplace" fact sheet for ALA publication Lung Hazards at Work, a program developed to inform employers and employees on the control of harmful occupational exposures that can lead to lung disease.

City of San Diego Fire Department. Developed and presented a risk communication program concerning the fetal health risks from physical and chemical exposures to female firefighters. The program covered the areas of health effects of heat stress, carbon monoxide and other agents on the fetus. The program was presented to all female firefighters with the City of San Diego in 1988 and 1990.

ANNEX 158

Exponent
1800 Diagonal Road
Suite 300
Alexandria, VA 22314

telephone 571-227-7200
facsimile 571-227-7299
www.exponent.com

Charles A. Menzie, Ph.D.
Principal Scientist and Practice Director

Professional Profile

Dr. Charles A. Menzie is a Principal Scientist and Director of Exponent's EcoSciences practice. His primary area of expertise is the environmental fate and effects of physical, biological, and chemical stressors on terrestrial and aquatic systems. Over the past two decades most of this work has been focused on chemicals. Dr. Menzie has worked at more than 100 sites and has been involved in approximately a dozen NRDA-related cases. He is recognized as one of the leaders in the field of risk assessment and was awarded the Risk Practitioner Award by the Society for Risk Analysis. He has served on the Council of SRA and the Board of SETAC, the two major professional organizations in this field. Dr. Menzie has led numerous peer reviews for industry and for government. He has taken the lead in developing guidance documents for industry and government and has focused on methods that are workable and acceptable to a broad range of parties. He was one of the committee members to draft the ASTM Standard for risk-based corrective action (RBCA) for chemical release sites and extended that standard to ecological considerations. In addition to his work on chemical risk-related matters, Dr. Menzie has developed and applied methods for identifying third parties who have contributed to contamination in aquatic and terrestrial environments. These projects have involved meshing historical information with transport and fate analyses, risk considerations (remediation drivers), and forensic analysis. Most of this work has been carried out for a select group of industrial clients. Dr. Menzie's expertise in chemical transport and fate includes organochlorine compounds (e.g., PCBs, dioxins, many pesticides), PAHs, benzene and other light aromatic hydrocarbons, chlorinated volatile compounds (e.g., TCE and PCE), phthalate esters, petroleum hydrocarbons, metals (e.g., arsenic, cadmium, lead, vanadium, nickel, and zinc), and cyanide compounds.

In addition to Dr. Menzie's work on chemical-related matters, he has been involved in evaluating the risks associated with habitat modifications and the introduction of species. Prominent among these efforts was work related to the introduction of shrimp viruses to U.S. coastal systems. Dr. Menzie has developed a number of software tools to analyze the effects of chemical and other stressors at the level of landscapes. Much of this work is being used to predict future effects and to sort among alternatives.

Academic Credentials and Professional Honors

Ph.D., Biology, City University of New York, 1978
M.A., Biology, City College of New York, 1974
B.S., Biology, Manhattan College, 1971

Licenses and Certifications

OSHA Certified Eight-Hour HAZWOPER Annual Refresher Training in Hazardous Waste Operations and Emergency Response, updated annually; OSHA Certified 40-Hours of Training in Hazardous Waste Operations and Emergency Response

Patents

Patent Application: SediMite: A Low-Impact Technology for Remediating Contaminated Sediments, patent pending.

Publications

Menzie CA, Booth P, Law SA, von Stackelberg K. Use of decision support systems to address contaminated coastal sediments: Experience in the United States. In: Decision Support Systems for Risk-Based Management of Contaminated Sites. Marcomini A, Suter II GW, Critto A (eds), Springer Verlag, 439 p, 2009.

Menzie CA, Southworth B, Stephenson G, Feisthauer N. The importance of understanding the chemical form of a metal in the environment: The case of barium sulfate (barite). Hum Ecol Risk Asses 2008; 14:5:974–991.

Menzie CA, Coleman AJ. Debate & commentary. Polycyclic aromatic hydrocarbons in sediments: An overview of risk-related issues. Hum Ecol Risk Assess 2007; 13(2):269–275.

Menzie CA, MacDonell MM, Mumtaz M. A phased approach for assessing combined effects from multiple stressors. Environ Health Perspect 2007; 115(5) 807–816.

Johnson, MS, Wickwire WT, Quinn MJ, Ziolkowski DJ, Burmistrov D, Menzie CA, Geraghty C, Minnich M, Parsons PJ. Are songbirds at risk from lead at small arms ranges? An application of the Spatially Explicit Exposure Model (SEEM). Environ Toxicol Chem 2007; 26(10):2215–2225.

Magar VS, Wenning RJ, Menzie C, Apitz SE. Parsing ecological impacts in watersheds. J Environ Eng 2006; 132(1):1–3.

Wickwire WT, Menzie CA, Burmistrov D, Hope BK. Incorporating spatial data into ecological risk assessments: The Spatially Explicit Exposure Module (SEEM) for ARAMS. In: Landscape Ecology and Wildlife Habitat Evaluation: Critical Information for Ecological Risk Assessment, Land-Use Management Activities, and Biodiversity Enhancement Practices. ASTM STP 1458. Kapustka LA, Galbraith H, Luxon M, Biddinger GR (eds). ASTM International, West Conshohocken, PA, 2004.

Menzie CA, Lacey R. Ecological risk assessment in a new millennium: Where are we going? Risk Policy Report 2002; 9(3):36–38.

von Stackelberg K, Menzie C. A cautionary note on the use of species presence and absence data in deriving sediment quality criteria. Environ Toxicol Chem 2002; 21(2):466–472.

Menzie CA, Hoeppner SS, Cura JJ, Freshman JS, LaFrey EN. Urban and suburban storm water runoff as a source of polycyclic aromatic hydrocarbons (PAHs) to Massachusetts estuarine and coastal environments. Estuaries 2002; 25(2):165–176.

Shatkin JA, Wagle M, Kent S, Menzie CA. Development of a biokinetic model to evaluate dermal absorption of polycyclic aromatic hydrocarbons from soil. Hum Ecol Risk Asses 2002; 8(4):713–734.

Menzie CA. Hormesis in ecological risk assessment: A useful concept, a confusing term, and/or a distraction? Belle Newsletter 2001; 10(1):17–20.

Menzie CA, Wickwire WT. Defining populations: A key step in identifying spatial and temporal scales. Toxicol Indust Health 2001; 17:223–229.

Menzie CA, Burke AM, Grasso D, Harnois M, Magee B, McDonald D, Montgomery C, Nichols A, Pignatello J, Price B, Price R, Rose J, Shatkin J, Smets B, Smith J, and Svirsky S. An approach for incorporating information on chemical availability in soils into risk assessment and risk-based decision making. Hum Ecol Risk Assess 2000; 6(3):479–510.

Menzie CA. Applying risk-based solutions—the importance of communication. Environ Eng 1999; 35(4):20–22.

Menzie CA. Risk communication and careful listening—resolving alternative world views. Hum Ecol Risk Assess 1998; 4(3):619–622.

Charles JC, Menzie CA. Identifying Southeast Asian immigrant populations in Massachusetts at risk from eating contaminated shellfish. J Environ Manage 1998; 52:161–171.

Menzie CA. Implementing risk management at manufactured gas plant sites. Soil Groundwat Cleanup 1997; August/September: 12–18.

Menzie CA, Freshman JS. An assessment of the risk assessment paradigm for ecological risk assessment. Hum Ecol Risk Assess 1997; 3(5):853–892.

Freshman JS, Menzie CA. Two wildlife exposure models to assess impacts at the individual and population levels and the efficacy of remedial actions. Hum Ecol Risk Assess 1996; 2(3):481–496.

Menzie CA, Henning MH, Cura J, Finkelstein K, Gentile J, Maughan J, Mitchell D, Petron S, Potocki B, Svirsky S, Tyler P. Special report of the Massachusetts weight-of-evidence workgroup: A weight-of-evidence approach for evaluating ecological risks. Hum Ecol Risk Assess 1996; 2(2):277–304.

Menzie CA. The question is essential for ecological risk assessment. Hum Ecol Risk Assess 1995; 1(3):159–162.

Menzie CA, Potocki B, Santodonato J. Exposure to carcinogenic PAHs in the environment. Environ Sci Technol 1992; 26(7):1278–1284.

Menzie CA, Burmaster DE, Freshman JS, Callahan CA. Assessment of methods for estimating ecological risk in the terrestrial component: A case study at the Baird & McGuire Superfund Site in Holbrook, Massachusetts. Environ Toxicol Chem 1992; 11:245–260.

Callahan CA, Menzie CA, Burmaster DE, Wilborn DC, Ernst T. On-site methods for assessing chemical impact on the soil environment using earthworms: A case study at the Baird & McGuire Superfund Site, Holbrook, MA. Environ Toxicol Chem 1991; 10(6)817–826.

Burmaster DE, Menzie CA, Freshman JS, Burris JA, Maxwell NI, Drew SR. Assessment of methods for estimating aquatic hazards at Superfund-type sites: A cautionary tale. Environ Toxicol Chem 1991; 10(6)827–842.

Menzie CA. Diminishment of recruitment: A hypothesis concerning impacts on marine benthic communities. Mar Pollut Bull 1984.15:127-129.

Menzie CA. Environmental concerns related to offshore oil and gas activities: Muddy issues. Oceanus 1983; 26:32–38.

Menzie CA. Contamination control can be cost effective. Industry Magazine 1982; August: 19–22.

Menzie CA. The environmental implications of offshore oil and gas activities: An overview of the effects of routine discharges based on the American experience. Environ Sci Technol 1982; 16(8):454A–472A.

Maurer D, Leathem W, Menzie CA. Macrobenthic invertebrates from the Mid-Atlantic continental shelf. Int Rev der Ges Hydrobiol 1982; 67(4):491-515.

Menzie CA, Cura JJ, Skinner WF. Thermal impact evaluation for Brunner Island Steam Electric Station: Toward a more realistic assessment. Environ Monit Assess 1982; 2:301-308.

Menzie CA. Production ecology of *Cricotopus sylvestris Fabricius* (Diptera: Chironomidae) in a shallow estuarine area. Limnol Oceanog 1981; 26(3):467-481.

Mauer D, Leathem W, Menzie CA. The impact of drilling fluids and well cuttings on polychaete feeding guilds from the U.S. northeastern continental shelf. Mar Pollut Bull 1981; 12(10):234-347.

Menzie C, Mariani G, Ryther, Jr. J. Seafloor mapping system applied to biological, environmental surveys. Sea Technol 1981; 22(2):15-16.

Menzie CA. The potential significance of insects in the removal of contaminants from aquatic systems. Water Air Soil Pollut 1980; 13:473-479.

Menzie CA. A note on the Hynes method of estimating secondary production. Limnol Oceanogr 1980; 25(4):770–773.

Menzie CA. The chironomid (Insecta: Diptera) and other fauna of a *Myriophyllum spicatum* L. plant bed in the lower Hudson River. Estuaries 1980; 3(1):38-54.

Menzie CA. An approach to estimating probabilities of transportation related spills of hazardous materials. Environ Sci Technol 1979; 13(2):224-228.

Menzie CA. Growth of the aquatic plant *Myriophyllum spicatum* in a littoral area of the Hudson River Estuary. Aquat Bot 1979; 6:365-375.

Mulligan HF, Menzie CA. How to prepare environmental reports for drilling on the OCS (outer continental shelf). Oil Gas J 1978; 86–87.

Books and Book Chapters

Lanno R, Menzie CA. Risk assessment of cyanide in water and soil. Chapter 17. In: Cyanide in Water and Soil: Chemistry, Risk, and Management. Dzombak DA, Ghosh RS, Wong-Chong GM (eds), CRC Press/Lewis Publishers, Boca Raton, FL, 2005.

Menzie CA, Efroymson RA, Ells SJ, Henningsen GM, Hope BK. Risk assessment and risk management. Chapter 2. In: Pellston Workshop on Contaminated Soils: From Soil-Chemical Interactions to Ecosystems Management. Lanno RP (ed), SETAC Publications. Pensacola, FL, 2003.

Menzie CA. The evolution of ecological risk assessment during the 1990s: Challenges and opportunities. Chapter 16. pp. 281–299. In: Environmental Analysis of Contaminated Sites. Sunahara GI, Renoux AY, Thellen C, Gaudet C, Pilon A (eds), John Wiley & Sons, Ltd., 2002.

Gaudet CL, Menzie CA, Ouellet S. Risk-based assessment of soil contamination: Generic versus site-specific approaches. Chapter 12. pp. 203–219. In: Environmental Analysis of Contaminated Sites. Sunahara GI, Renoux AY, Thellen C, Gaudet C, Pilon A (eds), John Wiley & Sons Ltd., 2002.

Cura, JJ, Kane Driscoll SB, Lacey R, McArdle M, Menzie CA. Assessing ecological risks of PAH-contaminated sediments. In: Sediments Guidance Compendium. Electric Power Research Institute (EPRI), Palo Alto, CA, 2001.

Menzie CA, Heiger-Bernays WJ, Montgomery CR, Linz DG, Nakles DV. Development of an ecological risk assessment framework based on contaminant availability. In: Ecotox—

Environmental Contaminants through the Macroscope. Wuerz Publishing Ltd., Winnipeg, MB, Canada, 1996.

Menzie CA. Perspectives on sediment risk analysis for hazardous waste sites. Proceedings, 22nd Pellston Conference Workshop, Sediment Risk Assessment. SETAC Special Publication, Pacific Grove, 1996, April 23–28, 1995.

Menzie CA. Work group summary report for site clean-up decisions. Chapter 6. Proceedings, 22nd Pellston Conference Workshop, Sediment Risk Assessment, SETAC Special Publication, Pacific Grove, 1995, April 23–28, 1995.

Cura JJ, Mariani G, Ketchum C, Gillmor R, Menzie C, Curtis W, Tuholke B. Site-selection criteria for deep ocean disposal of low-level radioactive wastes. Volume 3, Marine Waste Management: Science and Policy. pp. 177–185. In: Oceanic Processes in Marine Pollution. Champ M, Park K (eds), Kreiger Publishing Co., Melbourne, FL, 1989.

Menzie CA, Cura J, Gillmor R, Magnell B, Mariani G, Bartholomew T, Gardner W, Smith W. The optimum mix of pollution-monitoring platforms: Deepwater Dumpsite-106 Case Study. Volume 3 - Marine Waste Management: Science and Policy. pp. 260–276. In: Oceanic Processes in Marine Pollution. Champ M, Park K (eds), Kreiger Publishing Co., Melbourne, FL, 1989.

Nocito JA, Walker HA, Paul JF, Menzie CA. Application of a risk assessment framework for marine disposal of sewage sludge at mid-shelf and off-shelf sites. Proceedings, 11th ASTM Symposium by American Society for Testing and Materials, Philadelphia, PA, 1986

Gillmor RB, Menzie CA, Mariani GM, Levin D, Ayers RC, Sauer TC. . Effects of exploratory drilling discharges on the benthos. Volume 4, Energy Wastes in the Ocean. pp. 244–257. In: Wastes in the Ocean. Duedall IW, Kester DR, Park PK (eds), Wiley Interscience Publications, John Wiley & Sons, New York, NY, 1985.

Robson DS, Menzie CA, Mulligan HF. An environmental monitoring study to assess the impact of drilling discharges in the Mid-Atlantic. II. An experimental design and statistical methods to evaluate impacts on the benthic environment. In: Research of Environmental Fate and Effects of Drilling Fluids and Cuttings, 1980.

Menzie CA, Maurer D, Leathem W. An environmental monitoring study to assess the impact of drilling discharges in the Mid-Atlantic. IV. The effects of drilling discharges on the benthic community. In: Research of Environmental Fate and Effects of Drilling Fluids and Cuttings, 1980.

Proceedings, Conferences, and Symposia

Wickwire WT, Menzie CA, Burmistrov D. Enhancing the realism of wildlife exposure modeling: An introduction and demonstration of the Spatially Explicit Exposure Model (SEEM). In: An Introduction to the Terrestrial Wildlife Exposure Model (TWEM) and the

Spatially Explicit Exposure Model (SEEM). Johnson MJ, Sample BE, Wickwire WT, and Kapustka LA (eds.). SETAC 2004 Short Course Instructor. Society of Environmental Toxicology and Chemistry (SETAC) 4th World Congress and 25th Annual Meeting, Portland, OR, November 14–18, 2004.

Wickwire WT, Menzie CA, Burmistrov D, Johnson MS. Applying a spatially explicit wildlife exposure model to improve remedial efficiency: The SEEM case study (Abstract/Poster Presentation). Annual International Conference on Soils, Sediments and Water, University of Massachusetts, Amherst, MA, October 18–21, 2004.

Kane Driscoll SB, McArdle ME, Menzie CA, Coleman A. Application of sediment quality guidelines of PAHs to manufactured gas plant sites. Presented at the 23rd Annual Meeting of SETAC North America, Salt Lake City, UT, November 16–20, 2002.

Menzie CA, Cura JJ, Kane-Driscoll S, Lacey R, McArdle M. Assessing ecological risks of PAH-contaminated sediments. Proceedings, International Conference on Remediation of Contaminated Sediments, Venice, Italy, October 10–12, 2001. Battelle Press, Columbus, OH.

Cura JJ, Menzie C. Methodologies for ecological risk assessment: the overall process and recent advances. Conference Workshop #12 - Ecological Risk Assessment: Why and How—An Important Tool in Environmental Decision Making. Presented at the Water Environment Federation 69th Annual Conference & Exposition, Dallas, TX, October 5–9, 1996.

Menzie CA. Problems in ecological assessment related to contaminated site management. pp. 26–27. Proceedings, NRC-CNRC Workshop, Toxicity Testing Applied to Soil Ecotoxicology. NRC's Biotechnology Research Institute in collaboration with Environment Canada and the Quebec Ministry of Environment and Wildlife, Montreal, Quebec, November 28–29, 1995.

von Stackelberg K, Menzie CA, Cura JJ. Risk assessment: Helping to focus risk management objectives for MGP sites. Land Contam Reclam (Special issue) 3(4):24-29. Presented at the International Symposium and Trade Fair on the Clean-up of Manufactured Gas Plants, Prague, Czech Republic, September 19-21, 1995.

Menzie CA, Cura JJ. Environmental evaluations at hazardous waste sites. pp. 77–84. Proceedings, HMC-Northeast '91 Conference, Hazardous Materials Control Research Institute, Boston, MA, July 10–12, 1991.

Menzie CA, Cura J. Loadings of pollutants in Massachusetts Bay. Presented at U.S. Environmental Protection Agency Conference on Estuaries, Sarasota, FL, February 24–26, 1991.

Burmaster DE, Thompson KM, Menzie CA, Crouch E, McKone T. Monte Carlo techniques for quantitative uncertainty analysis in public health risk assessment. pp. 215–21. Proceedings, 1990 Hazardous Materials Control Research Institute Conference, New Orleans, LA, 1990.

Menzie CA. Application of Connecticut's aquatic toxicity program. Panel discussion and presentation to the 2nd Annual Workshop of the Connecticut Forum of Regulated Environmental Professionals, New Haven, CT, June 2, 1988.

Menzie CA. The use—and possible misuse—of risk assessment as part of overall site management. Presented at the 2nd Hazardous Waste Superfund Conference in San Francisco and Washington, DC, 1988.

Menzie CA, Burmaster DE. Overview of soil clean-up levels and risk based decision making. Presented at the HazMat '88 Conference, Atlantic City, NJ, June 14–16, 1988.

Menzie CA, Burmaster DE. Evaluation of environmental risk assessment methods. Presented at the 9th Annual Meeting of the Society of Environmental Toxicology and Chemistry, Arlington, VA, November 13–17, 1988.

Burmaster DE, Murphy B, Gushue J, Menzie CA. A risk assessment for the Baird & McGuire Superfund Site. Presented at the Hazardous Materials International Conference, Washington, DC, 1987.

Menzie CA, Cura JJ, Gillmor R, Mariani G, Wilson S. Research needs related to ocean disposal. Presented at the Ocean Waste Management Conference at the University of Rhode Island, Kingston, RI, May 1983.

Menzie CA, Ryther, Jr. J, Boyer LF, Germano JD, Rhoads DC. Remote methods of mapping seafloor topography, sediment type, bedforms, and benthic biology. pp. 1046-1051. In: Oceans '82 Conference Record, IEEE Publication Number 82CH1827-5, Piscataway, NJ, IEEE Service Center, 1982.

Gillmor, RB, Menzie CA, Ryther, Jr. J. Side-scan sonar and T.V. observations of the benthic environment and megabenthos in the vicinity of an OCS exploratory well in the Middle Atlantic Bight. In: Oceans '81 Conference Record. IEEE Publication No. 81CH1685-7, Piscataway, NJ, IEEE Service Center, 1981.

Menzie CA, Ryther, Jr. J. Diego Garcia (Indian Ocean): An Atoll estuary. Presented at the New England Estuarine Research Society at the University of Rhode Island, Spring Session, Kingston, RI, 1980.

Menzie CA, Frye D, Hazelwood RN. OTEC-1 environmental monitoring program. In: Proc. 7th Ocean Energy Conference, Washington, DC, June 1980.

Mulligan HF, Menzie CA. Phytoplankton as tracers of water masses on and around Georges Bank. Presented at the Second Informal Workshop on the Gulf of Maine and Scotian Shelf, May, Dalhousie, Nova Scotia, 1979.

Menzie CA, et al. The environmental impact of the Clean Water Act on the Hudson River Estuary. Presented at the 4th Hudson River Environmental Symposium, 1976.

Menzie CA, Hyman R, Woodward B. Investigations of the chironomid fauna of Haverstraw Bay. Presented at the 4th Hudson River Environmental Symposium, 1976.

Menzie CA, Logan D, Matousek J. 1976. Benthic investigations in the Hudson River Estuary. 1972-1974. Presented at the 24th Annual Meeting of the North American Benthological Society, Madison, WI, 1976.

Prior Experience

Principal and President, Menzie-Cura & Associates, Inc., 1983–2006
Manager of Environmental Services Department, EG&G Environmental Consultants, 1976-1983
Lecturer, Boston University and University of Lowell, Developed and presented graduate-level courses on Risk Assessment, Marine Pollution, and Environmental Science, 1978-1993

Project Experience

Manufacturing Industry (Metals and Organic Chemicals) with an Emphasis on Sediments

Worked on ecological and human health issues associated with contaminated sediments since the mid 1970s. Worked on projects involving the following classes of chemicals: organometallic compounds (e.g., methylmercury), inorganic metals such as chromium, lead, copper, cadmium, nickel, vanadium, and barium, chlorinated compounds such as PCBs, dioxins, and pesticides, petroleum related hydrocarbons, and chemicals arising from combustion (e.g., PAHs). This work has involved assessing transport and fate of these chemicals, evaluating risks, and providing guidance for remediation. Developed a low-impact remedial technology referred to as SediMite™.

Contribution Cases

Participated in several large contribution cases involving regional contamination from multiple sources. Most of this work has focused on PCBs, pesticides, and metals. Developed a line-of-evidence methodology that has been successfully applied to these cases. Risk assessment expertise has been an important element of establishing the connections between sources and environmental conditions. This framework also makes it possible to establish the implications and degree of risk associated with the particular sources.

Manufactured Gas Plants (MGP) and Other Utility Work

Twenty years of experience evaluating the human health and ecological risks associated with MGP sites. Primary author of the Gas Research Institute (GRI) guidance on risk assessment for MGP sites and has conducted assessments at more than forty sites. Currently a principal investigator for Electric Power Research Institute (EPRI)-funded research on the toxicity of soils and sediments at MGP sites. Principal investigator for the environmentally acceptable endpoints (EAE) program, which focused on the bioavailability of PAHs in surface soils. This program was subsequently extended to evaluations of PAHs in sediments. Co-author of the

industry white paper on naphthalene toxicity and implications for risk assessment and risk management.

Principal investigator for the Gas Research Institute, Gas Technology Institute, and currently serves as principal investigator for EPRI on effects of hydrocarbons associated with MGP operations. Authored human health and ecological risk assessment guidance developed for MGP sites.

Published several papers related to the assessment of risks at MGP sites; author of the critical review on sources of exposure to carcinogenic PAHs. This paper was prepared to help provide a perspective on PAHs in soils at MGP and other sites. Published work on exposures to cyanides, including the complex cyanides that can be present at some MGP sites.

Guided evaluations of background in a wide variety of cases. These evaluations have involved surface soils in urban and rural environments, and sediments in various water bodies.

Currently involved in permitting for coal-fired and nuclear power plants. For the latter, serves as an expert on chemical releases from such facilities. Also worked on approximately twenty projects involving entrainment/impingement and thermal discharges.

Led human health and ecological assessments related to the disposal of coal and oil ash at facilities.

Oil and Gas Industry

Has worked on upstream and downstream components of the oil and gas industry since the 1970s. Author of a key review paper in *Environmental Science and Technology* on the environmental implications of oil and gas exploration, development, and production. This paper addressed produced waters, drilling fluids, and other releases. Served as Principal Investigator for multi-industry study of the environmental risks associated with oil and gas exploration. Author of numerous reports related to potential environmental risks associated with onshore, coastal, and offshore oil and gas exploration and development. This includes an API report and associated peer-reviewed paper on the potential risks associated with barite.

Wrote the ecological risk assessment guidance related to petroleum releases for the American Petroleum Institute. Member of the ASTM RBCA work group. Served as the principal risk assessor for assessments at refinery sites: Bayway, New Jersey, Destrehan, Louisiana, Wood River, Illinois, Texas City, Texas, and Sugar Creek, Missouri.

Principal investigator for the Petroleum Environmental Research Form program related to the evaluation of ecological and human health risks associated with petroleum-contaminated soils. He has served as a participant within the Total Petroleum Hydrocarbon Criteria Workgroup, an industry- and government-sponsored effort to develop a methodology for evaluating complex mixtures of hydrocarbons.

Impacts and Natural Resource Damages to Aquatic Ecological Resources

More than thirty years of experience working on aquatic and marine environments. Natural resource work began in New York; documented the distribution of habitats in the lower Hudson River. Worked extensively on lakes in the northeast United States including the Finger Lakes, Lake Ontario, and Lake Erie. Published on the biological communities inhabiting submerged aquatic vegetation and benthic environments. Also involved in more than 100 reports that deal with various fish populations and their response to chemical stressors and habitat modification. These projects have included the development of multi-pathway food webs and models.

Developed the conceptual approach for the Spatially-Explicit Exposure Model, a system that uses information on the spatial distribution of habitats to evaluate the distribution of species and to account for exposures that occur at the population level. Served as topic chair for the SETAC Pellston Workshop on assessing risks to populations.

Invited to prepare an issue paper associated with evaluating the combined effects of multiple stressors. The approach includes a habitat-specific methodology that can be employed in either aquatic or terrestrial environments.

Impacts and Risk Evaluations for Desert and Tropical Environments

Principal investigator evaluating impacts of development on Diego Garcia (Indian Ocean). This is a desert island on which the U.S. Navy established a base to support military operations at countries bordering the Indian Ocean. The work involved an extended stay on the island with investigations of physical and chemical impacts on upland and coastal environments.

Evaluated the potential effects of aerial spraying of herbicides on environmental conditions in South America.

Evaluated the environmental impacts of pulp mill discharges on ecological conditions in a South American River.

Chaired the external peer review of radionuclide impacts associated with the Nevada Test Site, where nuclear weapons had been tested. Associated with this testing were a range of potential human health and ecological risks for this desert environment. Led a group of scientists who evaluated the studies performed by the Department of Energy.

Field operations manager and principal investigator for the Hawaiian Ocean Thermal Energy Conversion (OTEC) Program. Responsible for overseeing studies to evaluate the impacts of OTEC on Hawaiian coastal environments. The work involved an extended field program in coastal Hawaii. Also served as field operations manager and principal investigator for the evaluating of dredging and dredge material disposal for the Naval Roads Navy base in Puerto Rico.

Current Academic Appointments

- Adjunct Professor, University of Maryland at Baltimore County

Editorships and Editorial Review Boards

- Associate Editor, *Human and Ecological Risk Assessment,* 2003–present
- Editorial Board, *Human and Ecological Risk Assessment,* 1995–2002

Professional Affiliations

- Water Environment Federation
- Society for Risk Analysis, (Past President of New England Chapter)
- Society of Exposure Analysis
- Society of Environmental Toxicology and Chemistry, (Board Member)
- New England Estuarine Research Society
- Estuarine Research Federation
- Boston Bar Association, (Environmental)
- Association for the Environmental Health of Soils
- ASTM

ANNEX 158

Exponent
15375 SE 30th Place
Suite 250
Bellevue, WA 98007

telephone 425-519-8700
facsimile 425-519-8799
www.exponent.com

Katherine Palmquist, Ph.D.
Senior Scientist

Professional Profile

Dr. Katherine Palmquist is a Senior Scientist in Exponent's EcoSciences practice. She has a strong interdisciplinary background in insect biology/physiology, toxicology, Integrated Pest Management, and communications. Dr. Palmquist has experience in aquatic entomology and aquatic toxicology concerning the sublethal effects of insecticide exposure to aquatic invertebrates, specifically aquatic insect life history variables in relation to insects' sensitivity to synthetic pyrethroid insecticides. Additionally, she has experience with terrestrial and agroecosystem insect ecology and has been involved with the Integrated Pest Management programs in both Oregon and Washington states.

Dr. Palmquist has four years experience in designing and implementing novel laboratory studies utilizing field-collected stream invertebrates. She has developed and published methodology concerning the laboratory maintenance and rearing of several stream insect species. Additionally, she has experience in performing lotic and lentic benthic surveys, as well as terrestrial insect field sampling.

Academic Credentials and Professional Honors

Ph.D., Toxicology, Oregon State University, 2007
B.S., Entomology, Washington State University, 2003
B.A., Communications (print journalism), Washington State University, 2003

Recipient of the Best Doctoral Student Presentation—Pacific Northwest Branch Society of Environmental and Molecular Toxicology, Port Townsend, WA, 2007

National Institute of Environmental Health Sciences Training Grant Recipient— Oregon State University, 2003–2007

Outstanding Senior—Washington State University, Department of Entomology, 2003

Publications

Palmquist KR, Jenkins JJ, Jepson PC. Effects of dietary esfenvalerate exposure on three aquatic insects species representing different functional feeding groups. Environ Toxicol Chem 2008; 27(8): 8–14.

Palmquist KR, Jenkins JJ, Jepson PC. Impact of aquatic insects life stage and emergence strategy on sensitivity to esfenvalerate exposure. Environ Toxicol Chem 2008; 27(8):1–7.

Palmquist KR, Jenkins JJ, Jepson PC. Clutch morphology and timing of exposure impact the susceptibility of aquatic insects eggs to esfenvalerate. Environ Toxicol Chem 2008; 27(8):52–59.

Johnson KR, Jepson PC, and Jenkins JJ. Esfenvalerate-induced case-abandonment adversely impacts *Brachycentrus americanus* behavior and survival. Environ Toxicol Chem 2008; 27 (2):397–403.

Johnson JD, Johnson KR. Hybrid poplar genotype affects attack incidence by the Poplar-and-Willow Borer (*Cyptorhynchus lapathi*). West J Appl For 2003; 18: 276–280.

Presentations

Palmquist KR, Jenkins JJ, Jepson PC. Impact of aquatic insects life stage and emergence strategy on sensitivity to esfenvalerate exposure. Presented at the Pacific Branch Society of Environmental Chemistry and Toxicology Meeting and at the North American Benthological Society Meeting, 2008.

Johnson KR, Jenkins JJ, Jepson PC. Clutch morphology and the timing of exposure impact the susceptibility of aquatic insect eggs to esfenvalerate. Presented at the Society of Environmental Chemistry and Toxicology 28th Annual Meeting, 2007.

Johnson KR, Jenkins JJ, Jepson PC. Use of multiple life stages in assessing *Cinygmula sp.* mayfly nymph sensitivity to esfenvalerate. Presented at the Pacific Northwest Branch Society of Environmental Chemistry and Toxicology Meeting, Port Townsend, WA and presented at the Pacific Branch Entomological Society of America 91st Annual Meeting, Portland, OR, 2007.

Johnson KR. Pesticide sub-lethal effects in non-target aquatic organisms. Presented at Washington State University Pesticide Re-certification short courses, Lacey & Vancouver, WA, 2007.

Johnson KR, Jenkins JJ, P.C. Jepson. Esfenvalerate and chlorpyrifos differentially affect native Pacific Northwest aquatic insects. Presented at the American Chemical Society 232nd Annual Meeting, San Francisco, CA, 2006.

Johnson KR, Jenkins JJ, Jepson PC. Life stage influences Pacific Northwest aquatic insect susceptibility to esfenvalerate. Presented at the North American Benthological Society 54th Annual Meeting, Anchorage, AK, 2006.

Johnson KR, Jenkins JJ, Jepson PC. Esfenvalerate induces case-leaving in the Pacific Northwest caddisfly *Brachycentrus americanus*. Presented at the Society of Environmental Toxicology and Chemistry 26th Annual Meeting, Baltimore, MD, 2005.

Project Experience

Designed and coordinated laboratory experiments at Oregon State University to determine the impact of aquatic insect life history strategies and exposed life stage on pyrethroid insecticide sensitivity. Potentially sensitive life stages, morphologies and behaviors were explored during the course of these studies:

> Examined the influence of egg clutch morphology on esfenvalerate susceptibility in terms of hatchability, post-hatch neonate survivorship, and growth for three species of aquatic insect (*Baetis sp* mayfly, *Brachycentrus americanus* caddisfly, *Hesperoperla pacifica* stonefly)
>
> Defined *Brachycentrus americanus* caddisfly larval case-abandonment as a sub-lethal effect of esfenvalerate exposure, and determined impact on survivorship
>
> Determined toxic availability of particulate-bound esfenvalerate for trophic uptake and the affect of functional feeding strategy on consumption rates of three aquatic insect species
>
> Established the susceptibility of late-stage aquatic insects to esfenvalerate, and quantifying the effect on fecundity.

Performed lotic and lentic aquatic invertebrate samplings in Oregon and Washington states to obtain insect specimens for use in laboratory experiments and university collections, with proficiency in field and laboratory identifications of several aquatic insect taxa.

Assisted in agroecosystem insect sampling, species identification, and data collection for WSU research on the impacts of chemical and biological control methods on insect generalist predator populations in Washington State potato fields. Sampled surface- and canopy- active insects in both Oregon and Washington states.

Professional Affiliations

- Society of Environmental and Molecular Toxicology (current member)
- North American Benthological Society (current member)
- Entomological Society of America (former member)
- American Chemical Society (former member)

Exponent
The Lenz
1st Floor, Hornbeam Park
Harrogate
North Yorkshire
HG2 8RE
United Kingdom

telephone 0044 1423 853201
facsimile 44 (1423) 810431
www.exponent.com

Brian J. Prince, MRQA
Regulatory Efficacy Advisor

Professional Profile

Mr. Brian J. Prince is a Regulatory Efficacy Advisor in Exponent's Health Sciences Center for Chemical Regulation and Food Safety. Mr. Prince has extensive regulatory experience with plant protection products working for the UK regulatory authority for pesticides, and practical experience of efficacy and residues field testing of pesticides, working for several different Agrochemical companies. He has a comprehensive working knowledge of EU regulatory evaluation procedures and assessment methods, including relevant guidelines and EC Directives for the efficacy aspects of both existing and new active substances. He has written Biological Assessment Dossiers for clients, which have been exceptionally well received by EU regulatory authorities.

Mr. Prince's role in Exponent is to provide the lead within the area of efficacy under Directive 91/414/EEC (for plant protection products) and Directive 98/8/EC (for biocides), including the commissioning and co-ordination of efficacy studies and the writing of Biological Assessment Dossiers to support new and existing product registrations within the EU. In addition, Mr. Prince provides a service to clients wishing to gain certification for efficacy testing within the EU. The service includes the provision of detailed guidance and auditing of client facilities prior to application for certification under the 'Official Recognition of Efficacy Testing Facilities or Organisations' ('Official Recognition') also known as Good Experimental Practice (GEP).

Academic Credentials and Professional Honors

B.Sc., Hons (2.I) Agricultural Science (Crops), University of Leeds, 1984

MRQA (Member of Research Quality Assurance)

Publications and Presentations

Prince BJ. GLP for Efficacy Studies—Pesticide efficacy studies intended for submission to US EPA/GEP inspections update. BARQA GLP Field Studies Discussion Day, November 2007.

Prince BJ. Official Recognition/GEP Efficacy Inspections Update. BARQA Field Studies Discussion Day, November 2006.

Prince BJ. GEP/Official Recognition—One road to compliance, two routes to quality. Compliance & Quality, 2004 BARQA Annual Conference, November 2004.

Prince BJ. Regulatory requirements for the weed control claims that appear on product labels. AAB Meeting: Control of Weeds Not on the Product Label, February 2003.

Prince BJ. Sulfonyl-urea herbicides—rotational loading and management restrictions: A regulators view. BCPC 39th Annual Review of Weed Control, November 2002.

Prince BJ. Official Recognition of Efficacy Testing Facilities. BARQA 22nd Annual Meeting, November 1999.

Prior Experience

Higher Scientific Officer—Efficacy Section, Pesticides Safety Directorate, 1992–1997
Field Trials Officer, Dow AgroSciences Ltd., 1987–1992
Field Trials Officer, Cyanamid UK Ltd., 1985–1987
Field Trials Officer, A.H. Marks and Co Ltd., 1984–1985
Research Technician, University of Surrey (UK), 1980–1981
Research Technician, Camborne College/Rosewarne Research Centre, 1978–1980
Research Technician—ICI Plant Protection Division, 1975–1978

Project Experience

Written Biological Assessment Dossiers for clients in support of product authorisations under the Plant Protection Products Directive (91/414/EEC).

Written Efficacy Summary Dossiers for clients in support of active substance submissions and product authorisations under the Biocides Directive (98/8/EC).

Developed a Biocide Product Efficacy Template, specifically for the summary of product related efficacy data under the Biocides Directive (98/8/EC).

Involved in the development, implementation, and management of the UK scheme for 'Official Recognition of Efficacy Testing Facilities or Organizations' (required under Directive 91/414/EEC), also known as Good Experimental Practice (GEP).

Extensive experienced in evaluation of efficacy data in support of product authorizations under UK national legislation (Control of Pesticides Regulations) and European Union legislation (Plant Protection Products Directive 91/414/EEC), writing relevant sections of regulatory documents for consideration by expert committees. Involved in the production of efficacy guidance to applicants in the areas of herbicides, fungicides, plant growth regulators, and GEP. Involved in training regulatory staff in candidate/newly acceded EU Member States and COLEACP countries in GEP inspections or efficacy evaluation to EU, FAO or OECD data requirements.

Involved in the EU GEP Managers Group and the EU Herbicide Evaluators Group (forwarding the harmonization of requirements between EU Member States for GEP and efficacy data—particularly herbicides). Provided expert comments on OECD and EPPO guidance documents relating to non-target plant testing and efficacy testing, respectively.

Undertaken efficacy and residues field testing, across a broad range of plant protection products, for several national and multi-national agrochemical companies.

As a member of the Field Studies Group of the British Association of Research Quality Assurance (BARQA), provided guidance on quality systems relating to efficacy testing of plant protection products.

Professional Affiliations

- Member of British Research Quality Assurance (BARQA)
  – GEP/GLP Field Studies Liaison

ANNEX 159

Inter-American Drug Abuse Control Commission (CICAD),
Second Phase Environmental and Human Health Assessment of the Aerial Spray Program for Coca and Poppy Control in Colombia (date unknown)

SECOND PHASE ENVIRONMENTAL AND HUMAN HEALTH ASSESSMENT OF THE AERIAL SPRAY PROGRAM FOR COCA AND POPPY CONTROL IN COLOMBIA

---

1 INTRODUCTION

There are several issues that have been identified with respect to the production and eradication of coca in Colombia that require further investigation and understanding. Eradication issues relate to the efficacy and environmental toxicity of adjuvants use to enhance the efficacy of glyphosate. Testing of the glyphosate-Cosmo-Flux® formulation for toxicity to amphibians. Spray drift has not been measured under conditions of use in Colombia. Conduct a study to identify risk factors associated with time to pregnancy (TTP). The following are proposals to address these research needs.

1.1 ASSESSMENT OF ADJUVANTS ON THE EFFICACY OF GLYPHOSATE

At this time, glyphosate is mixed with Cosmo-Flux® prior to application. The mixture is somewhat more toxic to aquatic organisms than the formulated glyphosate. Other adjuvants are potentially less toxic to aquatic organisms than Cosmo-Flux® and there are several other commercial formulations of glyphosate that are less toxic to aquatic organisms than Roundup®. These formulations and/or mixtures of other adjuvants may be less toxic to non-target aquatic organisms that the currently used mixture, however, they may not be as effective as the current mixture in controlling coca. It is proposed that a number of formulations and adjuvants be tested for efficacy in controlling coca and, if they are as, or more effective, than the current mixture, they be tested for toxicity to key aquatic non-target organisms such as rainbow trout and frog larvae. This would allow the identification of more effective and less hazardous formulations and mixture of surfactants.

1.1.1 Proposed research methods

1.1.1.1 Selection of formulations and adjuvants

Several adjuvants have already been tested for efficacy {Collins, 2002 #1942}. The more active of these that also have low environmental toxicity will be included in the trial (Table 1). Additional surfactants will be sought on the recommendations of users of glyphosate in similar uses such as in aerial application for forestry. It is proposed that the current formulation of glyphosate be tested as a reference point and that additional

adjuvants, including those listed in Table 2, will be used. Additional surfactants will be added to this list as they are identified.

Table 1. Glyphosate and surfactant mixtures as previously tested at 2.2 and 4.4 kg/ha

Mixture	Rank order of efficacy[a]
Glyphosate without surfactant (Rodeo®) + 2%[(Agri Dex® - Heavy-range paraffin-based petroleum oil + polyethoxylated derivatives thereof + sorbitan ester based emulsifiers) + (Silwet L77®) – 50:50 mix] diluted in water.	1
Glyphosate (Roundup® original) + 2%[Optima® - Polyethoxylated alkyl amines [C8–C18] + alkyl polyoxyethyleneglycols + organic acids] diluted in water.	2
Glyphosate without surfactant (Rodeo®) + 2%[X-77® - Alkylarylpolyoxyethylene glycols 1 free fatty acids + isopropanol] diluted in water.	3
Glyphosate without surfactant (Rodeo®) diluted in water.	4
Glyphosate without surfactant (Rodeo®) + 2%[Cide-Kick II® D-Limonene + nonylphenol polyethyleneglycol ether] diluted in oil.	5

[a] Data from {Collins, 2002 #1942}.

Three rates of glyphosate will be tested. These will be 1.25, 2.5 and 5 kg/ha (X, Y, and Z). This will allow identification of more effective materials and the approximate rates of application needed for equivalent efficacy.

Table 2. Proposed adjuvants to be tested.

Treatment	Adjuvants (2.5%) added to glyphosate as currently used in Colombia
A-0	Unsprayed control
A-1	Glyphosate only
A-2	Glyphosate + Cosmo-Flux®
A-3	Glyphosate + [(Agri Dex® + Silwet L77®) - 50:50 mix]
A-4	Glyphosate + Silwet L77®
A-5	Glyphosate + Optima®
A-6	Glyphosate + X-77®[a]
A-7	Glyphosate + LI-700®[b] a lecithin-based surfactant consisting of a mixture of phosphatidylcholine, alkyl phenol ethoxylates, and methylacetic acid
A-8	Glyphosate + etc., etc.

[a] May be omitted as this surfactant is toxic to aquatic organisms {Solomon, 2003 #1674}.

[b] Shown to have low toxicity aquatic organisms {Solomon, 2003 #1674}.

1.1.1.2 Experimental plots

A series of small plots of coca will be planted from seedlings or from cuttings of *Erythroxylum coca* var. *coca* and *E. novogranatense* var. *novogranatense*, (A and B, respectively) will be used that represent the most commonly used strains. These plots will be planted with the aid of a person(s) with local expertise. All appropriate fertilizing and pest management will be done on these plots to ensure that the plants are healthy and representative of those grown locally. Each will have nine plants in a 3 x 3 pattern. Spacing will be 80 cm and the space between plots will be 200 cm. All treatments will be replicated four times and will be allocated to plots at random arranged within four blocks. All treatments will be replicated four times and will be allocated to plots at random arranged within four blocks. A total of more than 220 small plots will be set up and planted with coca bushes; >168 of which will be used for experimental work and 24 others kept as additional plots.

Provisional layout of the plots is shown in Table 3.

Table 3. Adjuvant plot allocations

	Strain 1				Strain 2			
Treatment	Block A	Block B	Block C	Block D	Block A	Block B	Block C	Block D
A-1-X	16	18	9	21	5	17	5	13
A-1-Y	8	12	1	9	16	1	10	15
A-1-Z	11	1	16	11	1	12	14	14
A-2-X	18	17	17	1	2	6	11	9
A-2-Y	10	21	6	19	11	7	13	12
A-2-Z	12	2	19	16	20	21	4	6
A-3-X	19	10	5	14	18	19	8	4
A-3-Y	6	16	14	3	3	20	21	20
A-3-Z	9	19	20	4	12	3	19	11
A-4-X	3	7	8	8	9	18	12	5
A-4-Y	4	14	3	7	13	10	6	18
A-4-Z	5	6	12	13	6	13	2	21
A-5-X	1	3	15	17	19	14	3	1
A-5-Y	17	15	7	20	10	8	1	19
A-5-Z	21	9	18	18	17	9	18	17
A-6-X	20	20	4	2	15	4	16	2
A-6-Y	15	11	10	5	21	11	17	3
A-6-Z	13	4	11	15	7	16	20	10
A-7-X	14	8	2	6	4	5	15	8
A-7-Y	7	5	21	12	8	2	9	7
A-7-Z	2	13	13	10	14	15	7	16

1.1.1.3 Treatments

Once the coca crop has reached a stage equivalent to the age when it would be sprayed with glyphosate (1 m tall) it will be subjected to the treatments summarized in Table 4. The mixtures will be applied to the plots using backpack sprayers between the hours of 7h00 and 15h00 on a day when rain is not predicted within the next 24 h.

1.1.1.4 Observations

The following observations will be made on the treated and blank plants (Table 4).

Table 4. Observation on treated and blank plants

Observations	**Measures**	**Times of observation (days after treatment)**
Disease incidence	Number of lesions per leaf, n = 10 per plant, 3 plants per plot.	-7, 0
Insect damage	Area of leaf eaten n = 10 per plant, 3 plants per plot.	-7, 0
Glyphosate effects	Scoring system of 0-5 with 0 = no visible damage, 5 = extensive damage. Per plant, 3 plants per plot.	1, 3, 7, 14, and 28 d after spraying
Yield	Wet mass and dried leaf mass.	28 days after spraying
Alkaloid yield	Mg/kg dry leaf tissue.	28 days after spraying

1.2 Spray Drift

A field experiment will be made with aerial application of a Cosmo-Flux® mix under field conditions. Three non-overlapping spray swaths will be sprayed and spray targets (water-sensitive paper and filter papers for dye catching) set out in transects so that a spatial representation of deposition can be mapped. Test plants of pot-grown maize will also be placed with targets to evaluate the biological impact of drift outside the target area. Applications can be repeated for four wind speeds (1, 2, 4, and 8 knots). A comparison of predictions with EPA drift models will evaluate the accuracy of risk predictions from drift events. Different spray heights will be used as well (30, 50, and 70 m).

1.2.1 Location

Secure airfield with typical semi natural vegetation similar to coca.

1.2.2 Application

Pre-programmed as for actual applications. Three spray applications for each set of conditions of wind speed and height. Three times of day
4 wind speeds * 3 Heights * 3 times of day = 36.
Spray mixture: glyphosate/Cosmo-Flux®
Spray plane available – 3 occasions Dec., Feb., April/May?

On-site records: wind speed, temperature, humidity, plane height.

1.2.3 Spray targets

Water sensitive papers.

1.2.4 Target locations

Four transects at 90° to the spray run, comprising 15 locations: swath centre, swath edge and at 1, 2, 5, 10, 15, and 20 m each side. Two further transects at each end of the spray area, with targets located at the swath edge, 2, 5, 10, and 20 m into the spray area and 1, 2, 5, 10, 15, 20, and 30 m outside the spray area (Figure 1).

Drift experiment: proposed layout of spray collectors

(distances in metres)

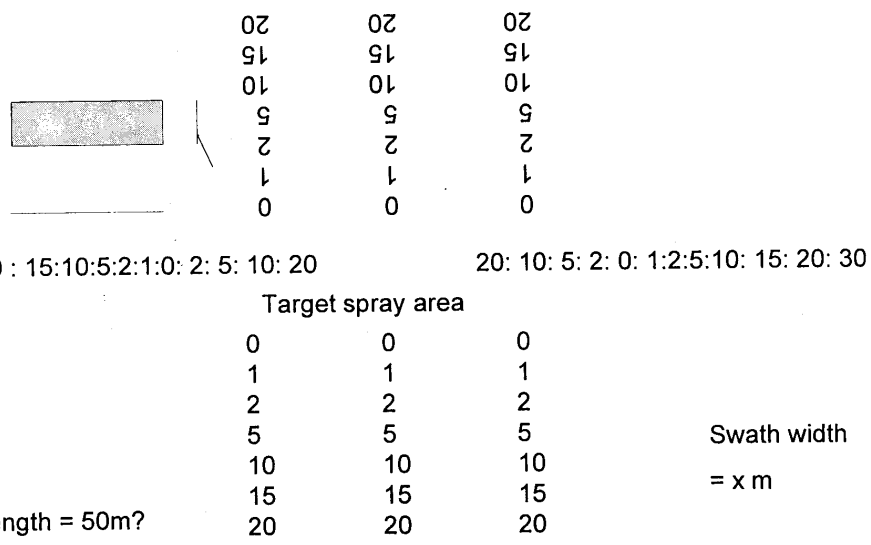


Figure 1 Layout of drift samples

1.2.5 Sample analysis

For water-sensitive paper, measure proportion of cover (can be done with image analysis, if available).

1.2.6 Analysis

Map depositions and quantify proportions of off-target application.
Derive drift scenarios from EPA models and compare with field observations.

1.2.7 Ancillary measures

Wind speed, wind direction, air temperature, and relative humidity at spraying.

1.3 Human Health Study

In the study carried out an assessment of time to pregnancy was done and no association with aerial spraying with glyphosate was established. However, there were differences among regions which were not explained by the data collected.

In the bibliographic review it was stated that acute, sub-acute, and chronic effects of the exposure to glyphosate have been assessed. Among the acute effects both skin and eye irritation have been documented and both resolve easily and with no complications. The National Institute of Health of Colombia is finishing an evaluation of acute effects in the country and results will be published soon.

Chronic effects, especially related to potential carcinogenesis, are, so far, not conclusive and its assessment requires long lasting and highly costly observational studies. In addition, there are ongoing studies in other parts of the world that will provide useful information regarding this matter.

Reproductive health still has unsolved questions regarding glyphosate exposure. Incidence of birth defects or miscarriage has not been completely evaluated. Studies on citotoxigenic effects that have been recently evaluated by other investigators in the region are not properly designed and sample size are inadequate.

We propose to carry out a prevalence study of citotoxigenic effects in the five areas where the former study was carried out. Sierra Nevada de Santa Marta where organic coffee crops are not exposed to any chemical, Boyacá where there is not aerial spraying of glyphosate but use of other chemicals may be found, Valle del Cauca where aerial spraying of glyphosate is used for sugar cane maturation and Putumayo and Nariño where aerial spaying of glyphosate has been and will be performed in the future.

Prevalence study will be carried out to assess frequency of citotoxigenic effect in the five areas. Ecologic study will be performed by conducting a second prevalence study after spraying in the three areas where it is done.

A random sample of the already interviewed women will be obtained and both interviews and blood samples will be taken after an informed consent has been signed by each participant. Differences in micronuclei, "cometa" effect, and chromosome alterations will be evaluated by the proper statistical tests. Samples and interviews will be taken again after aerial spraying of glyphosate in the three areas where it is done. Samples and interviews from the control areas will also be taken a second time to evaluate whether changes occur in citotoxigenic effects in both exposed and non-exposed areas to aerial spraying.

Further analysis will be performed with the new collected data and the already available information from the first phase of the study.

1.4 Amphibians

To be completed later after discussions with OAS

1. Glyphosate and adjuvant dissipation in 15 cm deep water bodies with sediment using a laboratory species such as *Xenopus laevis*.
2. Toxicity to Colombian frog species (tadpoles and juvenile).

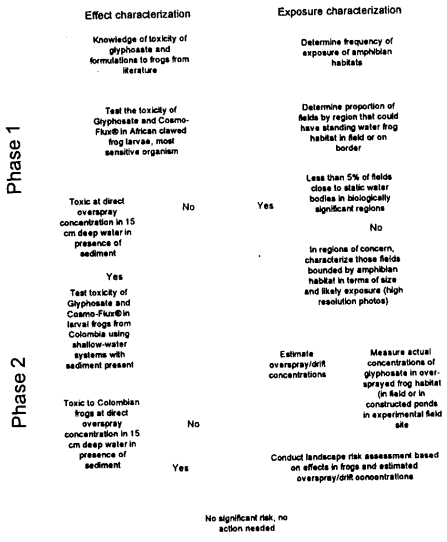
Table 5. Suggestions to address frogs questions.

Action	Usefulness	Done by	Days[1]
Effects			
A. Review knowledge of toxicity of glyphosate, formulations, and adjuvants to frogs from literature.	Background on toxicity data for extrapolation and comparison.	SAT or others	40, concurrent with B.
B. Test the toxicity of Glyphosate and Cosmo-Flux® in African clawed frog larvae, most sensitive organism.	As African clawed frog is presently the most sensitive frog to Roundup®, this would be a worst case estimate of effects.	Contract Laboratory with current experience and GLP	90
C. Test toxicity of Glyphosate and Cosmo-Flux® in larval frogs from Colombia.	Obtain additional data on locally relevant species under natural conditions with shallow water and sediment as well as vegetation and soil for terrestrial frogs.	People in Colombia. Would need to find them and set up the study. GLP unlikely but spirit of GLP possible.	+365, dependent on B.
Exposure			
D. Determine proportion of fields by region that could have standing water frog habitat in field or on border. Do this by Departments and use a subsample of fields (30 or 40 per Department).	Will give a low resolution estimate of which areas may have the highest risks of exposure.	Appropriate people in Colombia (DNE and others).	130, concurrent with A. and B.
E. In regions of concern, characterize those fields bounded by amphibian habitat in terms of size and likely exposure (high resolution photos).	Narrow the focus to those Departments and/or regions where risk of exposure is greatest. Collect high resolution images with GyroCam and use spray drift and surface area of habitat to estimate concentrations in	People in Colombia working with DNE. This would require that the new camera be operational and that the operators have training.	+365, dependent on D and technology.

Action	Usefulness	Done by	Days[1]
	the habitat. Collect data from a larger number of fields to get a better sample (50-60)		
G. Using the above data on the high-risk fields, use estimated exposures (based on direct overspray and drift, and topography of soil or water body). And/or, measure concentrations in a sample of typical water bodies on edges of fields immediately after spraying.	If toxicity data indicate a hazard (toxicity to frogs at relevant environmental concentrations), this will allow a risk assessment to be conducted.	People in Colombia working with others (SAT) and with an analytical laboratory.	+180, depend-ent on E. and C.
H. Conduct risk assessment.	Risk will be quantified.	SAT and people in Colombia.	+180, con-current with G.

[1] All times are estimated from approval of the protocols and contracts (early December). A "+" indicates that the time estimate follows from a previous study.

158



159
160 Figure 2: Frog studies

2 REPORT

Report content will include presentation of data, analysis, interpretation, and discussion of the following:

Field study methods
Discussion of the relevance of findings
List of any SOPs used

2.1 *RECORDS TO BE MAINTAINED*

A draft report containing the preliminary results of the project will be delivered within 6 months of the initiation of the study. A final report will be delivered on a mutually agreed date. All data, documentation, records, protocol information, specimens will be archived. The report will be confidential and will not be published without the prior approval of the Government of Colombia.

3 TIME LINES

The tentative timeline for the project is shown in Table 7. The time line depends on start-date of planting and on rate at which plants mature. It is assumed that the plants will be in the ground on November 01, 2005 and that they will be mature enough for the study to begin in 180 days.

Table 7. Proposed time lines

Adjuvant testing

Date	Target	Days	Total days
11/1/2005	Planting of coca	0	0
4/30/2006	Coca mature	180	180
5/1/2006	Begin treatments	1	181
5/2/2006	Begin observations	1	182
5/30/2006	Assess yields	28	210
6/20/2006	Determine alkaloid yield	21	231
7/11/2006	Data analysis	21	252
7/25/2006	Final report	14	266

Protection and rescue

Date	Target	Days	Total days
11/1/2005	Planting of coca	0	0
11/9/2005	Coca mature	180	180
11/10/2005	Begin protective treatments	1	181
11/12/2005	Spray coca	2	183
11/12/2005	Begin rescue treatments	0.04	183
11/13/2005	Evaluate plants	1	184
11/15/2005	Evaluate plants	2	186
11/19/2005	Evaluate plants	4	190
11/26/2005	Evaluate plants	7	197
12/10/2005	Evaluate plants	14	211
12/11/2005	Harvest leaves and determine biomass yield	1	212

12/16/2005	Interim report	5	217
1/7/2006	Evaluate pruned plants	22	239
1/28/2006	Determine alkaloid yield	21	260
2/18/2006	Data analysis	21	281
3/4/2006	Final report	14	295

Drift

Date	Target	Days	Total days
11/1/2005	Prepare sites	0	0
12/1/2005	Conduct first spraying	30	30
2/4/2006	Conduct first spraying	65	95
4/10/2006	Conduct first spraying	65	160
5/10/2006	Analyze data	30	190
6/9/2006	Final report	30	220

Shallow water exposures

Date	Target	Days	Total days

This will be done during the protection and rescue study.

Frog toxicity testing

Date	Target	Days	Total days
11/1/2005	Phase 1 *Xenopus laevis*	90	90
7/19/2006	Phase 2 Colombian frogs	260	350
8/28/2006	Final report	40	390

Human Health

Date	Target	Days	Total days
11/1/2005	DNA study	300	300

4 REFERENCES

ANNEX 160

Charles S. Helling & Mary J. Camp, United States Department of Agriculture, *Verifying Coca Eradication Effectiveness in Colombia* (date unknown)

Redactions by the Government of the United States of America.
Document obtained by Ecuador through the U.S. Freedom of Information Act.

VERIFYING COCA ERADICATION EFFECTIVENESS IN COLOMBIA

Charles S. Helling[1] and Mary J. Camp[2]

ABSTRACT

Controlling illicit coca (*Erythroxylum* sp.) cultivation, and thereby cocaine production, is accomplished in part by a program of eradication. In Colombia, the major source of both coca and cocaine, illicit crop suppression is achieved almost solely by aerial application of the herbicide glyphosate, beginning in 1994. Independent verification of the effectiveness of the spraying began in 1997; by December 2002, nine Verification Missions had been conducted, employing visual observation by a team of 3-4 raters. For the first time, a rigorous statistical evaluation of this 6-year data set (349 fields) has been done, and results are reported.

Coca control within the spray swath was initially somewhat low, but with improvements to the glyphosate spray tank mixture, had increased to 90-95% during the rating period 1998-2000. A highly significant decline then occurred, through December 2002, and this was reflected by a decreasing probability of fields becoming out-of-production. Growers' countermeasures combined with lowered herbicide rates (in much of 2002) and application problems (mountainous terrain, adverse weather in late 2000) may explain the reduced effectiveness. The chemical efficacy factor is used to adjust total annual sprayed area, then achieving an estimate of eradicated acreage of coca.

---

[1] Soil Scientist, Alternate Crops and Systems Laboratory, Agricultural Research Service, U.S. Department of Agriculture, Beltsville, MD 20705.

[2] Biometrician, Biometrical Consulting Service, ARS-USDA, Beltsville, MD 20705.

Redactions by the Government of the United States of America.
Document obtained by Ecuador through the U.S. Freedom of Information Act.

field being out of production for Mission #5 and Mission #9 are statistically different at the 0.01 significant level for all Swath-air thresholds and for the 80% Field threshold.

RESULTS AND DISCUSSION

Overall Summary of the Coca Verification Missions

In Table 1, the nine Colombia Coca Verification Missions conducted from October 1997 through December 2002 are summarized. To estimate herbicide effectiveness in controlling coca, 349 swaths were rated for coca fields sprayed between March 1997 and September 2002. Although initially, raters speculated that even 70% coca control might prove acceptable, very quickly the consensus among raters, in ca. 1997-1999, was that the mean swath control should be at least 85% in order to render sprayed fields virtually unusable.

Glyphosate Tank Mixture Composition, Glyphosate Rate, and Eradication Effectiveness.

Assuming that at least 85% swath control was necessary, the Mission #1 results (69%, Table 1) showed immediately that improvements must be made to the herbicide system, in order to achieve higher coca control. The ARS-USDA team members recommended, and Colombia approved, boosting the surfactant concentration in the glyphosate tank mixture through addition of Cosmo-Flux 411F (1% by volume) plus a second additive to minimize foaming in the spray tank, and potentially to reduce drift. The recommendation was based on on-going coca research, part of which was published recently [2]. Those subsequent changes, inclusion of two Colombian adjuvants to the spray tank mixture and a later modification of the commercial

Redactions by the Government of the United States of America.
Document obtained by Ecuador through the U.S. Freedom of Information Act.

glyphosate formulation, led to increased coca injury and death rates, especially as seen in Missions #3-7 (Table 1).

Apart from the early consideration of glyphosate system composition (Mission #1), Missions #1-8 primarily involved the variables of time of year (when spraying was done), geographic area of spraying, and different types of spray aircraft. Mission #9 incorporated an important added variable: the potential effect of different herbicide rates. Coca eradication in Colombia, since 1998, was treated with glyphosate at 5.0 kg (a.i.)/ha, which is equivalent to 3.74 kg (a.e.)/ha. The spray mixture, in water, was applied at the rate of 10.4 L/ha. In March 2002, the Government of Colombia required the glyphosate rate to be reduced to 2.85 kg (a.e.)/ha based on very limited testing which, they concluded, showed no significant decline in control of coca. Restoration of higher rates occurred on August 25, 2002 (to 3.56 kg/ha, in Putumayo only), and to 3.70 kg/ha on September 6, 2002. One of the most important objectives of Mission #9 was to determine, if possible, the effect of the three glyphosate rates on coca control, and so sampling deliberately included subpopulations of the two higher rates. Most samples had been treated only at the low rate, however.

As described elsewhere [5], the mean swath control in Putumayo (the only location where all three rates had been used) was 84.6%, 87.5%, and 91.3%, respectively, for the 2.85, 3.56, and 3.70 kg (a.e.)/ha rates. The sample population was 15, 6, and 6 sites, respectively. When all 74 rated fields treated at 2.85 kg/ha were included, the mean rating for those sites was but 70.3%. Thus, the verification mission confirmed that the highest rate of glyphosate should be continued in order to maintain at least 90% overall coca control. However, since eradication tended to be most successful in Putumayo Department, even with the higher herbicide dose, the nationwide

Redactions by the Government of the United States of America.
Document obtained by Ecuador through the U.S. Freedom of Information Act.