INTERNATIONAL COURT OF JUSTICE

CASE CONCERNING
AERIAL HERBICIDE SPRAYING
(ECUADOR v. COLOMBIA)

REJOINDER OF THE REPUBLIC OF COLOMBIA

VOLUME II

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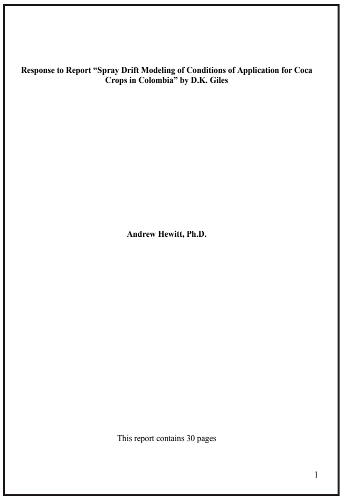
Annex 1

Dr A.J. Hewitt, Ph.D., *Response to Report "Spray Drift Modeling of Conditions of Application for Coca Crops in Colombia by D.K. Giles, Jan. 2011"*, November 2011


Response to Report "Spray Drift Modeling of Conditions of Application for Coca Crops in Colombia" by D.K. Giles

Andrew Hewitt, Ph.D.

This report contains 30 pages

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Summary

1. This report provides a response to a report prepared by D.K. Giles titled "Spray Drift Modeling of Conditions of Application for Coca Crops in Colombia", as well as reports cited in the Giles report.

2. The Giles report ignores the most important variable in the present scenario which is closer to forest spraying than to spray applications over low crops or bare ground – namely the presence of extensive canopy vegetation (trees and shrubs) in the area of the spray applications and downwind of the applications, between Colombia and Ecuador. These vegetation surfaces and structures act as excellent capturing media for airborne droplets, thereby reducing spray drift to *de minimis* levels within a few hundred meters of the applications. When properly accounted for in the modelling, this canopy reduces the spray deposition values from those reported by Giles to values that represent *de minimis* drift, i.e. <0.7 g/ha at a distance of 800 m from spraying 10 swaths with width of 50 m each, decreasing by an order of magnitude by 10 km downwind from the sprayed area. Furthermore, spray drift is directional and only occurs in the downwind direction. Predominant wind directions in the border region between Colombia and Ecuador include winds blowing away from Ecuador, which means that most of the time, any spray drift that does occur will be away from Ecuador.

Introduction

3. This report has been prepared by Dr Andrew Hewitt, who directs spray drift research and modeling programs at the Centre for Pesticide Application and Safety at the University of Queensland in Australia as well as related work in the US, New Zealand and Canada. Dr Hewitt has over 2 decades of experience in spray drift management, research, modeling, education and extension in Europe, North America, Australia, New Zealand, Costa Rica, Honduras, the Philippines and other countries. He was the Project Manager for the most comprehensive studies ever conducted into spray drift, in a $25 million U.S. dollar research program by the Spray Drift Task Force (www.agdrift.com). He is one of the developers of the AgDRIFT™ spray drift management and risk assessment model which is used by EPA and government agencies in many countries for assessing buffer zone and other protective measures for spray drift labeling and regulatory management. He is the initial technical advisor to EPA on an extensive drift reduction technology project initiated in late 2005. As a Science Fellow, he advises the Australian Pesticides and Veterinary Medicines Authority on buffer zone, spray drift management and risk assessment issues. Author of hundreds of papers and book chapters on spray application technology and drift management, he serves as Chair for international society committees relating to spray drift. His *curriculum vitae* is included in Appendix 1.

4. Pesticide drift is defined by most governments around the world as involving the movement of droplets of pesticide at the time of spray application to an off-target site. It

is important to prevent drift exposure at levels of concern for affecting people, animals, wildlife and other sensitive organisms.

5. Extensive research has been conducted around the world into the main factors that affect spray drift following applications of pesticides, and the key mitigation strategies are well-known. They include appropriate set-up and use of spray equipment, observance of meteorological conditions to ensure application does not occur under wind speed/ direction and other conditions that might cause spray drift exposure, consideration of the toxicity of the applied chemical and environmental/ canopy conditions such as barrier and buffer vegetation. Many of these factors can be assessed using validated models which have been developed specifically for spray drift exposure risk assessments.

6. The present report addresses off-target spray drift exposure risk from aerial applications of glyphosate to coca crops in Colombia in response to a report prepared by D. K. Giles, "Spray Drift Modeling of Conditions of Application for Coca Crops in Colombia". The report has been prepared based on knowledge and experience of aerial applications relevant to this situation. The author served as a member of a science advisory team for the Inter-American Drug Abuse Commission (CICAD) to the Organization of American States (OAS) studying atomisation as it relates to the potential drift of herbicide spray for aerial spraying operations conducted as part of PECIG. The research findings were presented in peer-reviewed literature (Andrew J. Hewitt, Keith R. Solomon, and E.J.P. Marshall, 2009, Spray Droplet Size, Drift Potential, and Risks to Nontarget Organisms from Aerially Applied Glyphosate for Coca Control in Colombia, Journal of Toxicology and Environmental Health, Part A, 72, 921-929). This paper presented a summary of wind tunnel droplet size research and subsequent modeling of spray dispersion for generic scenarios applicable to aerial applications in Colombia. Giles subsequently assessed the impact of a range of variables on spray drift potential. Those analyses are discussed in the present report.

7. In his Executive Summary (page 1), Giles presents several factors which can increase spray drift potential above safe levels. These factors were stated to be as follows:

- Higher aircraft flight speeds than prescribed in the Colombian Environmental Management Plan (EMP);
- Greater aircraft heights than prescribed in the EMP;
- High wind speeds (>2.57 m/s assumed in Hewitt *et al* (2009));
- Stable atmospheric conditions from night spraying, and
- Cumulative loading effects from multiple versus single flight lines.

These factors are evaluated in the Giles report using sensitivity analyses with the AGDISP version 8.25 spray transport/ deposition model.

8. It is acknowledged that whenever anything is released into the atmosphere, some small amount of the material may be detected at distances downwind of the release. However, for spray drift of pesticides and herbicides, the deposition rates downwind of the application must be considered in the context of levels of concern for sensitive areas

of interest. For glyphosate, the level of concern is 1368 g/ha for amphibians and 36-1958 for various crops according to a review of published data by Hewitt *et al* (2009): "Hewitt, A.J., Solomon, K.R. and Marshall, E.J.P. (2009). Spray droplet size, drift potential, and risks to non-target organisms from aerially-applied glyphosate for coca control in Columbia. *J. Toxicology and Env. Health*, *Part A,* **72,** 921-929". Such high rates will not occur at distances beyond a few meters for aerial applications of glyphosate in the PECIG program which is the Program for the Eradication of Illicit Crops by Aerial Spraying with Glyphosate.

AGDISP

9. AGDISP is a widely accepted model for spray drift modeling at near-field distances up to approximately 800 m from the spray release location. The model performs well at distances close to the spray release but tends to over-predict spray drift relative to field study data at distances beyond a few hundred meters, with an over-prediction level of approximately 4 x field data by 800 m downwind. This over-prediction was described by several authors from EPA and elsewhere, for example in the following paper: "Bird, S.L., Perry, S.G., Ray, S.L. and Teske, M.E. (2002) Evaluation of the AGDISP aerial spray algorithms in the AgDRIFT model, *Environmental Toxicology and Chemistry* 21(3), pp. 672-81". Hence AGDISP predictions are considered to be environmentally-conservative at far-field distances. The model includes a Gaussian extension toolbox which allows the predictions to be extended to much greater distances.

10. AGDISP is the engine for several other spray drift models, the most notable of which is AgDRIFT™, a model developed under a co-operative research and development between the US Environmental Protection Agency ("EPA"), the U.S. Dept of Agriculture Forest Service ("FS") and the Spray Drift Task Force ("SDTF"). Hewitt was one of the authors of AgDRIFT™ and a summary of the model features and operation is presented in the following paper: Hewitt, A.J., Teske, M.E. and Thistle, H.E. (2001) The Development of the AgDRIFT® Model for Aerial Application from Helicopters and Fixed-Wing Aircraft. Australian Journal of Ecotoxicology Vol. 8, pp. 3-6. If the same inputs are provided to AGDISP and AgDRIFT™, the model predictions will be the same. However, the presence of extensive libraries of input data in AgDRIFT™ allows end-users to avoid having to use generic values for many of the important variables affecting drift. One such variable is the evaporation rate for actual tank mixes, with AgDRIFT™ libraries providing values for a range of active ingredient tank mixes.

Canopy

11. The Giles report failed to properly acknowledge that the vegetation and structures surrounding and downwind of the spray applications would act as excellent receptors for airborne droplets, thereby preventing their off-target movement as drift. The report suggests that droplet size was probably in the order of 128 µm, based on wind tunnel measurements of the same nozzles, simulated aircraft speeds, nozzle types and tank

mixes. Interestingly, this is within the range of droplet sizes typically used for targeting sprays to foliage in applications around the world for tree, vine and other leafed crops. While the optimum size for a given application varies according to factor such as canopy type, product efficacy and sprayer setup, most applications of pesticides to tree canopy foliage involve droplets with average diameter somewhere between 50 and 150 μm because collection efficiency of the foliage is highest for these droplet sizes.[1]

12. Giles assumed a very low coca canopy for modeling spray drift in the initial sensitivity analyses sections of his report whereas the application areas are more likely to comprise trees with varying heights up to 30 to 65 meters, with an approximate average height in the order of 32.5 m based on the Hansman and Mena Report (ER Annex 1, p. 10), where it is stated that "The canopy height of the rainforest in the Ecuador-Colombia border region is in the range of 30 to 35 metres. Emergent trees may extend even higher, reaching 50 or even 65 metres above ground (Balslev, 2010)."[2]

13. While it is true that the initial spray release occurs above lower coca crops, there is typically a canopy in the areas near the crops as cultivation typically involves clearing strips of ground in an area of otherwise dense vegetation. To account for this mixture of clearings and taller trees/ vegetation, the average ground reference height for modeling across the entire area between the spray applications and sensitive areas downwind should be set to a value of approximately 30% of the average tree height, *i.e.*, 10 m. Once this is set, the model will calculate spray interception both by the canopy and on the ground. Based upon published literature regarding the canopy in the Amazonian rain forest, the canopy can be set as being Generic Deciduous with a Leaf Area Index of 6.[3] Even if the aircraft is above the canopy, rather than surrounded by canopy on both sides, any airborne spray drift will be intercepted by canopy downwind of the spray release.

14. Similarly, assessments by Giles of the effect of aircraft height on spray drift have ignored the significant canopy downwind of the spray applications which would effectively filter out any airborne spray drift. It is not appropriate to model these applications with an aircraft flying above little or no canopy when the region includes significant canopy and structures.

15. Many publications discuss the value of vegetation for intercepting spray drift with typical reductions of up to 90%.[4]

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[1] *See* Matthews, G.A. (2000) *Pesticide Application Methods* 3rd Edition. Blackwell Science, Oxford, 432 pages. This means that droplets would be collected very efficiently by the surrounding vegetation which would act as an effective filter to avoid drift losses.

[2] The Balslev article is contained in an Annex for the Ecuador Reply: The Vulnerability of the Ecuador-Colombia Border Region to Ecological Harm, Henirk Balslev, January 2011.

[3] *See* David B. Clarke, Paulo C. Olivas, Steven F. Oberbauer, Deborah A. Clark, and Michael G. Ryan (2008) First direct landscape-scale measurement of tropical rain forest Leaf Area Index, a key driver of global primary productivity, Ecology Letters 11, 163-172; A.-L. C. McWilliam, J. M. Roberts, O. M. R. Cabral, M. V. B. R. Leitao, A. C. L. de Costa, G. T. Maitelli and C.A. G. P. Zamparoni (1993) Leaf area index and above-ground biomass of *terra firme* rain forest and adjacent clearings in Amazonia, Functional Ecology 7, 310-317.

[4] *See* Raupach, M.R., Woods, N., Dorr, G., Leys, J.F. and Cleugh, H.A. (2001) The Entrapment of Particles by Windbreaks. *Atmospheric Environment*.; Anon (1997) Planning Guidelines: Separating Agricultural and

Evaporation Rate

16. On page 7 of his report, Giles discusses the effect of evaporation on spray drift. The suggestion that evaporation rates are higher for small droplets than large droplets and that this increases spray drift is an over-simplification of a complex process. A valuable feature of AGDISP is its complex evaporation algorithms which allow the process to be properly modeled when the user inputs the droplet size spectrum, tank mix evaporation rate, proportion of non-volatile materials in the spray (basically most components other than water), air temperature, relative humidity and wind speed. If a droplet does experience complete loss of all of its volatile components by evaporation prior to deposition, its final size will depend on the proportion of the contents which were non-volatile and typically such small droplets would be dispersed and diluted in the atmosphere to tiny (*de minimis*) amounts. The Giles report presents a sensitivity analysis for evaporation rate effects on drift potential (page 26). However, the implication that drift would involve slightly higher values and more concentrated droplets because the rate might be closer to that of water (84 µm/°C/sec) than the 37 value used by Hewitt *et al* (2009) is without foundation because Hewitt *et al* (2009) derived their value from that for glyphosate in the spray material library in AgDRIFT™. The spray material libraries in this model include data for actual tank mixes which were measured according to Good Laboratory Practice Standards ("GLPS") by the Spray Drift Task Force, subjected to peer and Scientific Advisory Panel review by EPA, and accepted as accurate data. Indeed, a realistic value for evaporation rate will support obtaining a more accurate model prediction of pesticide drift as in this assessment.

Application Rate

17. Giles suggests that the use rate of sprays applied in PECIG is higher than assessed in the Hewitt *et al* (2009) paper. On page 25 of his report, a table is presented showing application rates of 10.4 L/ha as assumed by Hewitt et al (2009) compared to various higher rates between 20 and 28 L/ha. Application rates for sprays applied by aircraft can be described by the total application volume rate (which includes everything in the tank mix, i.e. the carrier, which is usually water, plus the formulated pesticide product plus any adjuvants) and by the active ingredient application rate. The formulated pesticide product usually includes both the active ingredient (glyphosate in this case) and various inert materials used to optimize delivery/ mixing. Different rates are used for coca than for poppy spraying in PECIG. The applications for coca spraying were typically based on application rates of 10.4 L/ha formulated glyphosate/ 23.64 L/ha total spray mix (~680 L/min total flow rate for a swath width of ~52 m and the actual aircraft speed of ~93 m/s for the OV-10) of total tank mix with the glyphosate herbicide product included at a rate of 1.2 to 4.992 kg/ha, of which 75% was the actual acid equivalent product, glyphosate

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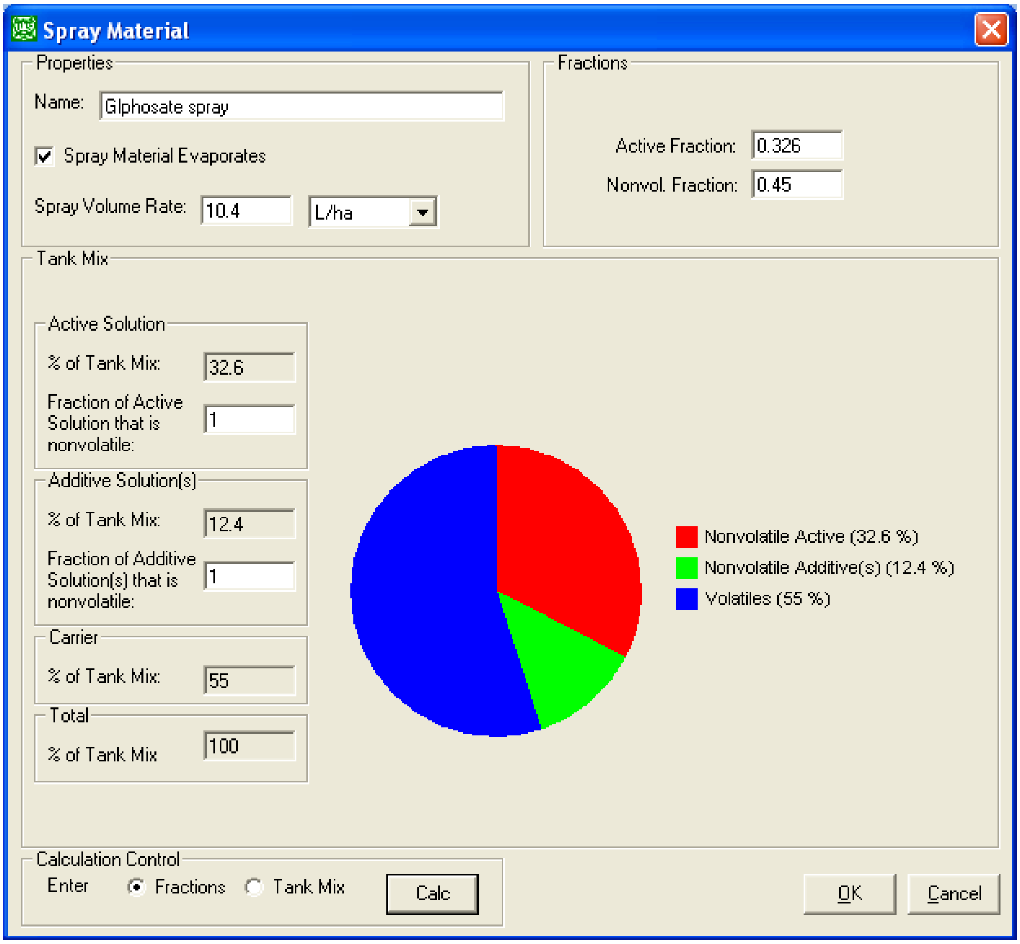
Residential Land Uses. Dept of Natural Resources, Queensland and Dept of Local Government and Planning, Queensland, Australia. DNRQ 97088; www.agdrift.com/PDF_FILES/drift%20filtration.PDF.

(the remaining 25% was inert materials included for product formulation optimisation). AGDISP has different model input sections which need to be populated to enter all of this information because the model requires information on the rates of the various tank mix components as well as the rate applied per hectare of sprayed ground. The following figure shows an example of the model section for input of this information.



18. In this example, the spray volume rate is 10.4 L/ha, of which approximately one third is active ingredient glyphosate. Because the key factor is the active ingredient rate, if the spray volume rate is changed for the same active ingredient rate, there will be little or no difference in drift from applications such as those in PECIG. Hence the Hewitt et al (2009) paper is not in error in its calculations of spray drift levels for using a spray volume rate of 10.4 L/ha rather than 23.65 L/ha or any other value cited from PECIG sources, because the active ingredient rate range was correct for the operational uses.

Atmospheric Stability

19. Page 27 and pages 42-44 of the Giles report consider atmospheric stability classes other than the “weak” option selected in the analyses by Hewitt *et al* (2009). However, there is no evidence of spray events with stable atmospheric conditions such as temperature inversions. Indeed, it is not appropriate to suggest high wind speeds and stable air existing at the same time because mixing in the atmosphere through the presence of wind movement of at least 3 km/h tends to break down inversions and produce unstable atmospheres.

20. Some rules of thumb can be used to estimate when stable atmospheres might exist – for example if the air temperature has increased by at least 2ºC from the morning low or decreased by less than 3ºC from the afternoon high, then an inversion is unlikely to exist. Applicators are typically well trained in observing temperature inversions and avoiding applications when inversions exist. They may also observe air temperature profiles against flying heights, or emit smoke to observe its dispersion, or spray when there is a wind speed above 2 km/h.

21. Temperature inversions are a normal part of the daily atmospheric cycle, and they are only of concern if their height is similar to that of the spray release height, in other words if they are local surface inversions. The normal daily cycle of heating and cooling means that temperature inversions are most likely in the very early hours of the morning (e.g. before 5 to 6 a.m.) and again in the evening. Based on the author’s personal experience of aerial spraying of bananas in the tropics (Costa Rica and the Philippines), by 7 a.m., the wind will have typically increased above 3 km/h to provide mixing and unstable atmospheric conditions appropriate for safe spraying. The 3 km/h wind speed rule of thumb is not a universal one because while an inversion will always be accompanied by little or no wind, the opposite is not always true. Under some circumstances such as heavy cloud cover at night, inversions may not exist even though the wind speed is very low.

22. Where temperature inversions do occur, they do not increase the amount of spray drift, but they can increase the effects of such drift as the spray can remain more concentrated rather than dispersed. However, if this drift is to be carried downwind, then some wind is needed for such displacement and hence it is contradictory to suggest long range transport (requiring reasonably high wind to offset the gravitational settling of droplets) under inversion conditions.

Wind Speed

23. As noted in the previous section, it is not appropriate to suggest that the atmosphere is stable and to select a high wind speed for modeling spray drift potential because when the wind speed is above ~3 km/h, the atmosphere is likely to be unstable. Near-field models such as AGDISP show that as wind speed increases, spray drift tends to increase, with the Giles report showing a relationship that is close to linear. However,

when more appropriate models such as CALPUFF are used for long-range modeling, the relationship between wind speed and deposition of drifting particles is not the same. Higher wind speeds often produce greater dispersion in the atmosphere as noted through stability classes, and hence with greater dilution there can be lower deposition at far-field distances.

Illustrative Example Application Scenarios

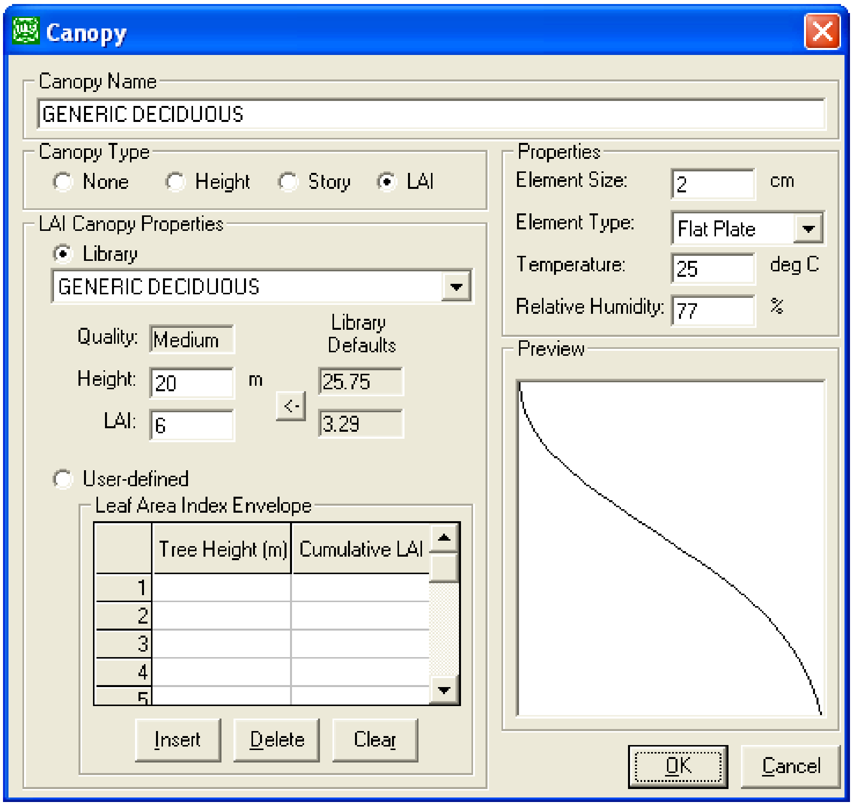
24. On pages 30-34 of his report, Giles presents some spray drift case studies for several applications: a) spraying near low vegetation with strong wind, and b) spraying at increased height and speed with strong wind. These produce predicted deposition rates in the order of 5-18 g/ha at distances up to 1 km, falling to less than 1 g/ha by 10 km downwind. While these values are below the levels of concern for sensitive areas, the assumptions used to calculate them are flawed mostly by the fact that there is considerable vegetation between the application area and Ecuador which filters out any airborne drift rapidly after its release. The AGDISP model includes comprehensive canopy interception algorithms based on decades of field studies and experience in aerial spraying by the US Forest Service and its co-operators. Trees are very effective filters of droplets of diameter 100-150 μm and will effectively catch any such droplets which do not reach the coca crop near the ground, thereby removing them from any airborne spray drift cloud. In the Giles report, scenario a) for spraying near low vegetation with strong winds is not applicable to the Plan Colombia spray events because nearby tree canopies will reduce wind speed close to the ground and will catch any drift through spray impaction. In scenario b), which involves spraying at increased height with strong wind, any displacement of the spray swath by the wind will see the applied herbicide droplets approach trees and vegetation downwind of the application and those trees will filter out any drift at upper canopy levels to prevent off-target drift beyond a few tens of meters.

Multiple Spray Lines

25. On pages 34-40 of the Giles report, the impact of cumulative deposition from multiple spray lines is assessed. Given that the highest deposition values reported by Giles from his analyses were in this section of the report, the present assessment re-examines those scenarios using more appropriate inputs for the canopy, i.e. specifying a 32.5 m tall generic deciduous canopy with a leaf area index of 6 and a ground reference height of 10 m, with a single 18 m swath as in the Giles assessment. However, for more representative assessment of multiple spray lines, the swath width was set to 50 m with 50 m separation distance between swaths – i.e. the model was run with a continuous spray block of 10 spray lines (rather than from overlaying and offsetting the calculated data from each swath by 50 m as in the Giles report). All other input values are the same as in the Giles report (i.e. 59.54 m aircraft altitude, 338.51 km/h speed, 5.14 m/s wind speed, 23.65 L/ha application volume rate). It is important to note that, contrary to suggestions in the Giles report, no location was sprayed twice in field operations. The same spray event is not repeated in the spray data from the Department of State (there

are, however , instances of duplicate records of the exact same spray event, due to technical errors of software processing: 123 duplicates in 2001, 781 duplicates in 2002 and 1 duplicate in 2006).

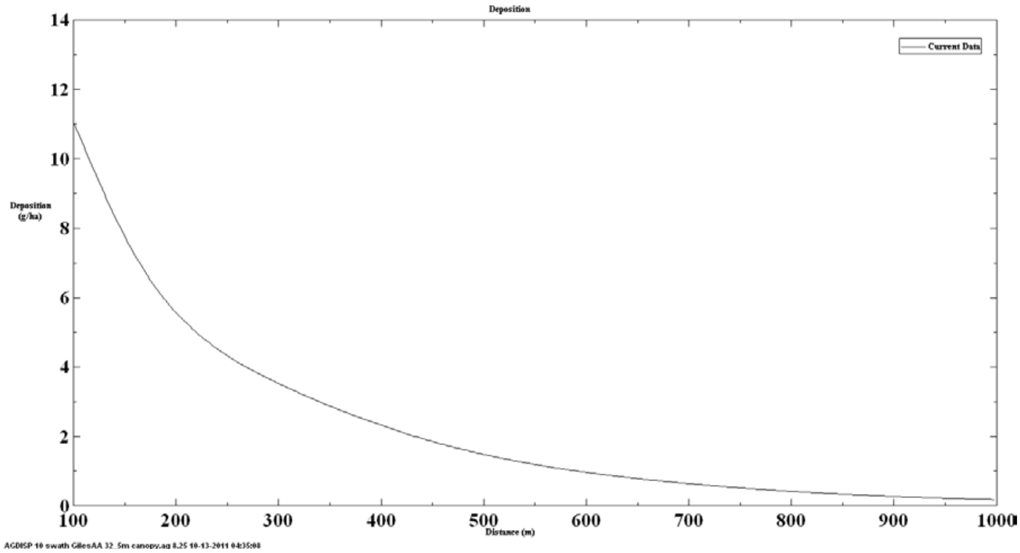
26. The following figure shows the model input screen for this tree canopy.



27. The following is a summary of the new values from this assessment and their respective values from Table 25 of the Giles report (rounded to nearest g/ha).

No. spray lines	Dep. 800m Giles	Dep. 800 m New	Dep. 2 km Giles	Dep. 2 km New	Dep. 5 km Giles	Dep. 5 km New	Dep. 10 km Giles	Dep. 10 km New
1	18	0.08	5	0.03	2	0.01	1	0.006
10	130	0.67	42	0.26	16	0.12	8	0.057

The 10 swath data are shown on the following figure for distances from 100 to 1000 m downwind of spray release, in 100 m increments.



28. If the ground reference height is set to the model default of 0 m, the values for the deciduous canopy assessment with 10 spray lines are also very low – i.e. 0.18 g/ha at 800 m falling to 0.005 g/ha by 10 km downwind for a single swath assessment. At 1 km and 5 km distances, the respective deposition rates were 0.16 and 0.02 g/ha. All of these values are so low that they can be considered as *de minimis* drift.

Additional Factors that Exacerbate Drift

29. On page 41 of the Giles report, it is suggested that the nozzles tested by Hewitt *et al* (2009) in atomization studies were not representative of field nozzles. However, these nozzles were supplied from actual aircraft used in PECIG – sent from Colombia to Hewitt for testing in the wind tunnel. The additional suggestion by Giles on pages 41-42 that the nozzles may have been routinely bent under field use has no foundation and there is no evidence that a damaged Accu-Flo nozzle will produce a finer spray because damage can cause leaks or blockages which could just as readily coarsen the droplet size as make it finer.

Colombia's Spray Drift Studies

30. Pages 44-46 of the Giles report discuss drift studies which have been reported for Colombian application scenarios. The use of finer sprays than those assumed by EPA in its risk assessments does not necessarily support the idea of higher drift potential. While most herbicide applications by aircraft for agricultural spraying involve Medium to Very Coarse sprays to reduce spray drift, the presence of extensive vegetation with high collection efficiency for small droplets in the areas sprayed under PECIG supports the concept of reduced drift potential for small droplets than applications where bare ground

or low surface cover exist. This is also applicable to the NNC assessment which presents an overly simplified analysis of spray drift potential, ignoring canopy interception and many other factors. The final study presented was one which used water sensitive papers to assess spray deposition. Water sensitive papers are not a reliable tool for such research and are easily contaminated by any moisture or humidity in the air. Reliable drift studies involve the use of tracers (preferably active ingredients where specific products are being assessed) and laboratory analysis for deposition rates. It should be noted that 128 µm is the lowest droplet size in the range, but should not be taken as the rule, since the average speeds of two of the aircraft that have been used in the Program result in larger droplets. According to the information supplied by the Colombian National Police, 3 aircraft have been used in the Program:

- The T-65 aircraft, with speeds of 193-241 km/h, which would result in a droplet size >219 µm. Aircraft of this type were in use in the Program until late 2007.
- The OV 10 aircraft with an average speed of 333 km/h). Droplet size at that speed would be 128 µm. Aircraft of this type were in use in the Program until January 2008.
- The AT 802 aircraft with an average speed of 203 km/h, which would result in a droplet size >219 µm. This is the only aircraft currently used in the Program.

31. It has been asserted by Ecuador with respect to higher aircraft speeds that "such violations of the speed limit have a dramatic impact on spray drift." However, aircraft speeds, such as those shown above from the spray data, do not constitute "violations" of the PECIG's operational parameters since aircraft speed is not included as a parameter in the EMP. According to Ecuador, this purported "dramatic impact" relates to decreased droplet size, the technical reasons for which are found in the report of its experts, Hansman and Mena, as follows: "If the spray aircraft airspeed is too high, the droplets from the spray nozzle will explode into much smaller droplets due to aerodynamic forces as they hit the high relative wind." However, higher wind speeds often produce greater dispersion in the atmosphere as noted through stability classes, and hence with greater dilution there can be lower deposition at far-field distances. This was corroborated by the results of the modeling of spray events with high speeds, in all of which deposition was insignificant.

Conclusions

32. The Giles report presents some interesting scenarios for studying the sensitivity of spray drift to a range of variables associated with the application of sprays by aircraft. However, the assessments are not presented in the context of the actual canopy present in Colombia which will act as an efficient filter of any airborne droplets that do not deposit on the ground beneath the aircraft. The average OV-10 spray droplet size in PECIG of ~128 µm is optimal for interception by foliage of which there is plenty in this forested and vegetated area of Colombia. When the canopy is appropriately entered into the

AGDISP model, levels of drift downwind of the spray applications rapidly approach zero within a few hundred meters and are well below levels of concern for exposure to sensitive areas. Other issues addressed in this report in response to claims of the Giles report include the fact that three aircraft types are used in Plan Colombia aerial spraying and that the OV-10 is the fastest of those aircraft, but not the only one used. Swaths are not sprayed multiple times in the operations and when the cumulative impact of several swaths over different flight lines is considered in modeling, off-target drift deposition rates are still very low, and indeed are at *de minimis* levels, insufficient to cause harm to sensitive areas.

Statement

As far as I know, the factual matters stated in this report are true and accurate. I have made all enquiries considered appropriate. I genuinely hold the opinions stated in this report. All matters which I consider to be significant are contained in this report. I understand my duty to the Court and have complied with the duty.

Andrew J. Hewitt, PhD, MSc, BSc, DIC
1 November, 2011

Appendix 1

Curriculum Vitae for Andrew Hewitt

NAME: Andrew Hewitt

ADDRESS: The University of Queensland, Gatton, QLD 4343, Australia

EDUCATION:

1988-1991 Imperial College (London University), Ph.D. and D.I.C., "Studies with air-assisted rotary atomizers for pesticide application". Developed equipment/ techniques as part of £2 million British Government project into vector control using space spraying in Africa.

1986-1987 Cranfield University, U.K. M.Sc. Bio-aeronautics (crop protection, space spraying, forest protection and remote sensing).

1982-1985 University of Sheffield, U.K. B.Sc. Hons. Nat. Environmental Science (plant biology, conservation, pollution management, chemistry, physics), Class: 2,1.

WORK EXPERIENCE:

2004-present Director, Centre for Pesticide Application and Safety, University of Queensland, Australia. Research into spray drift, application, atomization, transport, deposition, environmental fate, optimization and efficacy for industrial, agricultural, forestry and vector control applications in Australia, the U.S. and worldwide. Research into industrial spray applications, patternation, atomization processes and spray visualization. Management of wind tunnel facilities for spray research. Field and laboratory studies for diverse application types. Spray atomization and drift modeling. Education, including training courses for government and industry groups. Activities divided approximately equally among research for government (NZ, Australia, US and Canada), industry and academic projects.

Science Fellow on pesticide exposure to Australian Pesticides and Veterinary Medicines Authority (APVMA).

Advisor on safe spray application to Philippines Dept of Agriculture.

Advisor on PECIG aerial narcotics eradication program (to US State Dept. and government of Colombia).

Delegate to government at US Dept of Homeland Security on harmonized research and collaboration in science.

Head of Delegation to International Standards Organisation on ag. standards.

Extensive voluntary work for technical societies, e.g. member of Editorial Board for three international journals and Associate Editor of TRANS of the ASABE, Chair of technical committees of several international societies, organizer of several international conferences (including September 2011 workshop on international research collaborations with $31,000 grant from NZ government).

Member, U.S. EPA Exposure Modeling Working Group (meeting now as US EPA Exposure Modeling Public Meeting, EMPM).

1993-2004 Employed by STEWART. Project Manager, Spray Drift Task Force (40 member companies, $25,000,000 program). Co-ordinated and facilitated SDTF activities, data analysis and report preparation. Official representative of SDTF with EPA and other groups. Organized meetings (e.g. Spray Drift Conference with 260 attendees in CA, 2001); prepared Minutes and summaries of meetings, workshops and other events. Frequent testing at Spraying Systems Co. and other locations, using laser diffraction, laser imaging, and PDPA techniques. Designed airblast sprayer laser sampling procedures. Author of many major reports submitted to EPA. Co-ordinated SDTF interaction with international nozzle and drift schemes of BCPC and European ISO groups. Conducted 1 and 2-day computer model training sessions for AgDRIFT spray deposition model. Designed studies. Designed and managed large industry herbicide drift and lift-off study in California working with Dept. of Pesticide Regulation, University of California, Davis and others. Expert witness for drift situations. Conducted atomization droplet size measurements. Gave numerous invited presentations on spray application technology/ drift minimization/ spray modeling to diverse audiences. Participated in meetings of various organizations including the National Coalition on Drift Minimization (NCODM); ILASS; ASAE, ASTM; AAPSE; NAAA; BCPC; National Spray Modeling Committee; and others. Worked on project in New Zealand to link GIS with spray drift modeling for enabling applicators to make real-time decisions for spraying operations. Collection efficiency studies for different types of nozzle and drift control adjuvants. Field drift studies in Costa Rica to compare canopy effects and special equipment. Field drift studies in U.S. for drift control adjuvants. Drift potential factor measurements. Development of standard test methods. EU grant to develop single international database on spray drift.

1991-1993 Research Specialist, New Mexico State University - projects assessing droplet size spectra; spray distribution patterns; drift; pesticide application; equipment development; adjuvants. Presentations/ moderating sessions at conferences in U.S., U.K. and Canada. Preparation of grant proposals and final reports for EPA, PWG, SDTF, chemical companies and others; active research as Principle Investigator in many GLP studies. Writing SOP's. Performed a critical review of hundreds of papers on drift for SDTF. Consultant for SDTF and NORIC s.a. Contract external Quality Assurance Officer.

1991 Research scientist with Noric in U.K. & Belgium developing tunnel sprayers to minimize spray drift and loss to the ground beneath trees. Contract mosquito spraying research for Schering Agrochemicals Ltd.

1990 Field evaluation and implementation of new equipment and pesticides for armyworm control in Kenya with ODA NRI, FAO of the United Nations & Desert Locust Control Organization of East Africa.

Field trials in Honduras - citrus, oil palm and banana spraying.

1989	Evaluation of tsetse spraying in Somalia for ODA and National Tsetse and Trypanosomiasis Control Project spraying operations.
1988	Field lecturer/supervisor for Cambridge undergraduate students in France. Designed, supervised & assessed collection of meteorological data.
1988-1991	Research Assistant with International Pesticide Appln. Research Center at Imperial College, London University. Developed equipment for producing controlled droplet sizes, for the ODA NRI Armyworm Project and the Aerosol Technology Unit. Some teaching for MS degree pest management students. Attendance/presentations at conferences including BCPC, AAB, Shell Research, IUPAC, NRI, Royal Society, Cranfield Institute of Technology and The Aerosol Society. Also attendance at agricultural events in England, Germany and Belgium; close collaboration with sprayer manufacturers and chemical companies on application projects.
1987-1988	Research with Dole Fresh Fruit Co. in Costa Rica and Honduras. Designed and conducted experiments with spray applications to bananas, pineapples and grapefruit using aerial, ground and airblast equipment.
OTHER:	Associate Editor, *TRANSACTIONS of the American Society of Agricultural and Biological Engineers,* Member of Editorial Board, *Atomization and Sprays*, *and Journal of ASTM International.* Joint Chair, ILASS Agricultural and Biological Sprays Committee. Former member, ILASS-Americas Board of Directors. Chair and organizer of three International Conferences on Pesticide Application for Spray Drift Management, Chair, ASTM E29.04 liquid particle size measurement committee and laser measurements standards sub-group. Chair, ASTM Drift Management Task Group (within E35.22). Chair, ISO committee on development of droplet size classification standards. Former Head of Delegation for the U.S. at ISO meetings on spray drift and application technology standards. Consultant to U.S. EPA on spray drift reduction technology program, and author of advisory reports, standards and protocols for the program. Member of USDA Forest Service committee for modeling. Advisor to Spray Stewardship Program in California. Advisor on drift issues and management to California Dept. of Pesticide Regulation. Regular meetings with EPA on drift issues/ protocols. Reviewer for journals and conference proceedings. Member, OECD drift committee.
SKILLS:	Spray exposure modeling, including joint developer of the U.S. EPA/ USDA/ SDTF AgDRIFT model. Excellent Spanish, French & German. Certified in Good Laboratory Practice Standards. Regular computing. Extensive use of laser particle size analyzers. Operation of meteorological stations. Active research in all areas of drift research, application technology and buffer zone developments.

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Ice. W., Thistle, H., Karsky, R. and Hewitt, A. (2010) Attenuation of Aerially Applied Spray within a Riparian Management Area. *Forests and People, SAF National Convention*, Albuquerue, New Mexico, USA.

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Hewitt, A. J. (2010) *Invited Talk* – Development of a Drift Reduction Technology Deposition Model Based on Spray Characteristics from Wind Tunnel and Field Sampling. *Proc. ASTM 31st Symposium on Pesticide Formulations and Delivery Systems: Innovative Green Chemistries for the 21st Century, San Antonio, Texas, USA.*

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Connell, R.J., Hewitt, A.J., Wolf, T. and Miller, P.C.H. (2009) WTDISP – Adapting a Lagrangian Ground Sprayer Model Using Wind Tunnel Data. 18th World IMACS/ MODSIM Congress, Cairns, Australia. www.mssanz.org.au/modsim09/Z1/connell.pdf

Hewitt, A.J., Connell, R., Thistle, H., Miller, P.C.H., Teske, M.E. and Dorr, G. (2009) Lagrangian Spray Drift Ground Exposure Modelling with Wind Tunnel Droplet Size and Flux Source Data. *Proc. International Conference on Liquid Atomisation and Spray Systems*, Vail, Colorado.

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Teske, M.E., Thistle, H.W., Reardon, R., Cormier, G., Amirault, P., Davies, D., Cameron, S., Dorr, G., Hewitt, A.J., Brown, J., LeClerc, M. and Karipot, A. (2005) Aerial Application Variability Due to Release Height and Drop Size Distribution. ASTM Symposium on Pesticide Formulations and Application Systems, *Journal of the American Society of Testing and Materials International*. 2 (4).

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Annex 2

DR A.J. HEWITT, PH.D., *AERIAL SPRAY DRIFT MODELING OF PLAN COLOMBIA APPLICATIONS*, NOVEMBER 2011

Aerial Spray Drift Modeling of Plan Colombia Applications
by Andrew J. Hewitt

Executive Summary

1. This is an executive summary report presenting the modeling of spray drift from specific aerial applications of relevance to the Plan Colombia coca eradication operations. This modeling was conducted using the AGDISP aerial dispersion model, using the latest available version (8.25) at the time of this modeling in late October 2011. AGDISP is a model developed by the US Forest Service, NASA and US Army for predicting the dispersion, collection and deposition of droplets of sprays applied by aircraft. It is particularly well suited to modeling applications in areas of forest or other vegetation. The model has been validated through millions of dollars of spray research, including extensive field trials in several countries.

2. Background information and further details of the modeling approach are provided in the following report:

Andrew J. Hewitt (2011). Response to Report "Spray Drift Modeling of Conditions of Application for Coca Crops in Colombia" by D.K. Giles.

Model Inputs

3. The model was run using the inputs shown in the tables of this report. The following parameters are not shown in the tables:

Canopy: The approximate average canopy height in forested areas was assumed to be 20 m. Because the area between the spraying operations and Ecuador included both forested areas and cleared/river areas, the average ground reference height for modeling across the entire area between the spray applications and the border was assumed to be 50% of this height, *i.e.*, 10 m. The model allows the specification of ground reference height which is important for applications such as the present one, where the tree canopy is interspersed with open clearings, and the model will calculate spray interception both by the canopy and on the ground. Based upon published literature regarding the canopy in the Amazonian rain forest, the canopy was set as being Generic Deciduous with a Leaf Area Index of 6. *See* David B. Clarke, Paulo C. Olivas, Steven F. Oberbauer, Deborah A. Clark, and Michael G. Ryan (2008) First direct landscape-scale measurement of tropical rain forest Leaf Area Index, a key driver of global primary productivity, Ecology Letters 11, 163-172; A.-L. C. McWilliam, J. M. Roberts, O. M. R. Cabral, M. V. B. R. Leitao, A. C. L. de Costa, G. T. Maitelli and C.A. G. P. Zamparoni (1993) Leaf area index and above-ground biomass of *terra firme* rain forest and adjacent clearings in Amazonia, Functional Ecology 7, 310-317.

In reality, the canopy height is typically greater than that assumed in this modeling assessment. Other experts have suggested that a value between 30 and 35 m is typical for the region, whereas the present modeling assumed 20 m. A taller canopy will provide greater vegetation and opportunity to filter out spray drift, which means that the assumption here of 20 m is more worse-case than typical.

Droplet size spectrum: The droplet size spectra for the modeling runs were sourced from wind tunnel atomization studies conducted with the same aircraft speeds, tank mixes, nozzles and spray pressures used in Plan Colombia as reported in the following journal article:

Andrew J. Hewitt, Keith R. Solomon, and E.J.P. Marshall (2009) Spray Droplet Size, Drift Potential, and Risks to Nontarget Organisms from Aerially Applied Glyphosate for Coca Control in Colombia, Journal of Toxicology and Environmental Health, Part A, 72, 921-929.

Swath Width was assumed to be 15.24 m and each application simulation involved a single spray line.

Meteorology: The modeling was conducted with the reasonable worst-case scenario from D.K. Giles' expert report of relatively high wind speed of 5.14 m/s (for higher transport off the target site), low relative humidity of 70% and high air temperature of 35°C (for increased evaporation rates which makes droplet size decrease more rapidly and the resultant smaller droplets will tend to be more drift prone than the original larger droplets) was assumed. According to the following report, the actual meteorological conditions would often include lower temperature and higher relative humidity, making the assumed values reasonable worst-case for evaporation:

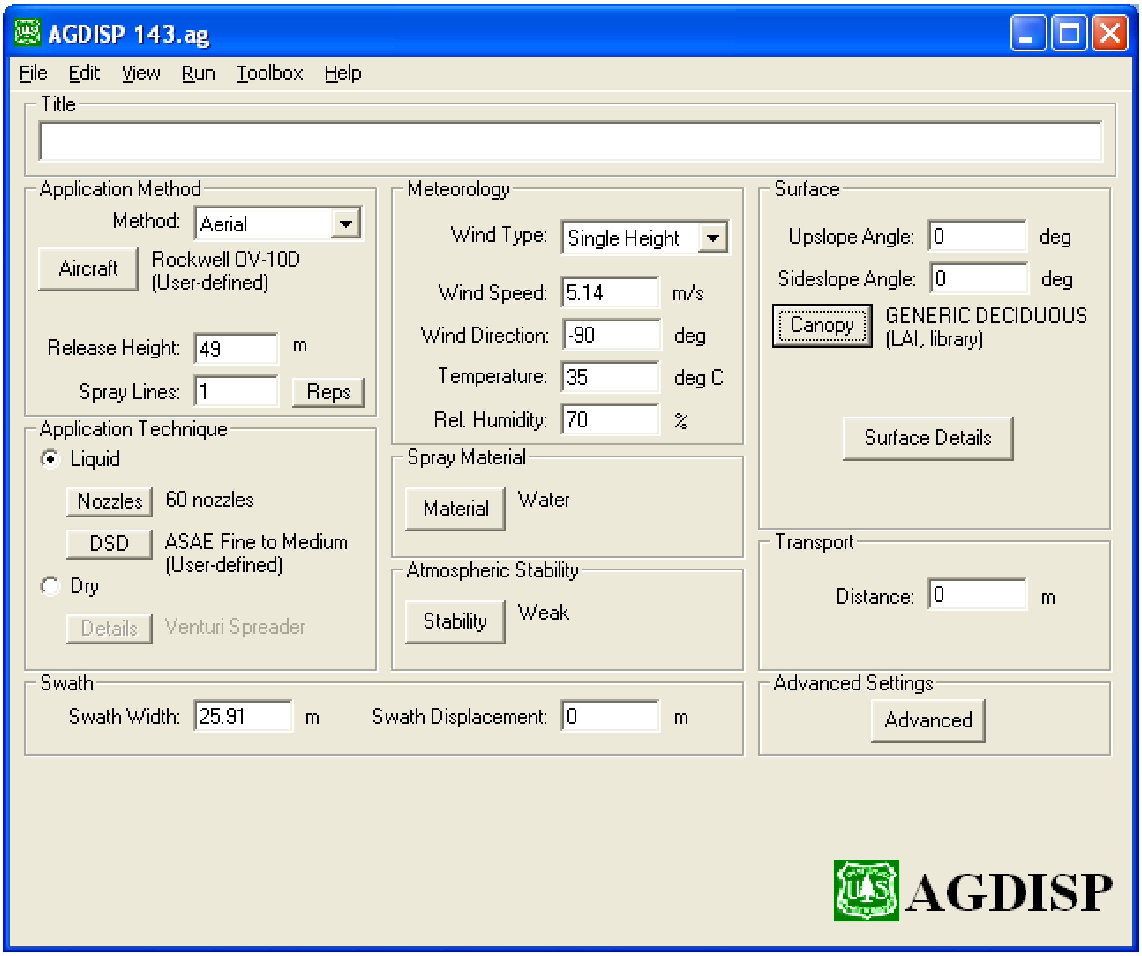
Climate Characterization of the Nariño and Putumayo Border Zone with Ecuador, IDEAM (Government of Colombia) 2011. Carrera 10 No. 20 – 30 Piso 6º. Bogotá D.C.

Atmospheric Stability was assumed to be weak, based on the typical time of day for the spray events.

Evaporation Rate was entered based on library data from the AgDRIFT model for a very similar tank mix of 49% glyphosate, i.e. 36.7 $\mu m^2/°C/sec$.

4. Once the model was run for each spray run assessment, the Gaussian extension toolbox in the model was opened and run in order to allow the off-target deposition (drift) rates to be calculated out to distances beyond the standard toolbox range of 1.6 km. Many of the model runs required assessments to distances of several kilometers and this toolbox uses a combination of initial Lagrangian modeling with a handoff to Gaussian dispersion once the spray droplets are out of the influence of the aircraft wake. Once the Gaussian extension calculations were complete, the Deposition Assessment toolbox was opened and the deposition rates at the distances specified in the report table were calculated. These are the distances from the spray line to the locations of concern for each run.

5. An example of the model screen (for line 143) is shown below:



Results

6. The model results are shown in the following table which is sorted by deposition rate across all runs (high to low).

Line ID/SEG	Spray Line Date	Ht. (m)	Speed (mph)	Application Rate	Application Rate Unit	Line Length (m)	Swath (ft)	Aircraft	Border Distance (m)	Deposition (g/ha)
143	10-Oct-02	49	200.100	2.4	gallons/acre	110.95	85	OV-10	570	2.71
3143	13-Sep-00	160.26	166.4700012	87.23000336	gallons/minute	114.385	50	T-65	947	1.66
671	22-Sep-02	139.22	155.3000031	0	gallons/acre	6.966	50	T-65	585	1.66
1058	9-Sep-02	122.63	151	2.299999952	gallons/acre	186.803	50	T-65	479	1.59
3667	13-Sep-00	141.84	150.6199951	86.81999969	gallons/minute	40.78	50	T-65	922	1.52
2010	15-dec-01	112.76	155.97	77.66	gallons/minute	72.85	50	T-65	571	1.46
1956	15-dec-01	113.83	162.83	81.8	gallons/minute	223.19	50	T-65	674	1.45
4250	23-Nov-05	50.68	211.70	6.700	gallons/hectare	112.696	85	OV-10	277	1.22
4250	23-Nov-05	50.68	211.7	6.700	gallons/hectare	112.7	85	OV-10	277	1.22
399	10-Oct-02	43	219.9	2.6	gallons/acre	232.8	85	OV-10	501	1.2
3519	08-Jan-07	122.16	160.6000061	7	gallons/hectare	269.942	50	T-65	964	1.17
135	7-Oct-02	43	212.800	2.600	gallons/acre	244.12	85	OV-10	891	1.15
401	10-Oct-02	48	224.8	2.3	gallons/acre	64.5	85	OV-10	541	1.1
3522	08-Jan-07	106.47	167.1999969	6.900000095	gallons/hectare	317.531	50	T-65	904	0.9404
391	6-Sep-02	50.4	242.90	2.700	gallons/acre	74.439	85	OV-10	807	0.7641
528	22-Sep-02	45	136.1	0	gallons/acre	6.1	50	T-65	480	0.75
132	8-Oct-02	40.71	207.10	0.000	gallons/acre	145.673	85	OV-10	153	0.706
358	26-Sep-02	61	142.200	2.600	gallons/acre	6.363	50	T-65	393	0.7004
4188	23-Nov-05	43.97	224.60	5.900	gallons/hectare	143.455	85	OV-10	683	0.6921
716	8-Sep-02	50	220.400	2.500	gallons/acre	662.37	85	OV-10	1696	0.6537
1254	22-Sep-02	58	153.200	Mean 21,75 l/ha	gallons/acre	13.63	50	T-65	86	0.6379
596	22-Sep-02	56	150.300	2.4	gallons/acre	201.67	50	T-65	169	0.633
4257	14-Jan-07	49	188.400	5.900	gallons/hectare	64.048	85	AT802	932	0.6199
319	24-Feb-03	53.39	174	2.800	gallons/acre	98.542	85	AT802	71	0.584
54	5-Feb-03	51.46	166.6	2.600	gallons/acre	246.25	85	AT802	12	0.5753
1977	13-Mar-01	47.75	224.040	216.540	gallons/minute	377.26	85	OV-10	979	0.56
2119	23-Jan-00	51.330	209.450	192.8300018	gallons/minute	159.305	85	OV-10	1153	0.551
4399	24-Dec-04	24	161.900	2.500	gallons/acre	341.92	50	T-65	439	0.506
135	2-apr-04	138.28	151	1.6	gallons/hectare	7.147	85	AT802	209	0.4349
562	22-Sep-02	43	143.3	0	gallons/acre	6.4	50	T-65	547	0.41
1785	13-Mar-01	37.41	211.690	5.700	gallons/minute	137.09	85	OV-10	728	0.386
4041	22-Nov-05	33.63	201.5	7.5	gallons/hectare	90.1	85	OV-10	710	0.3662
1238	13-Oct-05	46	204.500	6.300	gallons/hectare	109.577	85	OV-10	2539	0.36
3899	19-Dec-06	42.33	180.900	6.900	gallons/hectare	48.475	50	T-65	430	0.3158
155	3-Oct-02	35.61	205.400	3	gallons/acre	584.5	85	OV-10	704	0.314
6857	24-Dec-06	87	172	5.900000095	gallons/hectare	292.409	50	T-65	1145	0.3
2212	23-Jan-00	42.760	209.720	206.4299927	gallons/minute	278.391	85	OV-10	1225	0.281
4358	23-Nov-05	30.13	224.60	6.200	gallons/hectare	155.83	85	OV-10	638	0.261
13872	15-Mar-05	107.87	171.3999939	1.600000024	gallons/hectare	78.473	85	AT802	704	0.2586

697	22-Sep-02	41.00	156.500	2.6	gallons/acre	196.08	50	T-65	52	0.2317
2647	18-Jan-01	63	171	81.8	gallons/minute	0.004	50	T-65	1130	0.2
2835	14-Sep-00	54	151.9	62.4	gallons/minute	296.2	50	T-65	4560	0.192
13841	15-Mar-05	95.62	158	1.600000024	gallons/hectare	226.773	85	AT802	464	0.1907
1711	05-Jan-01	79	156	0	gallons/minute	0.006	50	T-65	2750	0.167
550	13-May-03	52	173.200	2.400	gallons/acre	7.755	85	AT802	2270	0.1439
101	14-May-02	37	197.1	2.5	gallons/acre	123.6	85	OV-10	970	0.14
123	22-Sep-02	38	155.600	2.5	gallons/acre	230.54	50	T-65	123	0.1376
51	03-Oct-02	40	202.200	2.700	gallons/acre	36.163	85	OV-10	2406	0.111
914	8-Sep-02	48	174.5	0	gallons/acre	7.8	50	T-65	2498	0.11
400	10-Oct-02	42	223	2.6	gallons/acre	220.5	85	OV-10	825	0.11
2771	04-Jan-01	70	165.1	0	gallons/minute	0	50	T-65	3131	0.106
1979	Jan-01	78	163.3	0	gallons/minute	0.002	50	T-65	1500	0.1
3293	31-Sep-00	66	185.8	91.3	gallons/minute	201.6	50	T-65	3890	0.099
4264	24-Dec-04	33	157.400	2.200	gallons/acre	148.078	50	T-65	340	0.0833
66	14-May-02	40	208.3	2.8	gallons/acre	173.4	85	OV-10	1430	0.08
730	10-Jul-03	63	178.3	2.5	gallons/acre	8	50	T-65	4910	0.076
1253	22-Sep-02	29	156.700	2.6	gallons/acre	254.05	50	T-65	117	0.0673
1651	2-Feb-07	30.28	160.300	7.000	gallons/hectare	64.639	85	AT802	552	0.066
291	14-Jul-03	49	168.1	2.5	gallons/acre	458.6	50	T-65	5100	0.0645
286	9 July 2003	46	171.2	0	gallons/acre	15.4	50	T-65	4952	0.0599
862	2-Feb-07	23.32	166.6	6.5	gallons/hectare	141.71	85	AT802	407	0.055
No record	07-Jan-02	25	No record	Mean 21,75 l/ha	No record	265.76	50	T-65	198	0.0529
2721	26-Sep-00	54	194.2	0	gallons/minute	153	50	T-65	1817	0.05
694	23-May-03	40	166.6	2.5	gallons/acre	402	50	T-65	4574	0.0395
928	20-Jan-03	35	167.000	2.600	gallons/acre	138.853	85	AT802	5200	0.0372
240	20-Feb-02	32	208.900	2.5	gallons/acre	500.347	85	OV-10	5160	0.0339
3527	Jan-01	30	186.3	10.7	gallons/minute	0.001	50	T-65	955	0.033
2994	8-Sep-02	36	152.4	0	gallons/acre	16.0	50	T-65	1760	0.015
2721	26-Sep-00	54	194.2	0	gallons/minute	153	50	T-65	2062	0.01
2552	18-Jan-01	62	174.2	75.1	gallons/minute	0.001	50	T-65	1850	0.01
2748	26-Sep-00	53	177.3	0	gallons/minute	1491.9	50	T-65	1960	0.01
2057	14-Sep-00	64	152.9	95.2	gallons/minute	252.8	50	T-65	2086	0.001

Discussion and Conclusions

7. The data show that spray drift tends to increase with greater aircraft height and is often higher for the faster aircraft speeds. However, off-target drift deposition rates were generally very low, with only 13 cases exceeding 1 g/ha and 1 case exceeding 2 g/ha. Even these values are extremely low, given that far greater amounts of glyphosate are required to cause harm to sensitive areas.

8. Deposition rates generally decreased with greater distance from spray release to the border.

9. It should be emphasized that these deposition rates are worst-case in that they are in the downwind direction only. Droplets do not travel against the wind so in cases where the wind direction was away from Ecuador, there would be zero off-target drift exposure and deposition.

Statement

As far as I know, the factual matters stated in this report are true and accurate. I have made all enquiries considered appropriate. I genuinely hold the opinions stated in this report. All matters which I consider to be significant are contained in this report. I understand my duty to the Court and have complied with the duty.

Andrew J. Hewitt, PhD, MSc, BSc, DIC
1 November, 2011

Annex 3

DR K.R. SOLOMON, PH.D., *EXPERT REPORT OF KEITH R. SOLOMON ON BEHALF OF COLOMBIA*, NOVEMBER 2011

BEFORE THE INTERNATIONAL COURT OF JUSTICE

CASE CONCERNING
AERIAL HERBICIDE SPRAYING
(ECUADOR v. COLOMBIA)

EXPERT REPORT OF KEITH R SOLOMON ON BEHALF OF COLOMBIA

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1 Executive Summary

1. Overall, Ecuador's Reply is based on a lack of understanding of the basic principles of toxicology and risk assessment, misinterpretation of data, erroneous use and interpretation of data and selective citations of the literature. These include, but are not limited to:

a. Toxicologically, there is no difference between the formulations of glyphosate used in the spray program. As sprayed in Colombia, formulations present *de minimis* risk to humans and non-target animals.
b. There is confusion between the toxicity of the concentrated product and the diluted spray. Based on tests with the spray mixture as used on coca, the risks to humans and animals are *de minimis.*
c. The adjuvant, Cosmo-Flux 411F is of low toxicity to animals and does not enhance the toxicity of the spray mixture to animals. Efficacy in plants may be enhanced to a small degree but not the 4-fold claimed.
d. Impurities and other products in the formulations of glyphosate used in the spray program are not of toxicological significance.
e. The modeling of spray drift used by Ecuador was flawed as it did not consider the presence of trees and interception of the spray drift. Refined modeling of spray-drift that incorporated all of the worst case assumptions but also included

interception by trees shows only very small amounts of spray-drift at distances close to the spray swath and that, in most cases no deposition occurred in Ecuador or, if drift occurred at all, amounts were extremely small and toxicologically insignificant.

f. Contrary to claims by Ecuador, there is a robust data set with which to assess the risks of the spray in non-target species. When this rich data set of information on toxicology and fate in the environment is combined with the refined estimates of spray drift, there is no environmental or human health risk in Ecuador.

2. Overall, Ecuador's Reply provides no proof that the spray used for control of coca in Colombia drifted into Ecuador in toxicologically significant quantities or that any harm occurred. Moreover, all of the scientific information shows that the spray does not cause the harmful effects attributed to it by Ecuador.

2 Expert credentials – Keith R Solomon

3. I am an Emeritus Professor in the School of Environmental Sciences at the University of Guelph, where I have served as a member of the faculty for over thirty years. I have a BSc degree in Chemistry and Zoology (Hons) from Rhodes University (1967), MSc degrees in Zoology and Entomology from Rhodes University (1971) and the University of Illinois (1973) respectively, and a PhD in Entomology from the University of Illinois (1973). I have more than 40 years of experience in research and teaching in pesticide science and toxicology and have contributed to more than 400 scientific publications and reports (more than 250 in the peer-reviewed literature) in the fields of pesticides, environmental toxicology, and risk assessment. I am a member of the Society of Environmental Toxicology and Chemistry, the American Chemistry Society (Agrochemistry), and the American Association for the Advancement of Science. I am the recipient of the 1993 Society for Environmental Toxicology and Chemistry-ABC Laboratories award for Environmental Education, was elected as a Fellow of the Academy of Toxicological Sciences in December 1999, and am a recipient of the 2002 American Chemical Society International Award for Research in Agrochemicals. In 2006, I was awarded the SETAC Europe Environmental Education Award and the Society for Environmental Toxicology and Chemistry Founders Award. I have served on and provided expertise on pesticides via advisory panels to the US EPA, the Institute of Life Sciences, the Pest Management Regulatory Agency in Canada, and various panels in Europe, and the United Nations Environmental

Programme. I was also appointed to the Board of Review for Siloxane D5 by the government of Canada. A book of which I am a co-author, Pesticides and the Environment, has been translated into Spanish and Portuguese and is distributed worldwide. In addition, I have been asked for advice, written reports, and testified at permitting hearings related to the use of glyphosate in forests and rights of way in Canada.

4. My research into the use and effects of glyphosate herbicides in the environment has resulted in a number of relevant publications, "Giesy JP, Dobson S, Solomon KR. 2000. Ecotoxicological risk assessment for Roundup® herbicide. *Reviews in Environmental Contamination and Toxicology* 167:35-120", "Solomon KR, Thompson DG. 2003. Ecological risk assessment for aquatic organisms from over-water uses of glyphosate. *Journal of Toxicology and Environmental Health B*, 6:211-246", Solomon KR, Anadón A, Carrasquilla G, Cerdeira A, Marshall J, Sanin L-H. 2007. Coca and poppy eradication in Colombia: Environmental and human health assessment of aerially applied glyphosate. *Reviews of Environmental Contamination and Toxicology* 190:43-125", "Solomon KR, Marshall EJP, Carrasquilla G. 2009. Human health and environmental risks from the use of glyphosate formulations to control the production of coca in Colombia: Overview and conclusions. *Journal of Toxicology and Environmental Health A* 72:914-920, *et seq*." A complete listing of my publications and a more complete listing of my expert credentials are available in my *curriculum vitae* (Exhibit A).

5. In 2003, I was contacted by the Inter-American Drug Abuse Control Commission (CICAD) section of the Organization of American States (OAS) to serve as the lead investigator on an independent Scientific Assessment Team (SAT) for what became a series of studies investigating the potential environmental and human health impacts of the glyphosate spray mixture used in the Program for the Eradication of Illicit Crops by Aerial Spraying with Glyphosate (PECIG) . The SAT operated independently of the US and Colombian governments, and other governments, none of which had input or editorial control of the reports of the SAT. The studies of the SAT were divided into two phases, Phase-I and II. Phase-I included a review of the literature on glyphosate and an epidemiological study conducted in Colombia and was published as a report to CICAD/OAS in 2005 and in the scientific literature in 2007. The Phase-II studies were completed in 2007-2008 and published in the scientific literature in 2009.

6. From the beginning of the process, it was recognized that the SAT would need to visit Colombia to observe firsthand how the coca fields were identified, how the herbicide was applied, and the locations and habitats where the spraying occurred. The first site visit took place in February 2004 with several members of the SAT and subsequent visits in Jun. 2004, Aug. 2004, Feb. 2005, Jun. 2005, Jul. 2005, Jun. 2006, Oct. 2006, Dec. 2006, Feb. 2007, May 2007, Jul. 2007, and Oct. 2007. These site visits included the areas of Putumayo, Tumaco, and Nariño and one visit included a flight along the border with Ecuador in the area where coca was being grown and sprayed. Spray operations were observed in detail during these visits. Members of the SAT were given complete freedom to observe all operations related to the spray program and were allowed to photograph all operations except those related to the gathering of intelligence about guerilla groups. We were allowed to travel with the spray operators and with the team that evaluated efficacy and off-target effects, but for safety reasons, we were accompanied by the Colombia National Police and their elite unit, the "Junglas," where appropriate. During these visits, we personally collected samples of the glyphosate formulation as well as the adjuvant, Cosmo-Flux, for the purposes of testing. These visits also provided us with the opportunity to meet regularly with contractors to CICAD who were working in Colombia in the studies related to Phase-I and -II, as well as to visit several Government and other agencies in Colombia where additional data for the assessment could be obtained.

7. In this particular case, I have been asked by the Government of Colombia to provide expert testimony the in the case before the International Court of Justice. I was provided with complete copies of the Reply of Ecuador (Vol. I-V) which I reviewed in preparation of this report.

3 Comments on Ecuador's allegations in Chapter 2, section I of the Reply

8. Section I of Ecuador's Reply (Ecuador 2011, 2.17- 2.21) makes a number of errors in interpretation of toxicity data that clearly show that Ecuador does not understand the basic principles of the toxicology or the use of pesticides. The following sections highlight these errors and show that the hazards of the mixture as sprayed during the aerial applications in Colombia are *de minimis*. Given the greatly reduced

exposures that would be found a short distance away from the spray swath, the hazards of the mixture to the environment[1] of Ecuador, if any, would be negligible.

9. The formulations of glyphosate used for the spraying of coca in Colombia were the following: Fuete-SL® , Roundup SL® (which are equivalent – as is Roundup Export® – since these alternate brand names are identical in ingredient formula composition (EPA Registration No. 524-308)), and Gly-41® (equivalent to Roundup-Ultra® (EPA Registration No. 524-475)) (EPA 2011). Because Fuete-SL and Roundup SL are equivalent, only two sprays were used (Romero Herrera 2002, EPA 2011). From the dates of sampling, all toxicity tests for the assessments by the SAT were conducted on the product in use at that time, Gly-41[2] (see also comments in Ecuador's Reply (Ecuador 2011, at para. 4.45). All of these products contain the same technical active ingredient (glyphosate isopropylamine (IPA) salt) in similar concentrations a surfactant, POEA, consisting of ethoxylated tallow-amines, and water. The amounts of POEA in the formulations ranged from approximately 15% to 11%, the latter for Gly-41. The smaller concentration of POEA in Gly-41 allowed classification in a less restrictive category (IV) (Romero Herrera 2002). However, as discussed below, the spray solutions of all these formulations have equivalent *de minimis* toxicity.

10. In addition another adjuvant, Cosmo-Flux® 411F, and water were added to the mixture prior to spraying (Weller 2011, Figure 10, p. 10). The addition of water to the spray mixture changes the exposure-concentrations and effectively reduces the hazard of the components.

3.1 Confusion between the toxicity of the concentrated commercial product and the diluted spray mixture.

11. In Ecuador's Reply (Ecuador 2011, at para. 2.19), there is confusion between the statements of hazard as appear on the label of the formulated product and the toxicity of the spray mixture. Statements such as "Harmful if swallowed" on the label of the product refer to the undiluted concentrated material in the container and are

[1] Hereinafter, "environment" is taken to include the natural environment consisting of plants and wildlife as well as humans.

[2] The reason for this lack of a specific product name was to protect the local representatives of the manufacturer (personal communication to K Solomon from the manufacturer, 2005). It was only after the publication of the 2009 studies in the Journal of Toxicology and Environmental Health A, Vol. 72 that the identity of the product was confirmed as Gly-41. The product is referred to as Gly-41 in this report.

intended for the information of those who handle the undiluted product. These instructions are intended for the mixers and loaders and are not relevant to bystanders who would be exposed to the diluted product as sprayed. These comments also are relevant to the discussion of the pictograms discussed in the response (Ecuador 2011, Figures 2.1 & 2.2, 2.41). By analogy, pure alcohol is "dangerous if swallowed" but, when diluted with a mixer or in wine, it is an enjoyable beverage.

12. None of the glyphosate-products used in the spray programs for coca and poppy in Colombia present a hazard to humans as sprayed. This is shown in the results of toxicity tests carried out on the mixture as sprayed in Colombia. This mixture consisted of the formulated product, Cosmo-Flux® 411F, and water in the proportion as loaded into the spray-aircraft. These tests on toxicity were carried out under Good Laboratory Practices, using standard protocols with appropriate Quality Assurance and Quality Control. Also included in the testing were confirmatory analyses of the content of glyphosate in the mixture to ensure that the values were consistent with the Environmental Management Plan of the spray program. These data are summarized in Table 1 and it should be noted that all of these mixtures fall in toxicity category III. This is similar to shampoo, vinegar, and a number of other household products.

Table 1. Summary of the mammalian toxicity data for the spray mixtures as used for control of coca in Colombia

		Product	
Product	**Fuete-SL**	**RoundupSL**	**Gly-41**
Code name	**Spray Alpha**	**Spray Bravo**	**Spray Charlie**
Toxicity test		**Results**	
Concentration of glyphosate a.e. as measured	16.3% (Springborn 2002b)	16.33% (Springborn 2003a)	16.53% (Springborn 2003b)
Acute oral toxicity in rats	LD50 >5000 mg/kg (Springborn 2002e)	LD50 >5000 mg/kg (Springborn 2002g)	LD50 >5000 mg/kg (Springborn 2003c)
Acute nose-only toxicity in rats	LC50 >3.27 mg/L (Springborn 2002f)	LC50 > 2.60 mg/L (Springborn 2003i)	(Springborn 2003h)
Acute dermal toxicity in rats	LD50 >5000 mg/kg (Springborn 2002c)	LD50 >5000 mg/kg (Springborn 2002d)	LD50 >5000 mg/kg (Springborn 2003g)
Primary skin irritant in rabbits	Primary Irritation Index = 0.5; slight irritant (Springborn 2002k)	Primary Irritation Index = 0.83; slight irritant (Springborn 2002a)	Primary Irritation Index = 0.25; slight irritant. (Springborn 2003e)
Dermal	All scores = 0; not a	All scores = 0; not a	All scores = 0; not a

	Product		
Product	**Fuete-SL**	**RoundupSL**	**Gly-41**
sensitization in guinea-pigs	dermal sensitizer (Springborn 2002l)	dermal sensitizer (Springborn 2002j)	dermal sensitizer (Springborn 2003f)
Primary eye irritation in rabbits	Mild eye irritant with recovery by 7 d (Springborn 2002i)	Mild eye irritant with recovery by 7 d (Springborn 2002h)	Moderate eye irritant with recovery by 7 d (Springborn 2003d)
Most severe toxicity category. Based on irritation of the eyes[a].	III (EPA) 2B (UN)	III 2B (UN)	III 2B (UN)

[a] EPA = U.S. Environmental Protection Agency Classification. UN = United Nations Global Harmonized System for classification (UN 2005).

3.2 Toxicity of POEA

13. In the same manner as the above, Ecuador's Reply (Ecuador 2011, at para. 2.45) confuses the toxicity of pure POEA with that of the mixture as used for spraying. The complete lack of significant oral, dermal, and inhalation toxicity of the spray mixture (Table 1) demonstrates that the exposures from the diluted spray are below the threshold of toxicity.

14. POEA consists of ethoxylated tallow-amines and is made from the natural product, tallow (animal fat). As a result, POEA consists of a mixture of products with differing chain of the fatty-acid "tail", i.e. the "blend" referred to in Ecuador's Reply (Ecuador 2011, at para. 2.48). This is characteristic of POEA and tallow itself. Tallow is animal fat and, despite being a blend, is not toxic to humans. Slight differences in chain-length have little impact on toxicological properties and the potency of the mixture is considered in the toxicity tests discussed above so the implication that the product is a blend is not relevant.

3.3 Composition and toxicity of Cosmo-Flux 411F

15. Ecuador's Reply (Ecuador 2011, at para. 2.49) also discusses Cosmo-Flux 411F and claims that the ingredients are in some way "secret". This is not the case. Despite Ecuador's assertion, the ingredients were listed (Solomon et al. 2007b) as "a mixture of linear and aryl polyethoxylates, (17% w/v) and isoparaffins (83% v/v)". This is also clearly stated on the label of the product (Cosmoagro 2004) so it is not "secret".

16. Ecuador's Reply (Ecuador 2011, at para. 2.55) also notes that Cosmo-Flux 411F enhances the toxicity of Gly-41. However, this does not apply to mammals (see discussion of this in Section 3.1 above), amphibians, and plants. The toxicity of a mixture of Gly-41 and Cosmo-Flux to mammals was reviewed in the 2005 assessment where "It was also concluded that the addition of the adjuvant Cosmo-Flux® to the glyphosate did not change its toxicological properties to mammals." (Solomon et al. 2007b) The same conclusion can be drawn for mixtures of Roundup-Ultra and Roundup-Export on the basis of the above data on toxicity to mammals (Table 1).

17. Although Cosmo-Flux 411F is added to many agricultural pesticides to increase their efficacy, the increase in toxicity to coca is not as great as is claimed in Ecuador's Reply (Weller 2011, p. 15, see section 7 below). Cosmo-Flux 411F, in and of itself, was shown to not be highly toxic to juvenile fish (*Piaractus brachypomus*) where an LC50 of >4,000 mg/L was reported (Rondon-Barragan et al. 2007). Based on these observations, it appears that Cosmo-Flux 411F does not significantly enhance the toxicity of formulations of glyphosate to plants or to fish that are, in fact, found in Colombia. The toxicity of the spray mixtures the tadpoles of *Xenopus laevis* was smaller (LC50 = 1300 µg/L) (Wildlife International 2006) than that of regular Roundup (Vision®), which was 800 µg a.e./L in the same species (Edginton et al. 2004).

3.4 Other potentially toxic ingredients

3.4.1 Dioxins

18. There are several other inaccuracies that relate to the presence of "other toxic ingredients" in the spray mixture. Perhaps the most egregious of these errors is the claim that the spray mixture contained dioxin. Dioxins are a class of halogenated contaminants formed during the manufacture of chlorophenols. There are no halogens in glyphosate or in the formulants added to the formulated product. This is likely an error on the part of a non-technical person who misread the word "dioxane" for "dioxin".

3.4.2 Dioxane

19. It is correct that small amounts of 1,4-dioxane have been found in formulations of glyphosate, however, the relevance of these must be assessed against the concentrations present – once again it is a case of "the dose makes the poison". Concentrations of 1,4-dioxane in formulations of glyphosate were reported to be less than 0.03% (Dykstra 1991). The estimated cancer risk for the group with the greatest exposure (Mixer-Loaders-Applicators) was 7.04×10^{-5}, while the risk of dietary

exposures is “non-existent” (Dykstra 1991). Because exposures of bystanders to sprays for control of coca are infrequent, the risk from 1,4-dioxane is less than Mixer-Loaders-Applicators and is likely similar to the dietary risks – *de minimis* and not of concern.

3.4.3 Formaldehyde

20. Formaldehyde is listed by the FAO as one of the two relevant impurities of concern in the technical active ingredient, glyphosate (FAO 2001). The limits on content are 1.3 g/kg of glyphosate (a.e.) and the hazard from this impurity was not determined by the WHO/FAO Joint Meeting on Pesticide Specifications to be toxicologically significant. This is a specification prepared for the FAO and all formulations conforming to the specification, including those sold in Ecuador, would contain formaldehyde. This is not a toxicological issue.

3.4.4 Cosmo IN-d

21. Mention is made of the use of COSMO IN-d in the spray mixture Ecuador’s Reply (Ecuador 2011, at para. 2.61). The toxicity of this material is referenced as being classified in Category I because of the potential for severe irritation of the eyes. This material is an adjuvant for the enhancement of penetration and reduction of foaming in the pump of the sprayer. It contains alcohol ethoxylates (16.3%) and polyoxyethylealkyl ethers (10.85%) (Cosmoagro 2011). As for the other additives discussed above, potential for irritation of the eyes would be reduced by dilution in the spray mixture and it would present a small hazard. In my several visits to Colombia to observe spray operations (2004-2007), I never observed the use of this product.

3.5 Conclusions

22. In conclusion, the material in Chapter 2, section I of Ecuador’s Reply does not make use of the appropriate data, shows a clear lack of understanding of the use of agrochemicals, a lack of understanding of toxicology and the concentration-response, and offers no analytical data to justify Ecuador’s claims. Contrary to these claims, the mixtures as sprayed in Colombian territory do not present a hazard to humans in that country. Given the greatly reduced or non-existent exposures in Ecuador, the spray mixture presents no hazard to humans and the environment in Ecuador.

4 Comments on Ecuador's arguments in Chapter 4, section II, sub-section A of the Reply

4.1 The areas sprayed

23. The statement in Ecuador's Reply (Ecuador 2011, at para. 4.36) that "Colombia sprayed vast quantities of chemical herbicides…." prior to March 2005 is incorrect. From the data in the Phase-I report (Solomon et al. 2007b) total area sprayed represented only 0.0000057 percent of the total land area of Colombia, hardly a vast area, even if all of this had been located close to the border. In addition, the use of glyphosate represented only 15% of the total use of glyphosate in Colombia – the balance was used in agriculture. As glyphosate is widely used in agriculture, it is likely that large amounts also were used in Ecuador at that time and continue to this day.

4.2 Studies conducted by the SAT

24. Ecuador's Reply (Ecuador 2011, at para. 4.37) attempts to minimize the relevance and/or the thoroughness of the Phase-I study conducted by the SAT. This study is very useful in the context of the assessment of impact. The Phase-I study was the product of a team of experts (SAT) and, at the express direction of the CICAD division of OAS, was a risk assessment – that is an assessment of the potential impact of the spray program on humans and the environment in Colombia.

25. That the Phase-I and the Phase-II studies and risk assessment did not include Ecuador does not mean the results cannot be applied to assess risks in Ecuador. The conclusion of the risk assessment for humans in Colombia was that the risk of adverse effects was negligible, even from a direct overspray (Solomon et al. 2007b). By extension, the risks in Ecuador would have been zero because there is no potential for exposure in Ecuador. Refined modeling of spray drift that takes into consideration the presence of trees and other vegetation as well as the contribution of adjacent spray swaths shows that exposures will be very small close to the swath and essentially zero at greater distances (1 km) (Hewitt 2011). It should be noted that the refined modeling conducted by Hewitt used the same worst-case assumptions for all parameters as in Ecuador's Reply (Ecuador 2011, Annex 2) with the exception of the consideration of the effect of trees on the interception of the spray.

4.3 Toxicity studies on the spray mixtures used in Colombia

26. Ecuador's Reply (Ecuador 2011, at para. 4.38) is again incorrect in its discussion of the lack of toxicity testing of the spray mixtures. As discussed in section

3.1 above, the toxicity of all of the formulations used for spraying coca and poppy in Colombia was tested. All formulations were tested by US-based Springborn Laboratories, using GLP and QA/QC and, in addition, tests of the Gly-41-based spray mixture were conducted in a Colombian Laboratory, Immunopharmos Ltda. Laboratorios in Cota, Cundinamarca, Colombia. As with the testing done by Springborn, all results demonstrated negligible toxicity via the oral, dermal, and inhalation routes and the reversible and mild irritation of the eyes placed all the spray mixtures in category IV.

4.4 Lack of studies of spray drift, toxicity to amphibians, and human reproduction

27. It is correct that the Phase-I study (Solomon et al. 2007b) identified a need to assess spray drift, however, that was not in response to allegations of spray drift into Ecuador; these were not known to the SAT at the time of the Phase-I assessment. Furthermore, the studies on spray-drift were directed specifically to the need to assess exposures for organisms in the environment, not humans who were at negligible risk, even from a direct overspray. It is correct that no tests with the spray-mixture had been conducted on amphibians prior to the Phase-I study (Ecuador 2011, 4.39) but other formulations had been tested and, at that time, amphibians were thought to be more sensitive than other aquatic organisms.

28. The statement in Ecuador's Reply (Ecuador 2011, at para. 4.39) that amphibians "…are particularly sensitive to herbicides" is incorrect. Data on sensitivity of tadpoles to pesticides shows that they are much more sensitive to insecticides and some fungicides than to herbicides (Brain and Solomon 2009). In fact, for aquatic organisms in general, endosulfan presented the greatest hazard (Solomon et al. 2007a) with a hazard ratio 20,000-times greater than glyphosate. Endosulfan is banned in Colombia but is used in Ecuador where eight formulations are registered for sale (Agrocalidad 2011).

29. Contrary to what is alleged by Ecuador in its Reply (Ecuador 2011, at para. 4.39), the spray's impact on human health has been adequately studied, including with respect to reproductive health. It is clearly stated in the report from Phase-I, that glyphosate is not a reproductive toxicant in laboratory animals except at large doses that are not relevant to exposures in humans (Solomon et al. 2007b). That there were equivocal epidemiological studies on the effects of glyphosate in humans was acknowledged in the Phase-I report (Solomon et al. 2007a) and this was the reason

why the study on time-to-pregnancy (TTP) was conducted in Colombia. The conclusions of this study – that there was no association between eradication spraying and TTP – were included in the report of Phase-I but were only published in detail in 2009 (Sanin et al. 2009). From this it appears that, at best, Ecuador did not read the report of the Phase-I study very thoroughly.

4.5 Field measurements of drift

30. Ecuador's Reply (Ecuador 2011, paras. 4.41-4.42) discusses one of the proposed studies on spray drift. This was one of a number of proposals considered in Phase-II but was not undertaken. This was because of the difficulty in finding a suitable site for the study where multiple sprays could be undertaken, as well as the logistical difficulty of collection and measurement of small droplets under different atmospheric conditions. The SAT determined instead that the most reliable method for measuring spray drift was through a wind tunnel analysis of spray droplet size and the use of AGDISP modeling of drift scenarios.

31. In paragraph 4.43 of Ecuador's Reply, there are two errors with respect to the spray-drift study. It was carried out in 2006-2007, not in 2009 and was paid for by the CICAD division of OAS, not by the "Governments of Colombia and the United States". All of the members of the SAT worked under contract to OAS-CICAD. All payments made to me and the other SAT members for work conducted on the Phase I and Phase II investigations were made by OAS-CICAD. That OAS-CICAD had received funding for these studies from other sources (including the United States and the United Kingdom) is of no consequence. It is my understanding that it is normal practice for divisions of the OAS to obtain outside funding from member states and other interested countries on many of its projects.

4.6 Effects on amphibians

32. Ecuador's Reply (Ecuador 2011, at para. 4.46) states that the rate of application used in the studies on amphibians was unrealistic. This is incorrect. In the work on frogs (Bernal et al. 2009b), a range of concentrations was chosen and the LC50 and LC1 calculated. From this realistic field study, the LC50s were all greater than the application rate of 3.69 kg a.e/ha. These studies were direct sprays on adults with no interception by foliage. Interception of droplets by foliage would further reduce exposures by between 50 and 95% (Linders et al. 2000) and provide the margin of safety from a direct overspray. Given the lack of toxicologically significant exposures, effects on amphibians in Ecuador would be negligible (see additional discussion of this

in section 6 below). Other adjuvants were tested by the SAT (Marshall et al. 2009) as part of a series of parallel studies. Because of time factors, the SAT studied other formulations of glyphosate and other adjuvants before the data from the toxicity tests on amphibians from Colombia were available. Because the spray mixture being used was later shown to present low risk to amphibians under realistic conditions (Bernal et al. 2009b), there was no need to recommend consideration of other formulations, even though some of these had similar efficacy to the current spray mixture (Gly-41 plus Cosmo-Flux).

33. Further, Ecuador's Reply is behind the times with respect to the sensitivity of amphibians. The statement that "….Amphibians may serve as indicators of more extensive environmental change because they are sensitive to environmental contamination and live in both aquatic and terrestrial environments" (Reply of Ecuador, Vol. II, Annex 4), is based on an incorrect conclusion that amphibians are inherently very sensitive to chemicals. They are, in fact, less sensitive than some other aquatic species (Kerby et al. 2009). As has been pointed out (Brain and Solomon 2009), amphibians are sensitive to changes in habitat and to diseases (Cheng et al. 2011). This is not as a result of exposures to glyphosate but to other activities of humans.

4.7 Conclusions

34. In conclusion, the material in Chapter 4, section II A of Ecuador's Reply shows a lack of understanding of the scientific experiments and the manner in which scientific studies are undertaken. Even though a specific Environmental Impact Assessment for the eradication program was not conducted by the SAT or OAS/CICAD, the data contained within the reports of the Phase-I and –II studies of the SAT do provide the appropriate information to make conclusions on the risks of the spray program to humans and the environment. Contrary to their claims, the mixtures as sprayed on coca do not present a hazard to humans and amphibians in Colombia and, because of insignificant or non-existent exposures in Ecuador, present no hazard there.

5 Comments on Ecuador's arguments in Chapter 4, section III of the Reply

35. In Ecuador's Reply there are several general statements about pesticides (Ecuador 2011, paras. 4.78-4.85) that do not apply to the uses of formulations of glyphosate for control of coca.

5.1 Off-label use of pesticides

36. Labels of pesticides are meant to provide instructions for correct use as well as protect the manufacturer from claims of lack of efficacy or adverse effects from users who do not follow the directions on the label. While it is true that labels on pesticides are used to convey information about use and safety of the product, a deviation from the directions on the label does not necessarily mean that harm will result; this depends on how the pesticide is used. The statement in para. 4.78 of Ecuador's Reply: "Since pesticides, if not used properly, can cause serious harm to human health and the environment" should read "…properly, may cause….". Depending on how they are used, certain products may or may not cause harm. In fact, in the quote from the Decree No. 1843 of the Colombian Government (4.83) states "Use products according to the instructions on the labels or with the technical assistance of the company". This specifically allows off-label use if approved by technical experts, in this case, from the company. The spirit of this statement is that, with appropriate technical advice, off-label uses are allowed. There was excellent technical and scientific advice provided on the spray program by scientists from the U.S. Department of Agriculture and the U.S. Environmental Protection Agency in many phases of the program which ensured the safe application of the formulations of glyphosate used in the eradication program. In addition, the spray program followed detailed directions for the conditions and manner of application (Government of Colombia 2001, 2003) that are more specific and detailed than a simple label.

37. All of the discussion of the off-label use of various formulations of glyphosate (Roundup SL (Ecuador 2011, paras. 4.86-4.91) and Gly-41(Ecuador 2011, paras. 4.92-4.95) is moot as the spraying was done with appropriate technical advice and guidance and the assessment of risks from these products demonstrated that they were being safely used (Phase-I and –II studies by the SAT).

6 Comments on Dr. Charles Menzie's response (Annex 6 of Ecuador's Reply, Vol. II)

38. The report by Menzie and Booth (2011) focuses on three areas: a hazard assessment, a discussion of uncertainties, and the managing of uncertainty. There are a number of unsupported assumptions in this report and, while there is much discussion of uncertainty, other than hand-waving, there is no attempt to quantify this uncertainty. One major point in this report is the bias in the way that uncertainty is applied. By statistical definition, uncertainty is around a mean or average value. Some values are

greater than the mean and others less than the mean. For this reason, scientists usually express mean or average values with a notation of the uncertainty such as a 95% confidence interval. For example, 9.5 ± 1.0 says to the reader that the average value was 9.5 and the in the data set, 95% of the values were between 8.5 and 10.5. Thus, the velocity of the wind is not always at the maximum and the direction of the wind is not always towards the border. In fact, because of geographical and topographical factors, the average value for wind direction may not always be zero. For example, in the border area Departments of Nariño and Putumayo between Colombia and Ecuador, the predominant direction (11 months a year) of the wind is from South to North i.e., from Ecuador towards Colombia (IDEAM 2011). In addition, these areas are in the Doldrums and the wind speed is generally small; in the range of 1-2 m/sec (4-8 km/h).

39. In addition, the authors assume that all of the uncertainties are additive, for example, the implied co-occurrence of high winds and thermal inversions is highly unlikely (Hewitt 2011). There is no attempt to address the probability of these occurrences; it is merely assumed that all factors are extreme and that they all co-occur in a way that maximizes the risk. Clearly, this is illogical and against the laws of probability. The following sections address several points in this report in the same order as they were raised by Menzie and Booth.

6.1 Validation of the hazard assessment by new modeling of drift

40. The arguments brought forward by Menzie and Booth in this section of their report are heavily reliant on the revised modeling data provided in the Reply of Ecuador (Ecuador 2011). The modeling conducted in the Phase-II study (Hewitt et al. 2009), was a worst-case analysis based on standard operational conditions. Maximum speed of cross-wind (9.3 km/h) was assumed; flight speeds for the aircraft were 333 km/h for OV-10, 274 km/h for AT-802, and 226 km/h for ATT-65; temperature was assumed to be 35°C; but type of trees and density of foliage typical for the region were not included in the model. All of these factors contribute to an overestimation of drift and result in worst-case values for drift. When the model was run using multiple swaths and the actual types of trees and foliage, drift values were smaller than had been estimated before (Hewitt 2011). The speeds used in the spray-drift tests are a reasonable worst-case that represent the 90^{th} centile of speeds claimed in Menzie and Booth (2011, p. 4). In addition, the claim of nighttime spraying is wrong and is based on the incorrect interpretation of the offset time set in the Del Norte navigation systems which was either Zulu time (GMT) or +5, instead of -5 (Story 2011). Spraying at night was never

observed by the SAT in its many field visits and makes no sense for safety reasons alone.

41. This small estimate of the drift of spray agrees with actual field observations in Colombia in the areas sprayed for the control of coca. In verification exercises conducted in Colombia (as discussed in Solomon et al. 2007a, Table 3), the amount of area affected by visible damage to plants caused by off-target deposition ranged from 0.25 to 0.48%. If spray drift was as severe as is claimed and was affecting areas 10 km from the border (Ecuador 2011, Menzie and Booth 2011), then damage from off-target deposition in Colombia would be much greater than has been measured. In addition, the weekly monitoring of surface waters for 24 weeks in sprayed and non-sprayed regions of Colombia (as discussed in Solomon et al. 2007*a*, Table 9) showed no detections of glyphosate associated with the spraying of coca. These measurements provide further evidence that spray drift is *de minimis*. Further, Ecuador's Reply (Ecuador 2011) does not report measurements of glyphosate in samples of soils or water from the border region so they have presumably not been able to detect the presence of glyphosate in environmental media. Ecuador's claims of widespread and pervasive drift of glyphosate into its territory are inconsistent with the evidence of very little drift and no pervasive contamination in Colombia, and are mere speculation.

6.2 Uncertainties associated with health and environmental effects

42. This section of the report by Menzie and Booth (2011, p. 6 et seq), refers to a number of factors that may introduce uncertainties into the assessment of risk. These are discussed in the following paragraphs.

43. **Meteorology** is important when spraying pesticides and adherence to procedures is important. Local meteorological conditions were considered during the application of sprays. Members of the SAT were present at a number of spray operations and made the following observations:

a. The spray operation was preceded by a reconnaissance of the area by a spray-pilot. If conditions (cloud, rain, etc.), were inappropriate the operation was postponed to later in the day or to the following day.
b. If spraying could not be initiated early enough in the afternoon, the operation was postponed to the following day. This was for two reasons; to ensure the safety of pilots and to avoid the possibility of stronger winds associated with localized thunder storms in the late afternoon.

c. Before initiating spraying, the lead spray-plane released oil smoke (known as "beeper") and the movement of the cloud of smoke was used to judge suitability of local wind conditions for spraying.

44. Thus, local meteorological conditions were considered on a case-by-case basis. In addition, and contrary to Menzie and Booth (2011, p. 6 and Section 2.1, pp. 9-10), spraying was not conducted at night (see discussion above in section 6.1 of this report). These allegations are thus incorrect.

45. **Composition of the spray mixture** did change over the period of spraying (Roundup SL to Gly 41), but this did not influence the hazard from the spray solution (Table 1). There is no basis for this argument (Menzie and Booth 2011, p. 7 and in Section 2.2, pp. 11-13) and this allegation is not based on appropriate scientific data. The allegation related to the use of other surfactants is discussed in Sections 3.1 and 3.2 above. Also, as stated above (Section 3.3), the composition of Cosmo-Flux F411 is known and was considered in the toxicity tests conducted on the spray mixture. The allegation that the change in the spray mixtures affected risks is not supported by the toxicity tests conducted on all of the spray mixtures that were used in the spray operations (Table 1 above).

46. The **vulnerability of the populations in the border area** is alleged to make the people more susceptible to the effects of glyphosate (Menzie and Booth 2011, p. 7 and Section 2.3, pp. 13-15) but this is pure speculation. There is no evidence to suggest that the individuals in the border area are made more sensitive by the conditions under which they live. In addition, for an interaction to occur, exposures to the spray would have to be at a dose close to that which would cause a response. Even the exposures expected from a direct overspray provide a margin of safety that would be protective (Solomon et al. 2007b) of just such a scenario. The *de minimis* exposures resulting from spray-drift would be so small and infrequent that these interactions would not occur. In addition, epidemiology studies conducted by the SAT in Colombia showed no link between time-to-pregnancy and aerial spraying (Sanin et al. 2009) or frequency of micronucleus in white blood cells and self-reported proximity to the spray or entry into the sprayed fields (Bolognesi et al. 2009). This further confirmed the lack of health effects in populations in the immediate vicinity of the areas sprayed in Colombia. As no exposures occurred in Ecuador, claims of health effects in populations near the border cannot be caused by spraying in Colombia. Furthermore, new studies conducted in Ecuador concluded that "the study population did not present significant

chromosomal and DNA alterations" (Paz-y-Miño et al. 2011). Again, these allegations of harm to humans are incorrect and are not supported by studies conducted on the exposed populations in Colombia or Ecuador.

47. The **Ecology of Ecuador** is different from that of the temperate regions of the world (Menzie and Booth 2011, p. 7 and Section 2.4, pp. 15-18) but Menzie and Booth do not provide examples of how this may have caused the SAT to "to neglect to consider important exposure pathways". If anything, exposures would be less and for shorter periods than experienced in temperate regions. The greater humidity and temperature results in more rapid dissipation of most chemicals, including pesticides (Racke et al. 1997), which reduces exposures and the concomitant risks. Once again, these allegations are incorrect and are inconsistent with scientific knowledge about the behavior of pesticides in the tropics.

48. Menzie and Booth also discuss the life history of frogs in Ecuador and seem to misunderstand the nature of the choice of the frogs tested in the studies conducted by the SAT. The frogs selected for testing under laboratory (Bernal et al. 2009a) and field conditions (Bernal et al. 2009b) in the tadpole stage were chosen specifically because their juvenile stages are found in water, a likely exposure pathway for the spray mixture. Another reason for the choice of these species was that they are typically found in lowland areas where coca is grown (<1000 m above sea level). Most of the diversity of species of frogs in Colombia and Ecuador are found at greater altitude in the Andes. This is the case for the members of the Strabomantidae (Menzie and Booth 2011, p. 20) which are montane frogs (Arteaga-Navarro and Guayasamin 2011) and would not be found close to areas where coca is grown. Frogs with other reproductive strategies that do not make use of surface waters could not be tested in this manner as aqueous exposure would be unrealistic. However, the responses of terrestrial stages of frogs to the spray mixture were studied as well (Bernal et al. 2009b), although it is unclear whether Menzie and Booth actually read this part of the paper. The species used in the testing of terrestrial stages included some that have different reproductive strategies such as the Dendrobatids (Menzie and Booth 2011, p. 18). The species tested was *Dendrobates truncatus*, along with seven others representing different habitats. These frogs were exposed by direct contact with the skin but under realistic conditions and showed a range of sensitivity (Bernal et al. 2009b). *D. truncatus* was the least sensitive with no effects at the greatest concentration tested, i.e., 14 kg a.e./ha. The lack of sensitivity of terrestrial stages of frogs is consistent with the results of other studies conducted in the U.S.A. and Canada (Dinehart et al. 2009, Edge et al. 2011). It is

correct that some of these species are almost strictly arboreal but, as pointed out ((Lynch and Arroyo 2009) and (Hewitt 2011)), the dense foliage of the canopy of the forest is protective of these organisms. Last, but by no means least, all of the discussion of the sensitivity of frogs in Ecuador is moot as the exposures are essentially negligible (Hewitt 2011) and the risks *de minimis*.

49. In their report Menzie and Booth (2011, p. 7) allege that the use of **sensitivity of species to spray mixtures** by the SAT was inappropriate as species from Ecuador were not tested. This is speculation as Menzie and Booth do not provide toxicity data from species of plants or animals from Ecuador. In fact there is evidence that there are no significant differences between species from the tropics and other regions in terms of sensitivity to pesticides and other chemicals. No significant differences were found in HC5 values derived from Species Sensitivity Distributions of tropical and temperate species to several pesticides (Maltby et al. 2005) as long as the species were from the same taxon (fish vs. fish). If anything, cold-water species (of fish) appear to be somewhat more sensitive than tropical species (Dyer et al. 1997) probably because of differences in metabolism and detoxification at lower temperatures (Daam and Van den Brink 2010). When the SAT completed Phase-I of the risk assessment, it identified a lack of toxicity data from amphibians in Colombia as a data-need (Solomon et al. 2007b). The hypothesis that the sensitivity of frogs to glyphosate was not different between Colombia and other locations was tested with laboratory data on tadpoles of eight species of frogs from Colombia (Bernal et al. 2009a). This hypothesis could not be falsified as was illustrated in distribution of data in Figure 1 of Bernal et al. (2009a). The theory that Ecuadorian species of amphibians would be consistently more (or less) sensitive than those from Colombia is even less plausible when one considers the similarity of climate and the closer relationship between species in these two countries as compared to Colombia and Europe or the U.S.A. In addition, as pointed out for amphibians (Lynch and Arroyo 2009), the same species are found on either side of the border in Nariño, in western Putumayo, and adjacent areas of Cauca and Caquetá where the exposures are alleged to occur. These allegations of greater sensitivity of species of frogs and other organisms from Ecuador are not supported by the studies conducted by the SAT or other scientists.

50. With regard to plants, Menzie and Booth (2011, p. 24) are correct that the Phase-II studies of the SAT utilized data on the susceptibility of crop plants only. These data were obtained from the ECOTOX database (USEPA 2001) because these are studies conducted using standardized protocols for the purposes of registration. Since

that time, more recent data for wild plants from a presentation by Olszyk et al. (2009) at a meeting of the Society for Environmental Toxicology and Chemistry have been added to the data set. A commonly used measure of effect on plants is the EC25 based on growth, yield, or size (Suter et al. 2007). These data were characterized by the use of Species Sensitivity Distributions (SSDs) using procedures as before (Hewitt et al. 2009) and are presented in Table 2 and Figure 1 below.

Table 2. Regression coefficients and intercepts for the toxicity data distributions for exposures of terrestrial plants to glyphosate (Roundup®)

Herbicide	n	r^2	y = ax + b		5th centile intercepts (kg a.e./ha)
			a	b	
Glyphosate (Roundup crop plants)	21	0.89	2.63	1.91	0.045
Glyphosate (Roundup wild plants)	13	0.95	2.32	3.02	0.0(Springborn 2003a)10

51. Crop plants are less sensitive to glyphosate than wild plants with a 5th centile of 0.045 compared to 0.01 kg a.e./ha. When compared to the refined data on drift (Hewitt 2011) deposition at 100 and 800 m were less than the 5th centile of the distribution of EC50 values for wild plants Figure 1. Deposition at 800 m also was less than the HC5 (equivalent to the 5th centile) of plants as tested by Boutin et al. (2004). These data show that allegations of harm to plants in Ecuador by Menzie and Booth (2011, p. 24) are without basis.

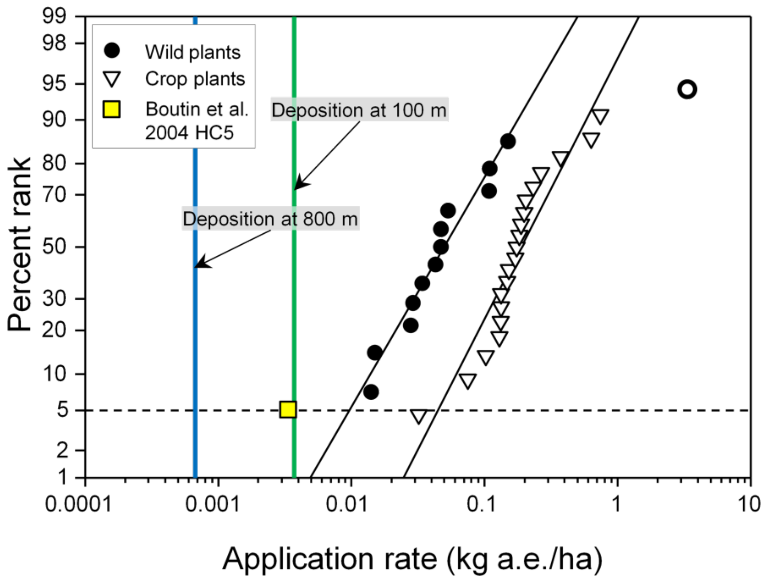

Figure 1. Distributions of EC25s for glyphosate in terrestrial plants and refined estimates of drift from a 10-swath aerial application. The yellow square is the HC5 as reported by (Boutin et al. 2004).

52. With regard to the discussion of the effect of Cosmo-Flux on toxicity of Gly-41 to plants, see the discussion in Section 3.3 above. With regard to the suggestion that the toxicity of glyphosate to all plants is increased by a factor of four-fold (Menzie and Booth 2011, p. 25), this would only be the case if the sensitivity was determined by penetration only. Menzie and Booth (Menzie and Booth) present no evidence to show that this is the case and apparently rely on the Weller report (Weller 2011) where these data were misinterpreted (see section 7.4 below).

53. Menzie and Booth (2011, p. 8 and Section 2.6, pp. 25-26) suggest that there is uncertainty in the **measurements of exposure** close to the border with Ecuador. Because of logistical issues, it was not possible for the SAT to measure exposures in these regions. Thus, the SAT relied on modeling of drift to estimate worst-case exposures. Ecuador has also relied on the same type of models and has not presented any measured values of exposures in Ecuador. In addition (as discussed in the section on drift (Hewitt 2011)), the modeling conducted by Ecuador did not consider interception of spray droplets by trees and foliage and their estimates of drift are much greater than is realistic for the environment where coca is sprayed. Thus, the modeled exposures used by Ecuador are, in fact, more uncertain than those used in the risk assessments of the SAT and the comment is incorrect.

54. Menzie and Booth (2011, p. 8 and Section 2.7, pp. 26-31) allege that **Colombia dismissed reports of adverse effects** and imply that this is contrary to accepted environmental regulatory practice. Firstly, this is incorrect – reports of adverse effects are not used in regulatory practice, they are used in risk assessment. However, not all data from these reports is appropriate for this purpose. The SAT did consider the anecdotal testimony of individuals who alleged harm from the aerial eradication operations in Colombia, where exposures, if any, would be greater than in Ecuador. Individual members of the SAT with medical expertise assessed the nature of the information provided in these anecdotal reports and concluded that it was not usable in a risk assessment. The major reasons for this conclusion were that the anecdotal reports were not collected in a consistent manner, often did not have necessary information such as medical records or measurements of alleged exposures, and could not be analyzed in any scientific way (epidemiologically) because of the absence of a control group. How this can be characterized as "strong testimonial evidence" (Menzie and Booth 2011, p. 27) is not clear, an anecdote is an anecdote and, for all we know, could also be a fairy-tale. For this reason, the SAT designed and carried out two epidemiological studies of the spraying operations, with inclusion of appropriate

reference and/or control groups and a standardized approach. The findings from these epidemiological studies are included in the studies of the SAT published in the peer-reviewed literature and do not suggest a link between exposure to the spray and significant adverse effects. As Ecuador has offered no alternative way to analyze these anecdotal reports in a scientific manner, there is no substance to their allegations. In Section 2.7, Menzie and Booth (2011) launch into an extensive study of the evidence used to assign causality; however, they fail to acknowledge that these criteria were developed for the analysis of properly conducted epidemiological studies and experiments (Hill 1965). The anecdotal evidence that they cite is poor evidence of causality and the lack of significant toxicity of the spray mixture in guideline tests (Table 1) shows, once again, that this is all pure speculation on the part of Ecuador.

55. Menzie and Booth (2011, p. 8) allege that **extreme adverse events may not be anticipated by modeling**, which is correct. Nevertheless, the environmentally refined modeling conducted (Hewitt 2011) does consider extremes of operational conditions as well as local conditions. However, Menzie and Booth raise this uncertainty as if it applied across all events. By definition, extreme adverse events are rare and the probability of their occurrence is small. When using these in a risk assessment context, one must consider the extent and frequency of the potential adverse effects, which Ecuador has failed to do. However, if one considers the extent of adverse effects, say from a greater than expected drift event, one must consider the relatively small area that would be affected and the very small increased exposures that may result from spraying at a greater altitude (Hewitt 2011).

56. The report of Menzie and Booth (2011, Section 2.8, pp. 31-32) provides some discussion of extreme events, but no discussion of probability of these. It appears that they wish to rely only on hypothetical possibilities when they have a wealth of data from which to derive conclusions. This is neither science nor deductive reasoning and is no more scientific than Chicken Little crying that the sky is falling.

6.3 Managing Uncertainty for Risk-Based Decision Making

57. In the section on managing uncertainty for risk-based decision making, Menzie and Booth (2011, Section 3, pp. 33-41), argue that, in the face of uncertainty, large safety factors are necessary for making decisions that are protective. They further argue that there is great uncertainty due to lack of knowledge. However, their own evidence is also lacking in knowledge and is flawed. The modeling on which their estimates of exposure were based was unrealistic as it failed to consider the presence

of trees that would act to intercept drift and their estimates of exposures are thus highly exaggerated. They claim that the toxicity of the spray mixture(s) is unknown, whereas it is well documented. They claim that the uncertainty factors are not used, when they were. The reference dose (RfD) used as a comparison for exposures of humans was derived by the U.S. EPA by the use of uncertainty factors. Menzie and Booth also imply that the database for glyphosate is "poor" (Menzie and Booth 2011, p. 35), whereas it is very robust for both human and ecological endpoints. This is illustrated in the wealth of data in published assessments from regulators ((World Health Organization International Program on Chemical Safety 1994, USEPA 1993, *et seq.*), (Williams et al. 2000, Giesy et al. 2000, Solomon and Thompson 2003)), and the work of the SAT. The discussion of uncertainty factors for ecological receptors is not relevant. The exposures calculated from the refined modeling of drift all include large margins of safety, i.e., they are all thousands of fold less that exposures of concern (Hewitt 2011).

7 Comments on the expert report prepared by Dr. Stephen C. Weller (Annex 3 to Ecuador's Reply, Vol. II)

58. Dr. Weller's report (Weller 2011) contains a number of errors and misinterpretations of information that bias the conclusions. The following sections highlight these errors and show how they have prejudiced the conclusions.

7.1 Rates of application

59. The comparison of the rate of application of glyphosate for control of coca (3.67 kg a.e./ha) in Colombia to its use in agriculture (1.5 kg a.e./ha) in the US (Weller 2011, p. 10) is inappropriate. A better comparison is to the rate of application in forestry where it is used to control herbaceous species similar to coca plants. In forestry, maximum label rates range from 2.14 to 11.2 kg a.e./ha (Thompson 2011). In this context, the rates used for the control of coca are not unusual, especially when one considers resistance of the waxy leaves to penetration of hydrophilic substances such as glyphosate.

7.2 Spray drift estimates

60. The estimates of spray drift used in the report (Weller 2011, p. 12) are based on older studies and only focus on the maxima. The loss to downwind drift from boom application (ground-based) is small. Based on analysis of >100 spray drift trials, the 90th centile drift value for ground sprayers is 2.7% of the rate applied (Rautmann et al. 2001), far less than the 14 to 78% from older studies. Similarly, aerial application of

glyphosate (1.07 to 2.14 kg a.e./ha) by helicopter for conifer release showed insignificant deposition from drift at distances of 30 to 60 m from the edge of the spray block (Thompson et al. 2004).

7.3 Tolerance of plants to glyphosate

61. That crop plants may be more tolerant to glyphosate (Weller 2011, p. 14) is correct. The 5th centile for wild plants (Table 2) was 10 g a.e./ha. However this ignores the fact that small concentrations of glyphosate can be stimulatory to plant growth. Rates of 1.8 to 36 g a.e./ha were stimulatory in three species of plants from Brazil (Velini et al. 2008) and in crop plants (barley) treated at rates up to 63 g a.e./ha (Cedergreen 2008). Thus, to extrapolate to very small rates and assume that damage will occur in all plants is incorrect. The observation of stimulation of growth shows that there is a threshold below which adverse effects will not occur, even in the most sensitive organisms, plants.

7.4 Enhancement of toxicity by Cosmo-Flux 411

62. The allegation (Weller 2011, p. 15) that Cosmo-Flux 411F enhances the efficacy of formulated glyphosate products is incorrect. The source of this information was claimed to be a paper by Collins and Helling (2002), in which several mixtures of adjuvants were tested; "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:…" (*emphasis added*). Cosmo-Flux 411F was not tested by Collins and Helling (2002) and the increase in efficacy referred to was in reference to a glyphosate formulation without surfactants (Rodeo®), not Gly-41 or its equivalent. In addition, studies of the efficacy of mixtures of Gly-41 and several adjuvants carried out in Colombia (Marshall et al. 2009, Table 3) showed little enhancement of efficacy for the mixture of Gly-41 and Cosmo-Flux in coca. To extrapolate from an advertisement from Cosmoagro that states that "Its effectiveness is four (4) times greater than conventional spraying oils due to synergism between the paraffinic oil and the stereospecific surfactant", demonstrates gullibility in the extreme. Glyphosate is not specifically mentioned in this claim and there is no evidence that paraffinic oils are synergistic (using the classical definition for pesticide synergists) or that the surfactant is stereospecific with regards to the vast range of products of very different molecular structure that it is claimed to enhance. In short, there is no support for the claim that Cosmo-Flux 411F enhances the efficacy of formulated glyphosate to a

significant degree. The extensive discussion of the enhancement of toxicity of glyphosate in the section on page 16 (Weller 2011) is moot as this enhanced toxicity does not occur.

7.5 Spray drift

63. The discussion on spray drift (Weller 2011, pp. 17-21) is addressed in the expert report prepared by Dr Hewitt in response to Dr Giles' report (Hewitt 2011). However, combining the sensitivity data (Table 2) and from Boutin et al. (2004), and combining this, in turn, with the exposures at various distances from the spray area from the refined analysis of drift (Hewitt 2011), shows a *de minimis* risk to plants at distances greater than approximately 100 m from the sprayed area (see section 6.2 and Figure 1, above).

7.6 Factors that enhance injury to plants

7.6.1 Humidity

64. That greater humidity may enhance the penetration of glyphosate through the cuticles of leaves (Weller 2011, p. 21) is correct, but the extent to which this enhances the penetration of glyphosate is not stated. Measurements of uptake of glyphosate through cuticle have shown that rate of penetration is increased by a factor of about 8 at 100% humidity as compared to 70% humidity (Schönherr 2002, Jordan 1977), but these observations were based on the use of pure glyphosate in the absence of surfactants. Addition of an ethoxylated fatty amine (Ethomeen T25) at a rate of 4 g/L did not enhance penetration but the interaction of this with humidity was not tested (Schönherr 2002). To what extent humidity enhances the efficacy of the spray mixture used in Colombia is uncertain.

7.6.2 Concentration of herbicide in the spray droplets

65. Greater humidity will also influence the rate of evaporative loss water from spray droplets; however, the humidity at the normal times of spraying in the Nariño and Putumayo regions of Colombia is high (IDEAM 2011), a factor that is considered in the modeling of spray drift (Hewitt et al. 2009, Hewitt 2011). Studies on the effect of volume of spray on efficacy were conducted in the field in New Mexico (Banks and Schroeder 2002) presumably at low humidity (this was not reported in the paper) or in the greenhouse (Yerkes and Weller 1996) (where the humidity was again not reported). Thus the effect of humidity on size of droplet and runoff from treated leaves is not known. In contradiction to these suggestions, others have shown that coarse (large)

droplets enhance the uptake of glyphosate by plants (Feng et al. 2003), so the suggestion by Weller (2011, p. 22) that small droplet size will increase efficacy is not necessarily correct.

66. This discussion of humidity as it relates to droplets of spray is, in any case, confounded. High humidity would reduce loss of water from the droplets and increase the effective volume of the spray, and may reduce efficacy. However, large droplets reduce the extent of spray drift. Weller attempts to argue for effects of high humidity in one case and low humidity in the other when they are mutually exclusive and cannot be additive.

67. Also relevant is that, even if there is complete evaporation of all of volatile components of a droplet by prior to deposition, its final size will depend on the proportion of the contents which were non-volatile (Hewitt 2011). Such small droplets would be dispersed and diluted in the atmosphere to tiny (*de minimis*) amounts that are not toxicologically relevant.

7.6.3 Secondary effects of glyphosate-based herbicides

68. Weller (2011, p. 22) states that glyphosate may affect the nutrition of plants and that this may in some way enhance toxicity. However, the sum of all the actions of glyphosate on the target system (the shikimic acid pathway) and other processes are included in the response of the plant in the bioassays and are quantified in the EC25. Thus this is not an additional effect and has no impact on the sensitivity of the plant beyond what is measured in the test.

69. Although glyphosate can penetrate plants and then be extruded from the roots and possibly affect microorganisms in the soil, these effects have only been reported in experiments where normal application rates are used (Kremer et al. 2005, Kremer and Means 2009) and are only relevant to direct deposition on a sprayed plant (coca), not to exposures via drift. This may be an issue in fields sprayed directly with formulations of glyphosate but there are no data to suggest that this occurs in plants exposed to much smaller amounts such as those that result from spray drift. The allegation that "Glyphosate is a potent mico (*sic*)-herbicide with toxicity to earthworms, myorrirhizae (*sic*) and many microbes …" (Weller 2011, p. 23) is attributed to Kremer and Means (2009) but there are no descriptions of potency in this paper and earthworms are not even mentioned. Glyphosate is not a mycoherbicide; these are bioherbicides based on fungi that are pathogenic in plants. These allegations are not supported in the literature.

70. Although it is alleged that glyphosate may increase susceptibility of plants to diseases (Weller 2011, p. 23), this is at rates of field application and, most likely, due to the infection of the dying plant by pathogens. In a review of the topic, Camberato et al (2011) concluded that "Overall, the claims that glyphosate is having a widespread effect on plant health are largely unsubstantiated. To date, there is limited scientific research data that suggest that plant diseases have increased in GM crops due to the use of glyphosate." To add to this, glyphosate has been shown to protect plants from some diseases (Feng et al. 2008). There is no basis for the claim that small amounts of glyphosate predispose plants to infection from disease.

8 Comments on other points raised in Ecuador's Reply

8.1 Measurement of residues of glyphosate in Ecuador

71. In Ecuador's Reply (Ecuador 2011, paras. 3.29-3.31) it is stated that it is pointless to test for glyphosate in water and soil because it easily dissipates and is carried away by river currents. This statement is only partially correct. In a flowing river, any residue of glyphosate would dissipate rapidly to the point of being undetectable. Sampling would have to be done on a regular basis or shortly after the spray event. In Phase-I of the SAT studies, samples of water were taken weekly for 24 weeks from creeks and rivers in five locations in Colombia. Glyphosate was detected twice but only in regions where it was being used for agricultural purposes. However, dissipation in pools would be slower, and these environments have been used to measure exposures after aerial spraying in forests (Thompson et al. 2004).

72. As is discussed above, glyphosate adsorbs strongly to soil and, by this process, is rendered biologically unavailable. However, adsorbed glyphosate can be displaced from the soil by the use of strong acids and then analyzed. This is the basis for the analytical method for glyphosate in soils.

8.2 Number of formulations used in Ecuador

73. The following formulations of glyphosate were used for the spraying of coca in Colombia:

a. Fuete-SL®, Roundup SL ® (equivalent to Roundup-Export® (EPA Registration No. 524-308)),
b. Gly-41® (equivalent to Roundup-Ultra® (EPA Registration No. 524-475))

74. Even though the labels are different, all of this discussion about different formulations is irrelevant because, as shown above in section 3.1 and Table 1, the spray mixtures used are toxicologically similar.

8.3 General comments

75. Overall, Ecuador's Reply (Ecuador 2011) is based on a lack of understanding of the basic principles of toxicology and risk assessment, misinterpretation of data, erroneous use and interpretation of data and selective citations of the literature. It provides no proof that the spray used for control of coca in Colombia drifted into Ecuador in any amounts, let alone toxicologically significant quantities, or that any harm occurred.

Respectfully submitted,

Keith R. Solomon

Dated: Nov 4, 2011

9 References

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Annex 4

Dr S. Dobson, OBE Ph.D., *Response to Scientific Papers in Annexes to Volume II of Ecuador's Reply (2011)*, December 2011

Birchtree Consultants Ltd.

Response to scientific papers in Annexes to Volume II of Ecuador's Reply (2011)

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Contents

1. Response

1. In this paper I respond, insofar as I am competent to do so, to the various scientific papers filed with Ecuador's Reply. My qualifications to do so were set out in my Report attached to the Counter-Memorial.

2. Spray drift and deposition beyond the intended area of spray application (Hansman & Mena, 2011; Giles 2011).

2. I am not an expert on spray drift. A paper from Hewitt (2011) addresses the issues raised in the Giles (2011) and the Hansman & Mena (2011) papers.

3. My understanding from the Hewitt paper is that spray drift extends very considerably away from the application site if there is no forest canopy intervening (as was assumed by Giles, 2011). However, if there is any canopy present, there is considerable amelioration of spray drift, approaching complete block of spray to areas even immediately adjacent to the spray swath. Hewitt's new modelling (Hewitt, 2011) demonstrates that very little to no spray drift occurs beyond the intended application area.

4. In my previous report (Dobson, 2010), I used Figure 5 from Hewitt et al. (2009) as the basis for calculation of risk associated with spray drift. Hewitt had taken a realistic worst case, assuming no amelioration of spray drift by forest canopy, to generate his Figure 5. Since Giles (2011) applied extreme conditions coupled with zero canopy to generate his predictions of spray drift into Ecuador and this approach was not scientifically justifiable, Hewitt (2011) modelled drift with a canopy present. This shows definitively that drift would not extend into Ecuador's territory. However, whilst the models can deal with <u>either</u> no canopy (as for the clearings which are sprayed in the coca eradication programme) <u>or</u> full canopy (which surround the sprayed areas), they cannot deal directly with spraying over open ground which ends in forest canopy. I therefore, asked Hewitt to model, as best possible, what happened at the end of a spray run from a clearing into surrounding forest. His response (Hewitt 2011 personal communication) is displayed in Figure 1 below:

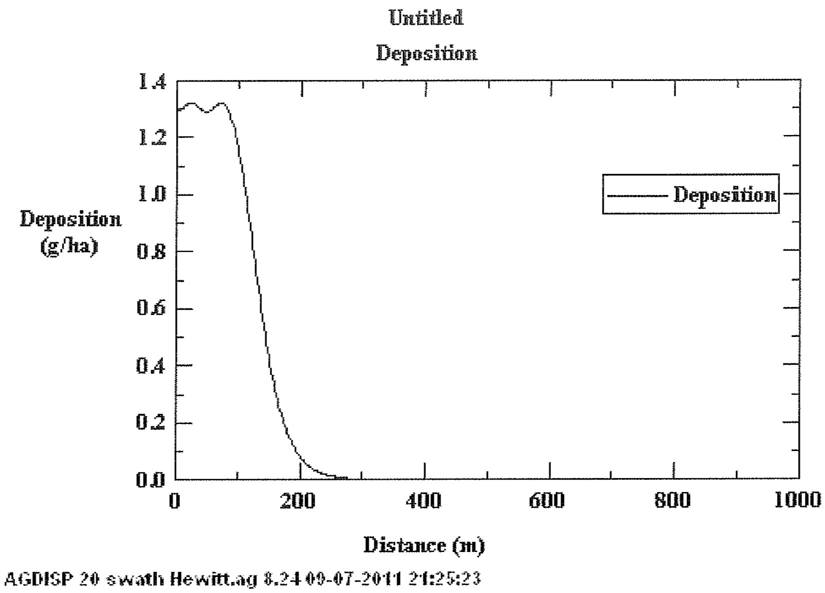

Figure 1: Deposition through the forest canopy to ground level when spray is applied directly to the canopy at full strength.

5. As illustrated, very little of the spray penetrates the forest canopy with the highest deposition rate at around 1.3 g/ha. This falls away, essentially to zero, within 300 metres of the edge of the spray application. I further asked Hewitt how much canopy was required to effectively intercept applied spray and prevent exposure of sensitive areas. His response (Hewitt personal communication 2011), was that conservatively, 20 metres of canopy totally protected from spray drift though any canopy was highly effective at ameliorating drift. This, he informed me, is well documented in regulations in countries such as Australia where urban areas are protected from spray drift from neighbouring agricultural areas. See: *Planning Guidelines: Separating Agricultural and Residential Land Uses, available from the Queensland Government* (www.nrm.qld.gov.au/land/planning/pdf/public/plan_guide.pdf).

3. Adverse effects on plants (Weller 2011)

3.1 Species sensitivity distributions and the derivation of protective dosage

6. Weller (2011) criticises the species sensitivity distribution conducted by Hewitt et al. (2009) for plants on the grounds that using crop plant species, largely from the Northern Hemisphere, is not representative. He compares the value derived by Hewitt et al. (2009) to another value derived by Boutin et al. (2004), describing Hewitt's value as "inconsistent with the threshold calculated by others". Weller quotes Boutin et al. (2004) as stating that the focus on northern hemisphere crop plants "causes an unacceptable bias with consequences that risk is underestimated." The Weller paper goes on to suggest that neither the Hewitt

evaluation nor the Boutin evaluation may be representative of either tropical crop plants or of the wild species present in Ecuador (or Colombia); "some of which may be particularly sensitive" and citing other papers in Ecuador's response (Balslev, 2011, Whitten et al. 2011) in support.

7. Boutin et al. (2004) were addressing the protection of field margins directly adjacent to crops sprayed with herbicides. Field margins represent an already degraded ecosystem which has been shown to be key to the maintenance and return of biodiversity in intensively agricultural areas in Europe. They, therefore, selected species found in field margins which were also easy to grow in pots. They further selected the growth stage of each species which would be most sensitive to the herbicides applied in their experiments. This is not given in the paper for each species and herbicide but it is made clear that early growth stages were the norm. The authors then calculated a species sensitivity distribution for each herbicide and generated a dosage protective of 95% of species at 5.5 g a.i./ha (which Weller has corrected to 4.1 g acid equivalent per hectare), entirely using their own data and ignoring all other toxicity test results for glyphosate. This is a factor of ten lower than the value derived by Hewitt et al. (2009) at 43 g a.e./ha based largely on crop plants, most of which came from temperate climates.

8. Breeze et al. (1992), also cited by Weller (2011), conducted toxicity tests on wildflowers. Their data were generated by spotting herbicide directly onto the growing tip of early growth stages and expressed as µg/plant so are difficult to compare directly with other toxicity test results. However, they make clear that size of plant makes a considerable difference in sensitivity to herbicide. Plants of the same age but having dry weights different by a factor of two showed sensitivity differing by a factor of ten; the larger plants were substantially less sensitive than the smaller ones.

9. The consequence of selecting highly sensitive life stages and highly sensitive species is the converse of Boutin et al.'s contention and "causes an unacceptable bias with consequences that risk is overestimated". The protective value derived by Boutin et al. (2004) equivalent to 4.1 g a.e./ha is a reasonable value to protect 95% of species in a nursery bed of plants representative of field margins. Indeed, this is what it aims to be according to the authors. Both the method and the value are attempts to protect existing field margin communities and to allow re-development of such communities directly adjacent to crops. This, it should be emphasised, is a proposed new, much more conservative approach to risk assessment in agro-ecological systems; it is not an accepted method for risk assessment in such systems.

10. Weller's subsequent argument (that the species in Ecuador may be more sensitive) is made as an assertion which appears to be backed-up by the citation of Boutin et al. (2004), Balslev (2011) and Whitten et al. (2011). However, the back-up citations also assert the same argument with no empirical evidence presented to support it.

11. Weller quotes Boutin et al. as noting that 'even that selection *[of sensitive stages of wild flowers]* was not necessarily representative of ecosystems affected by herbicide spray'. Both Boutin et al. and Weller interpret this assertion in one direction only – that other ecosystems might be more sensitive.

12. Balslev (2011) provides a comprehensive and fascinating picture of a highly diverse ecosystem in Ecuador along its borders with Colombia. No one would dispute that this is of

global biological importance. The author regularly describes the ecosystem as 'vulnerable' without indication of how this avowed vulnerability arises or is threatened. I do not think it is reasonable to equate 'valuable', which is not open to dispute, with 'vulnerable' which implies particular sensitivity, without some evidence.

13. "Aerial spraying with herbicides in this border region has the potential to cause significant damage to one of the World's richest and most diverse biological treasures" Balslev (2011). This is an assertion for which no evidence that the potential for harm is being realised is presented.

14. Similarly, Whitten et al. (2011) paint a fascinating, compelling and sympathetic picture of people living in harmony with and highly dependent on the diverse ecosystem. They state:

> "thus, exposure to herbicide that causes loss of crops, damage to forest resources, death of domesticated animals, or sickness, would have grave consequences for their health and livelihood".

Again, no evidence is presented that such exposure occurs or that loss of crops, forest resources or domestic animals have occurred.

3.2 Enhancement of toxicity by the addition of surfactants to the tank mix

15. Section V.C of the Weller (2011) paper considers the issue of surfactants present in glyphosate formulations and also added as an adjuvant to the tank mix specifically for coca control in Colombia. The point of contention is whether the addition of Cosmo-Flux 411F invariably increases the potency of the sprayed glyphosate formulation/adjuvant. Dr Weller and I seem to agree on all of the facts and all of the suppositions:

- The potency of the spray mix used in Colombia against the coca plant is increased fourfold by the addition of Cosmo-Flux 411F
- The increase in potency derives from increasing amounts of glyphosate reaching living cells in the plant because the Cosmo-Flux 411F overcomes the normally protective effect of the waxy leaf cuticle
- Plants with waxy cuticles very similar to that of the coca may also show increased susceptibility to the spray mix with Cosmo-Flux 411F
- Here the potency increase will be approximately the same as for coca (fourfold)
- Plants with a less developed waxy cuticle may also show increased susceptibility to the spray with adjuvant
- Plants with no waxy cuticle offer no protection from the full applied dose of glyphosate reaching the deeper, sensitive living tissues of the plant
- No potency increase would be seen for plant species with no cuticular protective layer because the increased potency comes only from the breakdown of cuticular protection
- If a plant would have been killed anyway by a spray not containing Cosmo-Flux 411F, the addition of Cosmo-Flux 411F would not influence the result of spraying – the dead plants cannot die more than once

- If Cosmo-Flux 411F is added to the spray mix, plants with some protection from waxy cuticles might be killed at a lower dose of herbicide than would otherwise be the case
- In practice, since the dose of glyphosate applied remains the same with or without Cosmo-Flux 411F, plants with cuticular protection might die further away from the point of maximum application (the spray swath) with than without Cosmo-Flux because the lower dose received would be more effective.

16. Where we appear to differ is on whether the addition of Cosmo-Flux shifts the low point of the species sensitivity distribution curve. Weller is mistaken in stating that I "discounted" the effect of the addition of Cosmo-Flux 411F. The difference of opinion is perhaps best illustrated diagrammatically.

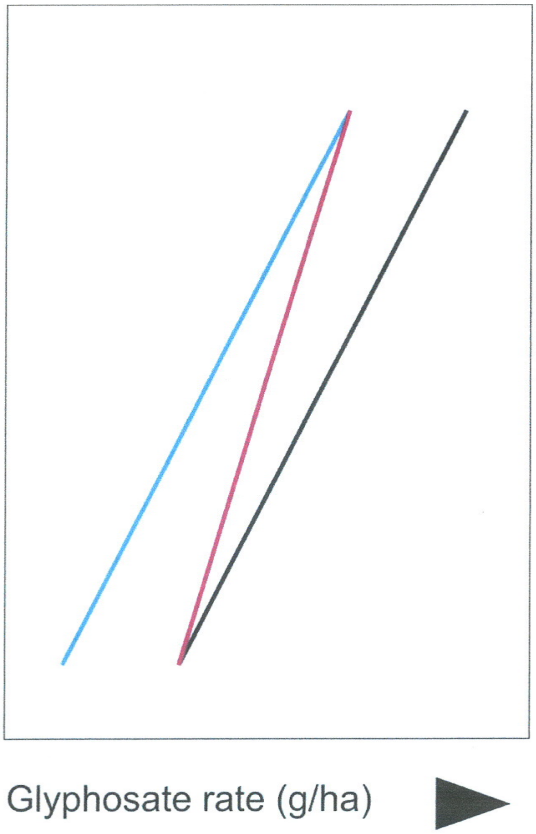

Figure 2: Diagrammatic representation of two possible scenarios for increased potency of glyphosate formulations to plants following addition of Cosmo-Flux 411F. Black line is the species sensitivity curve without Cosmo-Flux. The blue line is the proposed effect of adding Comso-Flux according to Weller (2011). The red line is the proposed effect of adding Cosmo-Flux according to Dobson (2010).

17. The black line in Figure 2 represents the species sensitivity distribution for plants experiencing spraying with a glyphosate formulation which does not have added Cosmo-Flux 411F. Plants lying at the upper end of the line (to the right) are insensitive to glyphosate. Species lying further down the line (and towards the left) are increasingly sensitive. The lower left extreme of the line represents the dose of glyphosate which would be protective of 95% of species (no adverse effects likely for the great majority of plants).

18. If we accept the bullet points above, addition of Cosmo-Flux 411F increases the sensitivity of the insensitive plant species at the upper end of the curve by reducing the protection offered by their waxy cuticles. At this upper end of the line, it is agreed that sensitivity is increased fourfold. The dose of glyphosate required to kill these plants falls because more penetrates to the sensitive, deeper tissues of the leaf. This shifts the position of the least sensitive species to the left on the graph to the upper extreme of both the blue and red lines.

19. Following the logic of the bullet points above, it is my contention that addition of Cosmo-Flux 411F increases the sensitivity of species to a lesser degree as we move down the black line of sensitivity distribution. The fourfold increase in sensitivity at the top of the curve reflects maximal protection from a waxy cuticle. The species at the bottom of the curve show no increase in sensitivity at all since they had no protection from a waxy cuticle at all. The new sensitivity curve with added Cosmo-Flux 411F, therefore, follows the red line. The dose protective of 95% of species remains at the same position.

20. Weller (2011), whilst accepting the logic of the bullet points, proposes that we should assume a fourfold increase in sensitivity for all plants (the blue line). This results in a shift of the dose protective of 95% of species to the left (lowers it) fourfold. I cannot see the logic of this proposal since it is not in accord with what both he and I accept in the bullet points.

21. We can now translate the species sensitivity curve into what happens in the field when vegetation is sprayed with a glyphosate formulation plus Cosmo-Flux 411F. Using the red line, insensitive species are more likely to die (or be affected sub-lethally) further away from the spray swath because, whilst the dose lowers with increasing distance, the effective dose is also reduced by the Cosmo-Flux 411F. A greater proportion of the total range of plant species is included in kills because the least sensitive ones become more sensitive. Insensitive species will also show more sub-lethal damage for the same reason. The dose of glyphosate does not change with or without Cosmo-Flux 411F at any point either in the spray swath or in drift downwind from it. The most sensitive species had no protection from glyphosate even without Cosmo-Flux 411F; their sensitivity, therefore, remains the same. The point in the downwind drift space where the dose protective of 95% is no longer exceeded remains the same. Whilst insensitive species are more likely to die or be adversely affected within the area between this point and the spray swath, the sensitive ones would have died anyway. Beyond this point, neither insensitive nor sensitive species are affected.

22. The dose protective of 95% of species is, therefore, not changed by the addition of Cosmo-Flux 411F.

3.3 Other factors which might affect toxicity to plants

23. In his Section VI, Weller (2011) raises other factors which might enhance injury to non-target plants under conditions of application in Colombia.

24. Whilst he states that hydration of the plant cuticle is an important determinant of herbicide penetration, he neither quantifies the effect nor provides any citations to support his argument. It is, therefore, difficult for me to comment.

25. Enhanced toxicity under conditions where water evaporates from droplets causing increased concentration of glyphosate is quantified at around fourfold (Banks & Schroeder (2002). However, Weller (2011) sees this as enhancing the efficacy of drifted droplets "the spray droplets that impact non-target plants may be significantly smaller and more concentrated than droplets that land in the target area". Droplets falling directly onto the target area are unlikely to be affected significantly. Since Hewitt (2011), in his response to Giles (2011), shows that under the conditions of spray application in Colombia, taking account of the extensive forest canopy, long range spray drift scarcely takes place, it is unlikely that evaporation of drifted droplets is a factor which needs to be considered. Hewitt (2011) also demonstrates that with the high humidity in the region, evaporation will be minimal.

26. Section VI.C raises secondary effects of glyphosate-based herbicides. This is re-opening similar issues raised by Menzie et al. (2009) which I covered in my previous report: Dobson (2010). As with Menzie et al., this section raises various secondary effects of the use of glyphosate but fails to provide any indication of the dose of herbicide applied which would cause the effects. The following table indicates dose for each of the effects cited:

Effect	Application rate	Reference
Impairment of growth and micronutrient status (hydroponic and soil cultivation). **Shoot but not root growth affected in one soil type only. Root but not shoot dry matter reduced in hydroponic culture. Mn, Fe and Zn (soluble and insoluble) only different for Zn in one soil type.**	Recommended application rates for weed control on glyphosate resistant crops (applied twice in the soil cultures)	Bott et al. (2008)

Study is on reversal of reduced yield of glyphosate-resistant soybean compared to non-resistant variety. Effect is observed reduced yield in GR crop attributed to reduced Mn uptake.	Assumed to be full recommended application rate (number of applications not stated)	Gordon (2007)
Again, study on application of Mn to counter observed reduced yield of glyphosate-resistent soybeans.	Assumed to be full recommended application rate (number of applications not stated)	Reichenberger (2007)
Reduced shoot and seed dry matter in soybeans. Marginal reductions in some trace elements.	Up to 0.6 or 1.2% of recommended application rate. 3 applications	Cakmak et al. (2009)
Increased colonisation of GR soybean roots by *Fusarium* fungus. Reduced nodule formation in GR soybean.	Recommended application rates for glyphosate-resistant soybean	Kremer et al. (2005) Kremer & Means (2009)
Inhibition of growth of 3 ectomycorrhizal fungi (which aid tree growth by facilitating nutrient uptake).	*In vitro*. Concentrations described as corresponding to initial soil concentrations after use in forestry.	Estok et al. (1989)
Inhibition of growth of mycorrhizal fungi associated with pine trees	*In vitro*. Authors state – "in most cases where a major decrease occurred, the herbicide rates were many times higher than would .. be expected to occur ... at the recommended rates of application"	Chakravarty & Chatarpaul (1990)
Inhibition of growth of mycorrhizal fungi associated with pine trees	*In vitro*. Dosing comparable to the study above. Substantially higher than application rates	Charavarty & Sidhu (1987)
Inhibition of growth of conifer seedlings under asceptic conditions (with	Effect at 10µg/litre of added nutrient solution. It is not stated what the overall	Sidhu & Chakravarty (1990)

and without mycorrhiza)	concentration in the growth flasks was nor how this relates to field concentrations	
Inhibition of nitrogen fixation in root nodules of subterranean clover.	Equivalent to 1, 2 and 5 times recommended application rates	Eberbach & Douglas (1983)
Disturbed phenolic metabolism in plants. Reduced nitrogenise activity in nodules.	"About half of recommended field application rate"	Hernandez et al. (1999)
Increased incidence of fungal disease in wheat and barley crops in the field	Occurred in crops grown in soils previously treated with glyphosate at recommended application rates	Fernandez et al. (2009)
Increased incidence and decreased resistance to fungal disease in glyphosate-resistant sugar beet	Equivalent to the recommended application rate for glyphosate-resistant sugar beet	Larson et al. (2006)
Increased incidence of fungal root disease in wheat	Equivalent to recommended application rate	Mekwatanakarn & Sivasithamparam (1987)
Suggestion that increased susceptibility to disease is part of the herbicidal action of glyphosate	10 µg/plant – how this dose relates to field application rate is unknown	Johal & Rahe (1984)
Immobilisation of soil nutrients (?)	Unknown. The Huber (2010) reference cited by Weller is a magazine article with no citations. The source of this effect cannot be specifically identified but chelation of micronutrients is an accepted effect of glyphosate.	Huber (2010)
"Inhibition of enzymic activity important in protecting plants from microbial attack" Weller (2011)	Unknown. No reference given for this paper and I have been unable to identify it.	Granson & Jensen (1988)

27. Whilst Weller (2011) presents mechanisms which might lead to these effects, reading these papers, and others on the same subject area, it becomes clear that no single mechanism

is accepted in the literature. Indeed seldom is the same mechanism suggested by different authors. Much of this research is related to a clearly observed phenomenon of poor performance of glyphosate-resistant varieties of crop plants over years of regular application of glyphosate to these crops. The research largely addresses how to overcome this observed reduction in yield. Similarly, other crops grown on soil which has had glyphosate treatment in previous years on glyphosate-resistant crops can also be adversely affected. This effect seems to be mediated either via reduced nutrient availability or increased susceptibility to disease. Other of the studies relate to the use of glyphosate in forestry and the possibility of adverse effects on soil ectomycorrhiza. The common thread from these studies is that the adverse effects noted occur following application of glyphosate at the full recommended application rate. Only one study, Cakmak et al. (2009), suggests effects at doses substantially below the field application rate of glyphosate; here minor sub-lethal effects on production of dry matter and marginal effects on nutrient levels in the plant are seen with 0.6 to 1.2% of the recommended application rate. This seemingly low effective exposure dose is still significantly higher than the predicted dose adjacent to the sprayed area.

28. Interestingly, a study was undertaken specifically to identify the buffer zone required to protect nature reserves from the effects of spray drift of herbicides including glyphosate Marrs et al. (1989). The authors exposed potted wild plants (23 different species) to spray drift from the herbicides applied at recommended field rate in the field. The exposed plants were then grown on in a glasshouse. The experiment was repeated at different times of the year. For glyphosate, the effect was greater for plants exposed in spring or summer than those exposed in autumn. Whilst the paper does not state the age and size of the potted plants at the time of exposure, these were young plants but well beyond the seedling stage exposed when roots were sufficiently established to show through the bottom of the pot; they were grown on until flowering for most species (personal communication from Roger Plant, the co-author of the study responsible for producing and tending to the plants). The maximum exposure recommended for complete protection of nature reserves corresponded to exposure of the plants to 11 g a.i./ha (approximately 0.5% of the recommended application rate). This value is comparable to the one generated by Cakmak et al. (2009). Also of interest is Marrs et al.'s observation in the discussion section of their paper that "most of the symptoms of damage were not necessarily caused by the herbicide *per se* as many were typical of nutrient, water imbalance, or pathogen attack." This comment, and many of the papers cited by Weller (2011), suggest that the "extra" factors raised in Weller's Section VI.C are inherent in the normal observed toxicity of glyphosate. Indeed, as Weller states "several researchers have suggested that plants exposed to glyphosate may be injured or killed due to pathogenic activity". One paper (Johal & Rahe (1984) suggests that this might be the principal herbicidal effect of glyphosate since plants treated with glyphosate but grown in sterile medium did not die when exposed to 'lethal' doses of glyphosate.

29. What is agreed, across all of the papers in the table above which commented on it, is that glyphosate has a greater effect in young plants or younger parts of more mature plants than in older leaves or plants. In addition, glyphosate is transported preferentially to the growing regions of plants including reproductive structures. The value of 4.1 g a.e/ha derived

from the Boutin et al. (2004) study on seedling wild species and the lowest reported effective dose reported at 3 g a.e./ha (Kruger et al. 2009) reflect this particular sensitivity. It seems, therefore, that age and development of seeds/fruit are of particular importance. Seedling field margins may, therefore, be much more "vulnerable" than mature forests. The conservative protection value derived by Marrs et al. (1989) at 11 g a.i./ha is substantially higher than the modelled exposure of 1.5 g/ha derived by Hewitt (2011).

3.4 Conclusion on plant toxicity

30. The new modelling performed by Hewitt (2011) demonstrates that, when the presence of a canopy is taken into account, very little of the spray drift extends beyond the clearing where the spraying takes place. Indeed, spray applied unintentionally on the canopy immediately beyond the clearing leads to approximately 1.5 g/ha reaching the forest floor. This is already much lower even than the overprotective value of 4.1 g/ha suggested by Weller (2011). The chances of such deposition occurring in Ecuador, therefore, become negligible.

4. Response to: "Critique of Evaluation of Chemicals Used in Colombia's Aerial Spraying Program, and Hazards Presented to People, Plants, Animals and the Environment in Ecuador" (Menzie & Booth 2011)

4.1 Spray drift

31. In their Section 1, Menzie & Booth (2011) rely on the modelling by Hansman & Mena (2011) and Giles (2011) presented in the Reply of Ecuador (2011). The paper presented by Hewitt (2011) in the Colombian response demonstrates that the assumptions made by Ecuador's experts do not apply to spraying where there is a significant forest canopy. If the canopy is taken into account, drift is hugely reduced and the suggested values for deposition at distance from the spraying are reduced by many orders of magnitude. The suggestion that the original 'assessment' by Menzie et al. (2009) is vindicated is, therefore, erroneous. Hewitt (2011) also covers points made previously by Menzie et al. (2009) and reiterated in Menzie & Booth (2011) regarding meteorological conditions, particularly temperature inversion, and shows that these do not significantly affect the estimates of spray drift resulting from spraying for coca control.

4.2 Composition of the formulation

32. Section 2.2 of Menzie & Booth (2011) repeats the same assertions made by Menzie et al. (2009) and ignores the responses made to them in Dobson (2010) and in Colombia's Counter Memorial (2010).

33. It seems to me Colombia has always been fully open about the information it has on the constituents of the formulations and the spray mix actually applied. No one, probably including the manufacturer, knows the exact constitution of the formulation. This is not because of secrecy (though exact constituents of formulations are often considered commercial information in confidence). POEA, as stated by Menzie & Booth (2011) and fully accepted by Dobson (2010) and the Colombian Counter Memorial (2010), is not a single substance but a mixture. It is produced from a natural material (tallow) and its manufacture produces a mixture of polyethoxylated products. It is also fully accepted that most, if not all, of the toxicity of glyphosate formulations to aquatic organisms derives from the POEA constituent. I stated (Dobson 2010) that POEA is a "worst case for surfactant toxicity" because the manufacturer of the glyphosate formulations and independent assessments (WHO 1994, Giesy et al. 2000) have always based risk estimation on POEA as the most toxic component of the mixture. Some common constituents of POEA mixture were recognised in the past as contributing more to the aquatic toxicity than others. Over time, POEA as used in pesticide formulations has changed to reduce the presence of these more toxic components. Since the risk assessments are based on tests done with formulation sold over this period, the earlier tests are likely to reflect the greater toxicity of earlier POEAs. More recent tests will probably reflect the current relatively lower toxicity of POEA to aquatic organisms. Even with more recent POEAs, the toxicity of the formulation will still reflect the toxicity of the surfactant rather than glyphosate. Other surfactants present, likely to be present or which might have been present in formulations over the years, are less toxic than POEA which, therefore, reflects "worst case". The manufacturer will not have a full analysis of each POEA batch used and these will have varied somewhat in detailed constituents. Secret, more toxic constituents of the formulations would require total dishonesty of the manufacturer to both national regulators and international assessors such as the World Health Organisation for its pesticide classification scheme; both require notification of any toxicologically relevant components. I can find no reason to suspect that this is the case.

34. It is accepted that a minor constituent of the formulation could be 1,4-dioxane. This is a common solvent which would be present in the formulation in very small amounts. It will not cause adverse health effects as a minor component of the glyphosate spray.

35. The author of the Note Verbale of 14th July 2001 could not have been referring to dioxin because this substance is not produced commercially and has no known uses (WHO 2010). The toxicity ascribed by Menzie & Booth (2011) to 'dioxin' is, anyway, not the toxicity of dioxin itself but of polyhalogenated dioxins (the dioxin substituted with either chlorine or bromine). Some of these halogen substituted dioxins have severe toxic effects on both human health and the environment. Similarly to dioxin itself, the polyhalogenated dioxins have never been deliberately produced commercially. They can arise unintentionally as bi-products of chemical synthesis or from incineration of waste or natural burning of organic materials at too low a temperature for their destruction. Extreme precaution is taken globally to prevent their accidental formation. Neither dioxin nor polyhalogenated dioxins would, or could, ever have been added to glyphosate formulations. Since neither glyphosate

itself nor the other components of the formulation contain chlorine or bromine, their accidental production is also impossible.

36. It is absurd to suggest that dioxin was ever included in glyphosate formulations and disingenuous to ascribe the toxicity of halogenated dioxins to dioxin.

4.3 Suggested extra vulnerability of human populations in Ecuador

37. Section 2.3 suggests that the greater vulnerability of human populations along the Ecuador/Colombia border should be taken into account in risk assessment. Menzie & Booth (2011) correctly state that special or specific vulnerability of human populations should be taken into account. This is a major current plank in the World Health Organisation's approach to public health effects of chemicals. However, all of the reported effects of glyphosate on human health even directly under the spray relate to mild irritancy to the skin and eyes which is transitory and fully reversible. These minor effects are not life-threatening nor do they lead to debilitating illness. Chemicals which cause illness or significantly affect the quality of life would have greater impact on vulnerable populations. Neither glyphosate nor other components of the formulations cause other than minor effects; there is no reason to suppose that these would become more significant or that they would increase the incidence or severity of local endemic disease.

4.4 Suggested extra vulnerability of non-human organisms in the Ecuadorian environment

38. Sections 2.4 and 2.5 raise uncertainties relating to species sensitivity. Menzie & Booth (2011) again raise the same points as raised by Menzie et al. (2009). Clearly it is impossible to test all species in an ecosystem against any actual or potential stressor, although that is the only way to be certain that the most sensitive have been identified. As Menzie & Booth (2011) acknowledge, the "standard approach" for dealing with this problem is to use species sensitivity distributions. This selects species which are "representative".

39. The original criticism that species included in the first sensitivity distribution (produced by the Colombian programme to assess risk from coca control to the wider environment; Solomon et al. 2005) might not be representative was raised by the programme's scientific management itself. Extra testing was commissioned on species local to the spray programme, subsequently published by Bernal et al. (2009 a,b). This was intended <u>both</u> to make the species covered more representative of the local ecosystem and also to address the possibility that local species were inherently more sensitive (to discover if the distribution of tropical species sensitivity compared to temperate species sensitivity). Species chosen were <u>obviously not</u> either critically endangered or endangered; it would be ethically totally unjustifiable to conduct toxicity tests on such species. Species chosen were those for which there was least concern under IUCN criteria; this was a responsible approach.

40. Results of the toxicity testing showed that the tropical species showed similar (or reduced) sensitivity relative to other species (largely temperate) previously tested (Figure 3).

The open triangles in the figure, representing the Colombian tropical species do not cluster towards either the left (most sensitive) or the right (least sensitive) ends of the plotted distribution.

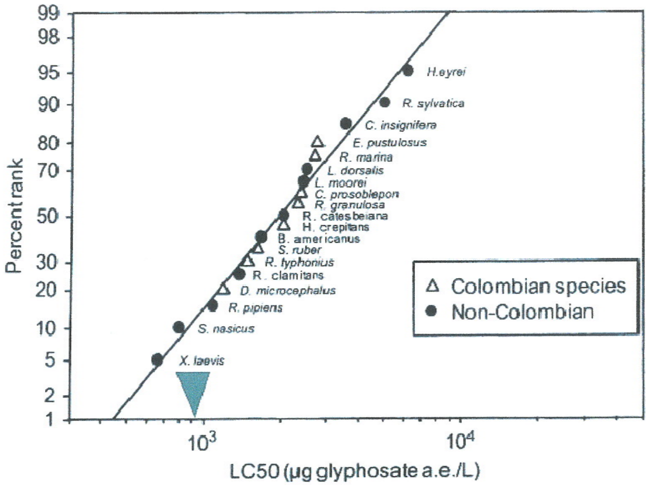

Figure 3: The calculated protective concentration for 95% of species of amphibian larvae (green arrow) at 917 μg/litre glyphosate (from Bernal et al. 2009b).

41. Menzie & Booth (2011) claim that the approach used in Dobson (2010) "is flawed because the evidence shows that the species sensitivity distributions upon which he relies are not representative of potentially exposed frog species in Ecuador".

42. To be "representative" in terms of a species sensitivity distribution for a chemical, the species should clearly ideally cover as broad a range as possible in response to the particular chemical. How does one know which species to select for testing? It is impossible to suggest, in advance, which species will be more or less sensitive to the chemical. Species which are possible to keep in the laboratory, which grow and develop under such conditions without showing stress in captivity and which are common in the wild are usually chosen.

43. In the case of glyphosate, a large number of different species from temperate and tropical habitats have been tested, many more than are usually available for the generation of species sensitivity distribution curves. A range of sensitivities has been found across these species with LC_{50} values extending over more than an order of magnitude. The distribution of sensitivity to glyphosate within tropical species is overlapped by the distribution in other species. There is absolutely no clustering of tropical species at the lower end of the distribution.

44. In terms of being "representative" of the range of sensitivity to glyphosate is concerned, this dataset is representative. Since this is the only evidence available, Menzie & Booth's contention is incorrect. The scientific evidence available shows that tropical species are no more sensitive than temperate ones to glyphosate. As cited in Dobson (2010) "a

systematic study (Maltby et al., 2005) concluded that there was no statistical difference in species sensitivity distributions between aquatic organisms originating from Nearctic (cold and temperate North America), Palearctic (Europe, North West Africa and North Asia) and tropical regions for 16 insecticides". There is, therefore, no scientific evidence suggesting that Ecuadorian species are more sensitive than any others. It is simply an assertion by Menzie and Booth (2011).

45. I am unsure how it would be possible to gather together a group of amphibians "representative" of amphibian fauna in Ecuador/Colombia. Indeed, Menzie & Booth (2011) explain at length that the amphibian fauna of the region is both large and varied in form and life cycle; it does not have 'typical' or 'representative' species. The aim of a species sensitivity distribution analysis for glyphosate sensitivity is not to be representative of the amphibian fauna of the region (even assuming that were possible); it is to be representative of their sensitivity to glyphosate. The evidence shows that it is; no local tropical species falls outside the range of sensitivity represented by the sensitivity distribution curve.

46. Menzie & Booth (2011) assume and assert that variability in type and life history of Ecuadorian amphibians equates to, or might equate to, sensitivity to glyphosate. Again they offer no evidence to support this assertion.

47. Solomon et al. (2005) and Dobson (2010) are accused of failure "to acknowledge the presence of endangered frog species in the border area, even though consideration of the presence of endangered species is standard practice in risk assessment".

48. On the contrary, Solomon et al. (2005) recognised that endangered and potentially sensitive species existed in the area and, therefore, identified extra studies required which were subsequently performed.

49. Dobson (2010) added consecutive layers of greater precaution to reflect the high value in biodiversity of the area:

- Level of protection was increased from 95% to 99% of species
- Further division of the protection value by a factor of 10 to cover possible initially sub-lethal effects which might lead to death over time (these two bullet points combined led to a reduction in estimated protective concentration from 917 to 47.3 µg/litre)
- Reduction of water depth used in the risk calculations to reflect the much smaller water bodies associated with amphibian in the region (this led to more than doubling the distance estimate for a safe margin from the spray swath)

This added precaution lies on top of the inherent precaution in toxicity testing as compared to exposure in the wild and the resilience of most species in the wild, as explained in Dobson (2010).

50. As for plants above, the new modelling conducted by Hewitt (2011) shows that, when the forest canopy is taken into account, drift of spray beyond the margins of the clearings

sprayed for coca control is minimal. Even when spray is inadvertently applied to the canopy immediately adjacent to the sprayed clearing, the dose reaching the ground (at 1.5 g/ha) will lead to concentrations in water much lower than the most conservative protection value for 95% of amphibian species.

51. Section 2.5.2 is a summary of Weller (2011) which has been addressed above.

4.5 Lack of exposure data

52. Monitoring of soil and water before and after spraying for coca control was conducted in Colombian territory. Results showed either no detectable glyphosate or AMPA, its principal breakdown product, or levels close to the limit of detection of the analytical method (Environmental Monitoring Chemical Laboratory, 2008).

4.6 'Cumulative risk'

53. Section 2.7 invokes the US EPA's cumulative risk framework (Suter et al. (2010)) and implies that this is the standard approach to risk assessment. Whilst it is gratifying to see Menzies' conversion to risk assessment compared to his previous reliance solely on hazard identification, it is incorrect to portray this interesting approach as 'standard'. It is clearly beneficial to address all possible stressors in an overall assessment of possible adverse effects on human or environmental systems. This has been an aspiration in risk assessment for several decades. However, it remains an aspiration and is not regularly applied in regulation of pesticides or any other chemicals.

54. On the detail in applying this EPA approach to the spraying of glyphosate formulations for coca control (Table 2 in Menzie & Booth 2011), the claimed 'strength of evidence' is unfounded.

55. There is no 'spatial co-occurrence' since the Ecuadorians do not live in the area which is being sprayed but some distance away from it. Colombians living directly in the sprayed areas have been extensively studied and showed no adverse effects comparable to claimed effects in Ecuador.

56. There is no temporal co-occurrence. I am told that Colombia's evidence is that claimed effects cannot be correlated in time with known spray events.

57. Whilst the modelling of Giles (2011) suggest that significant amounts of the glyphosate formulation spray would drift into Ecuadorian territory, new modelling by Hewitt (2011) demonstrates that this is not the case.

58. There is no consistency of association; effects claimed vary wildly and have been progressively reduced in successive papers from Ecuador. Some claims have been absurd, as demonstrated in Dobson (2010). This undermines completely the claims of plausibility.

59. Methodology for reducing spray drift and the possibility of exposure of both Colombian and Ecuadorian populations was followed. Estimation of exposure took into account the likely extremes in the latest modelling.

4.7 Uncertainty factors and the relevance to the spraying of glyphosate formulations for coca control

60. In their Section 3, Menzie & Booth (2011) cover the management of uncertainty for risk based decision making. Their Table 3 summarises typical uncertainty factors and the reason for their application as used in international and national programmes on chemical safety. They make no actual suggestion nor recommendations on which of the identified areas could or should lead to additional uncertainty factors specifically for either glyphosate or the surfactants in the coca control mixtures. As will be seen below, this is because there are no grounds for applying any of the factors.

61. We can consider each of the areas suggested in their Table 3 and their following text (Section 3.1) for human health:

- Interhuman (or intraspecies). As stated, this factor is used when long-term valid studies have shown an effect on healthy humans. It is applied to cover the possibility that a less healthy or more sensitive population would show similar effects at a lower exposure dose. Since long-term studies are often conducted on the occupationally exposed, it is often referred to as the 'fit worker effect'.
    - There are no long-term studies on healthy humans showing adverse effects of either glyphosate or surfactants at exposure equivalent to direct overspray. Human studies have been conducted on Colombian populations known to have been exposed to the sprays during coca control. These studies indicated no significant effects in the key areas which had been identified as potential problems. The uncertainty was addressed by conducting these targeted, specific studies. No additional uncertainty factor is appropriate
- Experimental animal to human. Since there are human field studies, as stated above, no uncertainty factor is appropriate.
- Sub-chronic to chronic. This factor is used where there are indications of toxicity of a specific type in medium-term tests which suggest that long-term effects are possible and where no specific long-term tests have been conducted.
    - There are no medium term test results which would suggest long-term effects for glyphosate or surfactants. If such suggestions had arisen, national, regional and international programmes would have demanded chronic testing of glyphosate and/or its formulations. No uncertainty factor is appropriate.
- LOAEL to NOAEL (lowest to no adverse observed effect). This is for use when no clear no-observed-adverse-effect level has been identified for a key toxic endpoint. This is not the case for glyphosate or surfactants. No uncertainty factor is appropriate.

- Modifying factor. None identified for glyphosate or surfactants. No uncertainty factor is appropriate.
- Age, sex, genetic background or ethnicity and health and nutritional status. Since field studies were commissioned for key suspected areas of toxicity within a population directly exposed through the spraying, these factors should have impacted on the study results if they were relevant. No uncertainty factor is appropriate.

62. With regard to uncertainty factors for protection of fish, wildlife and other biota, we can similarly consider the areas suggested by Menzie & Booth (2011) in their Section 3.2.

63. As outlined above, the protective concentration derived for amphibians was adjusted for the factors identified by Menzie & Booth in Dobson (2010). Provision was made for sensitivity below the tested range, for sub-lethal effects and for special vulnerability of endangered species. The species sensitivity distribution analysis is the standard scientific approach "designed to protect the most sensitive species". Menzie & Booth suggest no other. The suggestion that this makes loss of 4 species of amphibians in Ecuador acceptable is a complete misrepresentation. In deriving a 99% protection concentration, Dobson (2010) accepted, along with Lynch & Arroyo (2009), that a few species of frog were at risk in Colombia if their distribution coincided solely with directly sprayed areas. No species of frog in Ecuador would be at risk, even if its distribution was geographically severely limited, because the modelling presented in Hewitt 2011 demonstrates no significant long-range drift of the coca sprays.

5. Summary and conclusions

64. Modelling of spray drift must take into account the presence of forest canopy since this accounts for most of the amelioration over distance. Forest canopy effectively absorbs most of the applied herbicide spray within a very short distance (within 300 metres). A canopy of 20 metres depth effectively eliminates all spray drift beyond it through droplet interception by foliage and structures.

65. Arguments have been made in the response from Ecuador suggesting that deposition rates protective of wild plants derived by Hewitt et al (2009) and supported by Dobson (2010) were inadequate to protect plant life from the effects of glyphosate spray drift.

66. Whilst it is highly likely that the alternative deposition rates for plant protection are over conservative, even if they are accepted at face value, they are not exceeded by actual deposition even at a point directly adjacent to the sprayed clearing (Hewitt 2011). The highly conservative, over-protective value derived by Weller (2011) at 4.1 g/ha compares with the predicted deposition rate of 1.3 g/ha at ground level immediately adjacent to the sprayed clearing.

67. Claimed enhancement of toxicity of formulated glyphosate (Weller 2011) by the addition of surfactant adjuvant to the spray mix is not founded on evidence. The most sensitive end of the sensitivity distribution is unaffected by the adjuvant since the most sensitive plants die with or without the additional surfactant directly under the spray.

68. Other factors claimed to add to toxicity of the glyphosate formulation sprays in the field occur mainly at full application rates and are, therefore, irrelevant to areas outside the intended spray zones. Examination of various studies, including a field study directly addressing spray drift effects of glyphosate on wild plants, give close consensus that deposition at 11 g/ha causes no adverse effect.

69. Continued claims that there is a secret component to the sprayed formulations used in Colombia have no foundation. Claims that dioxin was a component are demonstrably absurd. Claims that the toxic properties of halogenated dioxins could apply to Colombia's formulated sprays are outrageous.

70. Assertions of extra vulnerability of both human populations and organisms in the environment are exactly that, assertions. All of the available scientific evidence shows no extra vulnerability. Species sensitivity distributions demonstrate that local tropical species show similar or lower sensitivity than temperate ones. The presence of high biodiversity in local ecosystems was fully accounted for in risk assessments conducted in Dobson (2010).

71. Whilst the response from Ecuador highlights international and national systems which apply uncertainty factor to assessed risk in some circumstances, they provide no argument for their application in the specific case of coca control with glyphosate. Detailed consideration shows that uncertainty factors would not be applied and that there is no scientific justification for suggesting 'precautionary' buffer zones.

Stuart Dobson

7th December 2011

Stuart Dobson
7/12/2011

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Annex 5

A. Tait, International Mapping Associates, *Statistical Summary of Data for Spray Events Within the Relevant Area Along the Border between Colombia and Ecuador*, December 2011

Statistical Summary of Data for Spray Events Within the Relevant Area Along the Border between Colombia and Ecuador

Alex Tait
International Mapping Associates, Inc.

1. Introduction

1.1 This report provides a statistical summary of spray events near the Colombia-Ecuador border in the period of 2000 to 2007 that were part of the Colombian Government's anti-narcotics effort known as the *Program for the Eradication of Illicit Crops by Aerial Spraying with Glyphosate* (PECIG). Planes flying for this program used on-board electronic data recorders to capture detailed information about their flight and about their aerial spraying of herbicide.

1.2 The spray event data analyzed in this report come from the electronic datasets that were filed by Ecuador with the Court as part of their Reply in these proceedings. The datasets were compiled by the U.S. Department of State from the output of the on-board electronic data recorders and were then provided by the Department of State to the Government of Ecuador.

1.3 The data consists primarily of a set of geographic information system (GIS) files in standard shapefile format.[1] The shapefiles include the geographic extent of each spray event as a line and a linked table that contains values for specific attributes for each line such as altitude, airplane speed, and application rate. It is important to note that the attributes recorded for spray events (also referred to as a spray lines) are not completely consistent year to year. The U.S. Department of State provided a reference file describing the attributes recorded in each year. As described in more detail below, in some cases the units used to record the data changed and in other cases there was a change in the variable itself.

2. Spray Events in the Relevant Area

2.1 International Mapping processed the entire set of spray event shapefiles that were included in the datasets compiled by the U.S. Department of State and submitted to the Court in Ecuador's Reply, this included files for the years 2000 to 2009 and events within 20km of the border. All data were placed in ESRI's ArcGIS software to evaluate geographic location and to assess the attribute values associated with each spray line. The analysis of all the spray event records provided to Ecuador by the Department of State (events within 20km of the border) showed that the datasets contained some erroneous records and also contained numerous zero values for attributes. These and other aspects of the Department of State data are discussed below.

2.2 From the total dataset we then selected for further analysis those lines of which any portion are within one kilometer of the Colombia-Ecuador border ("the relevant area"). The reasons why Colombia defined this area for analysis are described in detail in the text of the Rejoinder.[2]

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[1] The shapefile format is a standard developed by ESRI for ArcView and ArcGIS software and is widely used format for transferring geographic data.
[2] Colombia Rejoinder, Vol. I, Chap. 2.

2.3 The border between Colombia and Ecuador used for this purpose was based on 1:100,000, 1:50,000 and 1:25,000 printed maps and digital mapping data provided by the Instituto Geográfico Agustín Codazzi (IGAC) of the Government of Colombia. We were instructed that, under the relevant treaty between Ecuador and Colombia, the border between the two States is defined simply as "the river" without further specification. However, because there is the necessity for a single-line border in our geographic analysis, we calculated a line equidistant from the banks of the river on each side to define the border. This newly derived course for the Colombia-Ecuador border varies only in a few small sections from the course of the border displayed on Ecuador 1:50,000 series topographic maps. Because the Government of Ecuador in its geographical analysis of spray events used a border derived from its own 1:50,000 and 1:25,000 series topographical maps,[3] there are likely only small differences in the border used by Ecuador and that used in this analysis.

2.4 Table 1 provides a summary of the number of lines by year for the relevant area of one kilometer from the border. There were no spray events in the relevant area for the years 2008 and 2009. The total number of spray events in the relevant area for the period of 2000 to 2007 was 4,128.

Table 1. Summary of spray events in the relevant area

Events	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	All years
Within 1km of the Col-Ecu border (minus duplicates)	17	184	2,268	156	528	589	177	209	0	0	**4,128**
Duplicates within 1km of the border	0	0	32	0	0	0	0	0	0	0	**32**

3. Evaluation of Department of State Spray Event Data

3.1 In processing the full set of spray events from the Department of State (those within 20km of the border) we discovered compilation errors that resulted in duplicate spray lines in three of the years: 2001, 2002 and 2006. These lines shared the exact same geography and all attributes except in some cases for minor differences in part of the flight code (LOG, ASCIINAME or FILE_NAME attribute), the segment number or the time stamp.

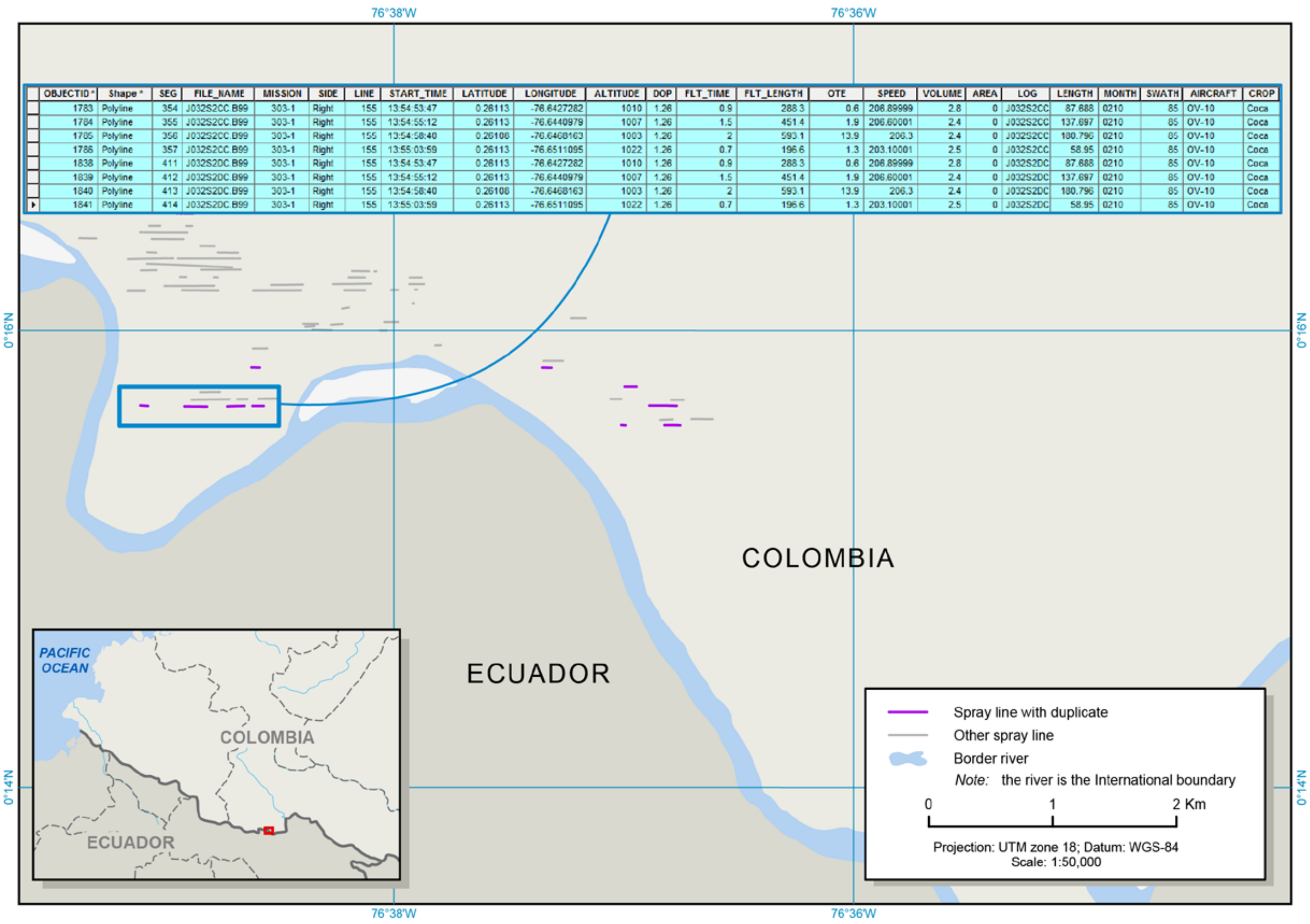
3.2 In the complete Department of State dataset, there are 300 lines with duplicates and 93 lines with triplicates in 2001, 1481 lines with duplicates in 2002, and 35 lines with duplicates in 2006. In the relevant area of within one kilometer of the border there were 32 duplicate lines in 2002 and no lines with duplicates or

[3] Ecuador Reply, Vol. II, Annex 1, Hansman and Mena, p. 7.

triplicates in 2001 or 2006 (see summary of duplicates in Table 1). Figure 1 shows an example of four pairs of duplicate lines within the relevant area in 2002, and their corresponding attributes. In this case, the pairs of lines sharing identical geography have every attribute the same except for the segment number. The 32 duplicate lines within the relevant area in 2002 were removed from the data for the purposes of our statistical analysis and summaries.

3.3 In addition to the duplicates and triplicates in the dataset, we also found that there were 7 lines in 2001 that had no geography in the GIS. They were present as features in the attribute table for 2001 but had no corresponding line. Running a "calculate length of line" function in the GIS software resulted in a value of zero. Because these lines lack geography, it is not known whether or not they are in the relevant area of within one kilometer of the border and they have been excluded from our analysis.

3.4 Several of the attribute columns in the data tables had values of zero for some of the spray event records. Most pertinent to this statistical summary, there were zero values recorded for some spray event records for speed and for spray rate. The individual sections and tables below set out summaries of the number of records with zero values.



OBJECTID *	Shape *	SEG	FILE_NAME	MISSION	SIDE	LINE	START_TIME	LATITUDE	LONGITUDE	ALTITUDE	DOP	FLT_TIME	FLT_LENGTH	OTE	SPEED	VOLUME	AREA	LOG	LENGTH	MONTH	SWATH	AIRCRAFT	CROP
1783	Polyline	354	J032S2CC.B99	303-1	Right	155	13:54:53:47	0.26113	-76.6427282	1010	1.26	0.9	288.3	0.6	206.89999	2.8	0	J032S2CC	87.688	0210	85	OV-10	Coca
1784	Polyline	355	J032S2CC.B99	303-1	Right	155	13:54:55:12	0.26113	-76.6440979	1007	1.26	1.5	451.4	1.9	206.60001	2.4	0	J032S2CC	137.697	0210	85	OV-10	Coca
1785	Polyline	356	J032S2CC.B99	303-1	Right	155	13:54:58:40	0.26108	-76.6468163	1003	1.26	2	593.1	13.9	206.3	2.4	0	J032S2CC	180.796	0210	85	OV-10	Coca
1786	Polyline	357	J032S2CC.B99	303-1	Right	155	13:55:03:59	0.26113	-76.6511095	1022	1.26	0.7	196.6	1.3	203.10001	2.5	0	J032S2CC	58.95	0210	85	OV-10	Coca
1838	Polyline	411	J032S2DC.B99	303-1	Right	155	13:54:53:47	0.26113	-76.6427282	1010	1.26	0.9	288.3	0.6	206.89999	2.8	0	J032S2DC	87.688	0210	85	OV-10	Coca
1839	Polyline	412	J032S2DC.B99	303-1	Right	155	13:54:55:12	0.26113	-76.6440979	1007	1.26	1.5	451.4	1.9	206.60001	2.4	0	J032S2DC	137.697	0210	85	OV-10	Coca
1840	Polyline	413	J032S2DC.B99	303-1	Right	155	13:54:58:40	0.26108	-76.6468163	1003	1.26	2	593.1	13.9	206.3	2.4	0	J032S2DC	180.796	0210	85	OV-10	Coca
1841	Polyline	414	J032S2DC.B99	303-1	Right	155	13:55:03:59	0.26113	-76.6511095	1022	1.26	0.7	196.6	1.3	203.10001	2.5	0	J032S2DC	58.95	0210	85	OV-10	Coca

Figure 1. Sample duplicate spray events within the relevant area, 2002

3.5 The length column in the attribute table for the year 2001 in the full Department of State dataset contains apparently erroneous values for spray line length. Analysis of these lines showed that the underlying cause of these errors appears to be that in the transfer of data from the plane's recording device to the compiled GIS files delivered by the Department of State, there was a decimal point error in translating numbers. In addition, it appears that the length values were truncated and rounded at only three decimal places. As a result, nonsensical lengths of less than one meter were created for the affected spray lines. In order to correct this error, we calculated line length from the actual geometry of the lines. Table 2 shows a comparison of the original and calculated length attributes columns for example records from the full dataset.

3.6 In all cases, the length of the line calculated from the actual geometry of the lines accorded with the hypothesized cause for the apparently erroneous spray line lengths due to decimal point errors and truncation. The corrected values derived from the actual geometry of the lines were substituted for the original values for the purposes of our statistical analysis.

Table 2. Sample spray event data from 2001 showing erroneous length records

OBJECTID*	Shape*	LINE_ID	TIME	ALTITUDE	XTRACK	MPH	HEADING	S	SPRAY_RATE	DOP	SV	USED	DF	STNID	ASCIINAME	LENGTH	Length_Check
1	Polyline	001204	07:39:21.18	2	-10.13	169.99001	1.8	1	0	0.8	12	11	0	-1	I011ebac	0.003	290.54047
2	Polyline	001245	07:39:58.89	1.9	-7.76	169.99001	1.79	1	0	0.8	12	11	0	-1	I011ebac	0.001	99.00724
3	Polyline	001256	07:40:06.83	1.8	15.17	172.81	1.79	1	0	0.8	10	11	0	-1	I011ebac	0.001	105.36766
4	Polyline	001264	07:40:11.74	1.8	35.59	174.7	1.79	1	0	0.8	10	11	0	-1	I011ebac	0.002	246.64302
5	Polyline	001286	07:40:30.51	1.7	25.23	165.10001	1.8	1	0	0.8	12	11	0	-1	I011ebac	0.001	139.25467
6	Polyline	001295	07:40:36.92	1.7	12.11	161.47	1.8	1	0	0.8	12	11	0	-1	I011ebac	0.001	165.46054
7	Polyline	001518	07:44:16.64	1.7	11.02	167.73	0.1	1	0	0.8	12	11	0	-1	I011ebac	0.002	238.18127
8	Polyline	001548	07:44:43.92	1.8	41.58	161.45	0	1	0	0.8	12	11	0	-1	I011ebac	0.002	194.96626
9	Polyline	001582	07:45:15.02	1.9	53.65	157.63	3.6	1	0	0.8	12	11	0	-1	I011ebac	0.002	219.42143
10	Polyline	001592	07:45:21.63	1.9	-0.6	156.3	2.4	1	0	0.8	12	11	0	-1	I011ebac	0.002	178.36406
11	Polyline	001801	07:48:37.66	1.9	13.43	176.71001	1.8	1	0	0.8	12	11	0	-1	I011ebac	0.004	408.0596
12	Polyline	001841	07:49:15.20	1.8	-13.41	172.12	1.8	1	0	0.8	12	11	0	-1	I011ebac	0.001	154.00258
13	Polyline	001862	07:49:33.00	1.8	12.14	174.08	1.8	1	0	0.8	12	11	0	-1	I011ebac	0.003	277.76117
14	Polyline	001873	07:49:41.12	1.7	8.18	173.94	1.79	1	0	0.8	12	11	0	-1	I011ebac	0.001	77.516106
15	Polyline	001883	07:49:47.63	1.7	-0.82	172.84	1.82	1	0	0.8	12	11	0	-1	I011ebac	0.001	95.99572
16	Polyline	001889	07:49:51.07	1.7	-21.18	172.89999	1.81	1	0	0.8	12	11	0	-1	I011ebac	0.001	136.3725
17	Polyline	001956	07:50:54.99	1.6	-17.59	168.45	1.82	1	0	0.8	12	11	0	-1	I011ebac	0.002	223.37579
18	Polyline	002011	07:51:47.00	1.6	-191.2	163.53	6.9	1	0	0.8	12	11	0	-1	I011ebac	0.001	105.90755
19	Polyline	002082	07:52:54.95	1.7	55.52	166.59	0.8	1	0	0.8	12	11	0	-1	I011ebac	0.001	112.54094
20	Polyline	002089	07:52:59.72	1.7	49.48	167.24001	0.2	1	0	0.8	12	11	0	-1	I011ebac	0.002	172.59416
21	Polyline	002159	07:54:06.47	1.8	15.53	173.55	0.9	1	0	0.8	12	11	0	-1	I011ebac	0.004	440.92737
22	Polyline	002378	07:57:25.35	1.9	21.64	184.42999	1.79	1	0	0.8	12	11	0	-1	I011ebac	0.004	456.29672
23	Polyline	002441	07:58:25.49	1.7	-25.51	170.89999	1.8	1	0	0.8	12	11	0	-1	I011ebac	0.001	94.392937
24	Polyline	002450	07:58:31.66	1.7	-13.91	171.31	1.78	1	0	0.8	12	11	0	-1	I011ebac	0.002	179.77718
25	Polyline	002458	07:58:37.24	1.7	2.59	172.50999	1.79	1	0	0.8	12	11	0	-1	I011ebac	0.001	109.92994
26	Polyline	002938	08:06:18.13	1.8	15.86	173.64999	1.8	1	0	0.8	12	11	0	-1	I011ebac	0.001	82.420334

4. Speed

4.1 We analyzed the spray lines within the relevant area by speed for defined ranges: greater than 333 km/h (207 mph); between 333 km/h (207 mph) and 341 km/h (212 mph); and greater than 341 km/h (212 mph). A summary of the counts of spray lines within the relevant area for each year and for the defined ranges of speed is shown in Table 3.

4.2 As noted above there were some spray events with recorded values of zero for the speed attribute. In 2001 there were 13 such records within the relevant area and in

2002 there were 198. These 211 spray events were discarded for the summary statistics resulting in a total of 3,917 spray events with usable speed records within the relevant area.

Table 3. Speed recorded for spray events within 1 km of border

For 2000-2007, no spray events occurred in 2008 or 2009

Number of events	2000	2001	2002	2003	2004	2005	2006	2007	All years
Total by year	**17**	**171**	**2,070**	**156**	**528**	**589**	**177**	**209**	**3,917**
Speed below 333 km/h (207 mph)	13	150	1,867	156	528	461	177	209	**3,561**
Speed above 333 km/h (207 mph)	4	21	203	0	0	128	0	0	**356**
Speed between 333 km/h and 341 km/h	4	12	95	0	0	78	0	0	**189**
Speed above 341 km/h (212 mph)	0	9	108	0	0	50	0	0	**167**
Highest speed (mph)	209.72	224.04	242.90	185.90	186.40	224.60	193.90	204.30	**242.90**

4.3 Counts of spray events with speeds above and below the 333 km/h and 341 km/h levels were tallied as well as events between those two speeds.

4.4 The top ten fastest speeds recorded for spray events in each year from 2000 to 2007 are shown in Table 4 along with each event's height above ground and spray line length.

4.5 At the request of the Government of Colombia, we evaluated all the spray lines with a speed over 333 km/h (207 mph) to determine which of these was the closest to the border. Using the measurement tools in ESRI's ArcGIS software, and a heads-up visual proximity assessment, the spray line (over 333 km/h) closest to the Colombia-Ecuador border for each year with spray events over 333 km/h was identified. More than one spray line was selected when several were about the same distance away from the border.

4.6 The two extreme spray lines for each year, i.e., the highest speed within the relevant area from Table 4 and the closest to the border of those over 333 km/h as determined above, were given to Dr. Andrew Hewitt drift modeling. These selected spray events and their key attributes are shown in Table 5.

Table 4. Ten highest speed spray events within 1 km of border, by year

For 2000-2007, no spray events occurred in 2008 or 2009

Length for 2001 spray events was calculated from the geometry of the lines, length attribute was invalid

2000	Speed (mph)	Height (meters)	Length (meters)
1	209.72	42.76	278.39
2	209.54	41.52	174.82
3	209.45	51.33	159.31
4	209.06	51.76	73.66
5	206.30	47.93	85.06
6	205.85	48.49	111.83
7	180.05	60.18	217.44
8	169.34	66.46	58.57
9	167.56	61.27	161.52
10	166.80	117.55	212.96

2001	Speed (mph)	Height (meters)	Length (meters)
1	224.04	47.76	377.26
2	222.99	47.64	129.97
3	222.88	48.50	158.98
4	220.57	51.81	142.21
5	218.71	43.12	285.98
6	215.48	35.42	180.67
7	212.96	39.81	140.84
8	212.61	41.20	310.94
9	211.95	38.72	61.32
10	211.86	43.92	90.53

2002	Speed (mph)	Height (meters)	Length (meters)
1	242.90	50.39	74.44
2	242.80	47.92	94.64
3	238.70	49.97	110.54
4	226.50	43.85	10.31
5	224.80	48.71	64.49
6	224.40	57.72	688.86
7	224.40	56.85	118.86
8	224.40	47.72	466.88
9	224.10	46.21	26.89
10	223.70	50.74	86.58

2003	Speed (mph)	Height (meters)	Length (meters)
1	185.90	51.84	249.88
2	183.80	73.36	117.27
3	181.60	43.07	81.45
4	181.20	50.01	89.33
5	181.10	48.91	32.44
6	180.90	53.32	129.68
7	180.70	61.60	469.76
8	180.60	36.60	88.94
9	180.40	48.01	105.11
10	180.00	45.41	153.12

2004	Speed (mph)	Height (meters)	Length (meters)
1	186.40	52.45	67.37
2	185.30	48.45	54.41
3	185.10	40.93	55.72
4	185.00	54.96	431.18
5	185.00	53.40	49.70
6	185.00	44.97	472.97
7	184.50	33.05	61.90
8	184.00	40.95	404.02
9	183.80	44.19	32.91
10	183.40	43.97	98.10

2005	Speed (mph)	Height (meters)	Length (meters)
1	224.60	43.97	143.46
2	224.60	30.13	155.83
3	224.00	44.97	182.08
4	223.60	37.83	114.61
5	223.40	42.77	29.02
6	223.30	34.06	116.15
7	222.10	63.41	124.42
8	221.40	64.18	15.93
9	220.80	41.51	144.26
10	220.20	53.36	156.58

2006	Speed (mph)	Height (meters)	Length (meters)
1	193.90	41.90	65.06
2	191.10	38.38	102.73
3	189.50	43.55	270.96
4	189.10	32.00	118.37
5	187.60	41.45	243.24
6	187.40	25.74	192.81
7	186.40	41.58	33.34
8	186.00	33.76	49.90
9	185.90	29.77	133.11
10	185.70	54.36	326.47

2007	Speed (mph)	Height (meters)	Length (meters)
1	204.30	45.91	103.35
2	188.90	50.38	166.36
3	188.40	48.55	64.05
4	186.10	38.72	6.83
5	185.90	44.53	57.92
6	185.00	43.61	172.59
7	184.10	62.10	51.24
8	183.90	52.32	91.91
9	183.70	52.67	16.26
10	183.20	42.68	192.65

Table 5. Spray events with speeds Over 333 km/h: fastest and closest to the border

For 2000, 2001, 2002, and 2005; no spray events exceeded 333 km/h in 2003, 2004, 2006 or 2007.

		Spray Line Attributes									
Year	**Type**	**Ground Speed (mph)**	**Distance to Border (Metres)**	**Line ID/ SEG**	**ASCII_Name/ File Name**	**Date**	**Height above ground level (Metres)**	**Application rate**	**Appl. rate units**	**Length (Metres)**	**Aircraft**
2000	Fastest	209.720	1225	2212	a230r4cc	23-Jan-00	42.760	206.43	gallons/minute	278.391	OV-10
2000	Closest	209.450	1153	2119	a230tnbc	23-Jan-00	51.330	192.83	gallons/minute	159.305	OV-10
2001	Fastest	224.040	979	1977	c131q5ac	13-Mar-01	47.75	216.540	gallons/minute	377.26	OV-10
2001	Closest	211.690	728	1785	c131q5ac	13-Mar-01	37.41	5.700	gallons/minute	137.09	OV-10
2002	Fastet	242.90	807	391	I062QGAC.B99	6-Sep-02	50.4	2.700	gallons/acre	74.439	OV-10
2002	Closest	207.10	153	132	J102R9AC.B99	8-Oct-02	40.71	0.000	gallons/acre	145.673	OV-10
2005	Highest	224.60	683	4188	K235TIAC.B99	23-Nov-05	43.97	5.900	gallons/hectare	143.455	OV-10
2005	Highest	224.60	638	4358	K235X{AC.B99	23-Nov-05	30.13	6.200	gallons/hectare	155.83	OV-10
2005	Closest	211.70	277	4250	K235VSAC.B99	23-Nov-05	50.68	6.700	gallons/hectare	112.696	OV-10

5. Height Above Ground

5.1 Data for the spray events include altitude above mean sea level for all 4,128 events within the relevant area. We were informed that the on-plane devices record the airplane's altitude at the first press of the spray release button and therefore at the beginning of each spray line. To determine the height above ground level of this point for each event we used a digital elevation model derived from data from the Shuttle Radar Topography Mission (SRTM). The elevation data was provided by the U.S Department of State and is at a 30-meter cell size.

5.2 In order to determine the actual altitude above ground level of the start points of each spray event, the SRTM digital elevation model was placed in ArcGIS software. The starting point for each of the spray events was derived from the event lines feature class in the original Department of State dataset to create a points feature class.

5.3 Thereafter, using the *"Add Surface Information"* function with its default *"linear"* setting, ArcGIS determined the approximate ground level elevation at each of the start points.[4] The linear mode estimates the ground level elevation value from the plane defined by the TIN (triangulated irregular network) triangle that contains the X/Y location of the query point. This results in a value that can differ from the cell value directly below the point but better takes into account the actual characteristics of the terrain. Once determined, the ground level elevation was subtracted from the altitude resulting in a value for above ground level elevation for the airplane and the spray event.

5.4 As noted in the attribute descriptions provided by the Department of State, there were mixed units for the altitude attribute in 2001 and 2004. Some altitudes are recorded in feet and some in meters. Because of this, both years were discarded for the analysis performed for the purposes of the Government of Ecuador's Reply.[5] However, when the recorded altitude values in the spray data are

[4] ESRI ArcGIS Online Help Library, last accessed 8 December 2011, http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html.
[5] Ecuador Reply, Vol. II, Annex 1, Hansman and Mena, p. 6.

processed with derived ground level values to create an above ground level height and are then assumed to all be in meters and then all be in feet, a split appears between those values that were recorded in one unit or the other.

5.5 For the complete set of records obtained from the Department of State, the split becomes apparent when the calculated above ground level values are compared to a reasonable range of values. For our evaluation of height above ground level, we assumed that a range of reasonable heights was from 0 meters to 200 meters. The analysis performed by the Government of Ecuador supports this range for reasonable heights, only 2 spray events out of 92,644 they checked showed a value over 200 meters.[6]

5.6 Once the height above ground level values are sorted and evaluated in relation to reasonable heights, the units used to record altitude for spray events in the relevant area in 2001 and 2004 become clear.

5.7 In this regard, all altitude data for spray events in 2001 in the relevant area appeared to be in feet, not meters. Table 6 sets out a comparison of height above ground level values resulting from a calculation using each unit, with the individual entries in the table ranked from largest to smallest on the basis of the column containing the values assuming meters. If it is assumed that the altitude values are meters, the values start at 1117 meters, well beyond the reasonable range. Following the ranked data from highest (1117m) to lowest (345.62m), it can be seen that assuming meters for altitude does not result in a reasonable range of height above ground level values. By contrast, if it is assumed that altitude was in feet, this results in reasonable values, ranging from 29.58 to 113.83 meters for all data lines.

[6] Ecuador Reply, Vol. II, Annex 1, Hansman and Mena, Annex 1, p. 7

Table 6. Height above ground level assuming meters and feet, 2001

For spray events within 1 km of the border

OBJECTID	LINE_ID	TIME_	ALTITUDE	ASCIINAME	LENGTH	MONTH_	SWATH	TYPE	AIRCRAFT	LOG	AGL in meters assuming units = meters	AGL in meters assuming units = feet
43	1956	52:12.2	1443	l151k1bc	0.002	112	50	Coca	T-65	l151k1bc	1116.995849	113.827629
18	2010	52:07.7	1393	l151efbc	0.001	112	50	Coca	T-65	l151efbc	1081.172851	112.764404
49	2184	55:36.5	1376	l151k1bc	0.005	112	50	Coca	T-65	l151k1bc	1039.902954	83.312812
33	2490	58:48.0	1361	l151efbc	0.003	112	50	Coca	T-65	l151efbc	1037.978515	91.816421
53	2688	02:57.4	1388	l151k1bc	0.001	112	50	Coca	T-65	l151k1bc	1037.525756	72.593315
47	2076	54:00.6	1365	l151k1bc	0	112	50	Coca	T-65	l151k1bc	1036.404418	87.461494
50	2285	57:11.2	1346	l151k1bc	0.005	112	50	Coca	T-65	l151k1bc	1018.58435	82.850166
45	2017	53:07.8	1349	l151k1bc	0.001	112	50	Coca	T-65	l151k1bc	1014.708679	76.88887
22	2079	53:04.4	1343	l151efbc	0.001	112	50	Coca	T-65	l151efbc	1007.248596	73.599975
19	2015	52:09.2	1334	l151efbc	0.001	112	50	Coca	T-65	l151efbc	998.107055	70.715232
30	2368	57:09.7	1320	l151efbc	0.001	112	50	Coca	T-65	l151efbc	996.475097	78.815986
35	2651	00:51.7	1346	l151efbc	0.003	112	50	Coca	T-65	l151efbc	990.993225	55.258991
24	2143	53:59.8	1323	l151efbc	0.002	112	50	Coca	T-65	l151efbc	988.799194	69.054519
48	2084	54:05.2	1323	l151k1bc	0.001	112	50	Coca	T-65	l151k1bc	987.836853	68.09217
106	2264	48:01.3	1273	a071k#bc	0.002	101	50	Coca	T-65	a071k#bc	986.024597	101.039703
There were 184 total spray events for 2001, this table shows only highest and lowest as ranked by height above ground level in meters, assuming altitude units are meters.												
81	1839	14:22.0	885.400024	c131umac	0.001	103	85	Coca	OV-10	c131umac	654.247314	38.720493
85	2071	17:31.5	879.599975	c131zuac	0.002	103	85	Coca	OV-10	c131zuac	651.677368	40.182731
70	1779	14:22.0	878.299987	c131q5ac	0.002	103	85	Coca	OV-10	c131q5ac	650.873046	40.282157
71	1785	14:25.2	872.799987	c131q5ac	0.001	103	85	Coca	OV-10	c131q5ac	644.183105	37.415779
173			700		0.001	108	85	Coca	OV-10	H131USCC	587.273986	100.636596
176			674		0.002	108	85	Coca	OV-10	H131ZLCC	575.475463	106.913177
175			751		0.001	108	85	Coca	OV-10	H131USCC	564.795104	42.702705
172			660		0.001	108	85	Coca	OV-10	H131USCC	559.140869	100.311309
174			732		0.002	108	85	Coca	OV-10	H131USCC	543.134338	34.250637
184			519		0.001	108	85	Coca	OV-10	H241Q$AC	424.262908	63.456027
181			482		0.001	108	85	Coca	OV-10	H221ZMAC	386.759887	51.67527
178			474		0.001	108	85	Coca	OV-10	H221S9AC	379.298065	49.775032
182			472		0.003	108	85	Coca	OV-10	H221ZMAC	366.051452	37.918811
179			461		0.001	108	85	Coca	OV-10	H221S9AC	364.76358	44.278087
177			450		0.001	108	85	Coca	OV-10	H221S9AC	352.495208	39.656887
180			445		0.001	108	85	Coca	OV-10	H221S9AC	348.518432	39.156089
183			443		0.001	108	85	Coca	OV-10	H221ZMAC	345.615783	37.643829

Note: not all attribute columns are shown for these spray events and not all spray events are shown for this year.

5.8 Table 7 shows a similar evaluation of height above ground level calculations for the spray lines from 2004, with an assumption of altitude units as meters and a separate assumption of altitude units as feet. Again, the table is sorted by the calculated height above ground level assuming meters, from highest to lowest. The division between lines recorded in one unit of measurement and lines recorded in the other unit is apparent where values in the reasonable range end for feet, and then begin for meters. The ranges for height above ground level, after splitting the spray events at the line shown in the table, are from 24.01 to 138.28 meters for events with altitude in meters and (after conversion) from 15.85 to 57.78 meters for those events with altitude recorded in feet.

Table 7. Height above ground level assuming meters and feet, 2004

For spray events within 1 km of the border

OBJECTID	SEG	FILE_NAME	LINE	START_TIME	ALTITUDE	LENGTH	MONTH_	SWATH	AIRCRAFT	AGL in meters assuming altitude units = meters	AGL in meters assuming altitude units = feet
89	4306	L244A1AC.B01	27	8:06:01:50	1472	7.581	412	50	T-65	1061.301391	37.972404
185	4549	L244EDAC.B99	24	13:02:28:03	1471	13.491	412	50	T-65	1061.271972	38.638275
90	4307	L244A1AC.B01	27	8:06:01:80	1469	75.777	412	50	T-65	1057.714477	36.471096
186	4550	L244EDAC.B99	24	13:02:28:43	1469	223.248	412	50	T-65	1056.534545	35.291141
91	4308	L244A1AC.B01	27	8:06:02:90	1463	15.165	412	50	T-65	1053.177124	36.104988
187	4551	L244EDAC.B99	24	13:02:31:32	1463	23.514	412	50	T-65	1049.988647	32.916496

There were 528 total spray events for 2004, this table shows only highest and lowest as ranked by height above ground level in meters (assuming altitude units are meters) and a section showing the apparent break in units from meters to feet.

OBJECTID	SEG	FILE_NAME	LINE	START_TIME	ALTITUDE	LENGTH	MONTH_	SWATH	AIRCRAFT	AGL in meters assuming altitude units = meters	AGL in meters assuming altitude units = feet
43	3639	L204EFAC.B99	26	19:15:59:75	1002	18.411	412	50	T-65	735.049011	38.462322
40	3620	L204EFAC.B99	24	19:13:20:54	1000	19.082	412	50	T-65	732.984252	37.787933
14	3491	L204A!AC.B01	25	14:13:15:40	1005	79.536	412	50	T-65	732	33.327724
44	3640	L204EFAC.B99	26	19:16:00:10	999	50.172	412	50	T-65	731.662475	37.161376
45	3641	L204EFAC.B99	26	19:16:00:84	993	9.776	412	50	T-65	724.915039	34.585124
37	3614	L204EFAC.B99	22	19:11:48:20	996	7.148	412	50	T-65	724.868347	32.452816
36	3613	L204EFAC.B99	22	19:11:44:96	994	214.466	412	50	T-65	722.949157	31.92406
38	3618	L204EFAC.B99	24	19:13:07:39	993	119.156	412	50	T-65	711.859252	21.529348
39	3619	L204EFAC.B99	24	19:13:09:12	981	11.024	412	50	T-65	708.202819	26.215276
528	135	D0240QBC.B99	1	23:37:13:14	231	7.147	404	85	AT802	138.28096	-22.309381
436	281	D0442~AC.B99	29	22:47:56:80	155	382.569	404	85	AT802	63.862548	-43.892875
449	309	D0442~AC.B99	49	22:58:32:40	162	94.535	404	85	AT802	63.559715	-49.062084
446	300	D0442~AC.B99	44	22:55:11:10	150	55.251	404	85	AT802	60.769042	-43.510402

There were 528 total spray events for 2004, this table shows only highest and lowest as ranked by height above ground level in meters (assuming altitude units are meters) and a section showing the apparent break in units from meters to feet.

OBJECTID	SEG	FILE_NAME	LINE	START_TIME	ALTITUDE	LENGTH	MONTH_	SWATH	AIRCRAFT	AGL in meters assuming altitude units = meters	AGL in meters assuming altitude units = feet
256	151	D2441YAC.B99	2	20:52:12:55	96	174.507	404	85	AT802	32.584884	-34.153961
504	523	D0440QAC.B99	22	22:44:45:74	139	108.125	404	85	AT802	32.346664	-64.285621
333	552	D2446OAC.B99	12	21:02:04:10	135	147.425	404	85	AT802	32.275421	-61.57608
338	593	D24406AC.B99	5	10:56:38:30	116	107.316	404	85	AT802	32.159748	-48.48302
298	365	D2442%AC.B99	7	10:57:02:43	107	65.958	404	85	AT802	32.123577	-42.262428
502	521	D0440QAC.B99	22	22:44:38:35	132	109.966	404	85	AT802	31.946905	-59.819007
257	152	D2441YAC.B99	2	20:52:26:28	100	327.795	404	85	AT802	31.633808	-37.885822
522	571	D0440QAC.B99	64	23:09:01:33	151	83.901	404	85	AT802	31.312511	-73.662132
294	361	D2442%AC.B99	7	10:56:50:83	107	160.035	404	85	AT802	31.203443	-43.182559
467	396	D04445AC.B99	21	12:44:36:64	137	498.769	404	85	AT802	30.19156	-65.050331
322	531	D2446OAC.B99	8	20:56:52:40	112	235.051	404	85	AT802	28.745672	-49.116313
280	218	D2441YAC.B99	10	21:02:04:98	134	90.429	404	85	AT802	28.668024	-64.488281
316	508	D2446OAC.B99	4	20:52:30:70	98	142.046	404	85	AT802	28.459028	-39.670207
355	773	D16406AC.B99	1	11:33:00:20	92	288.667	404	85	AT802	27.491956	-36.466102
339	594	D24406AC.B99	5	10:56:42:00	114	84.44	404	85	AT802	26.69621	-52.556167
346	608	D24406AC.B99	9	11:00:51:70	98	121.774	404	85	AT802	24.218799	-43.910434
317	509	D2446OAC.B99	4	20:52:35:50	98	112.25	404	85	AT802	24.01371	-44.115528

Note: not all attribute columns are shown for these spray events and not all spray events are shown for this year.

5.9 A summary of the counts of spray lines within the relevant area for each year and within defined ranges by height above ground level is shown in Table 8. Counts of spray events with heights above and below 50 meters and 77 meters were tallied as well as events between those two heights. The height of 50 meters was used as a threshold because it is the general height guideline set out in the Government of Colombia's Environmental Management Plan and the additional range of 50 to 77 meters represents a normal height for avoiding obstacles.

5.10 There were 3,550 spray events below 50 meters, 578 events 50 meters or above, and 51 events above 77 meters. The 51 events above 77 meters represent 1.2% of the total number of spray events within the relevant area. The spray events above 77 meters had speeds ranging from 134 to 172 mph.

Table 8. Height above ground level recorded for spray events within 1 km of border									
For 2000-2007, no spray events occurred in 2008 or 2009									
Number of events	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**All years**
Total by Year	**17**	**184**	**2268**	**156**	**528**	**589**	**177**	**209**	**4,128**
Height below 50 meters	4	72	2,008	115	473	532	162	184	**3,550**
Height 50 meters or above	13	112	260	41	55	57	15	25	**578**
Height 50m or above but below 77m	9	98	237	41	54	53	14	21	**527**
Height above 77 meters	4	14	23	0	1	4	1	4	**51**
Highest height above ground level, meters	160.26	113.83	139.22	73.36	138.28	107.87	86.94	122.16	**160.26**
Range of speeds for events above 77 meters, miles/hour	150.6 to 166.8	149.8 to 162.8	134.3 to 160.5	x	151.0	158.0 to 171.4	172.0	149.4 to 167.2	**134.3 to 172.0**

5.11 Similarly, the top ten heights above ground level recorded for spray events within the relevant area in each year from 2000 to 2007 are shown in Table 9 along with each event's speed and spray line length.

5.12 At the request of the Government of Colombia, we evaluated all the spray lines with a height above ground level over 77 meters to determine which of these was the closest to the border for each year. Using the measurement tools in ESRI's ArcGIS software, and a heads-up visual proximity assessment, the spray line over 77 meters that was closest to the Colombia-Ecuador border was identified for each year. More than one spray line was selected when several were about the same distance away from the border.

5.13 The two extreme spray lines for each year, i.e., the highest line above ground level within the relevant area from Table 9 and the line closest to the border of those over 77 meters as determined above, were given to Dr. Andrew Hewitt for drift modeling. The selected spray events and their key attributes are shown in Table 10.

Table 9. Ten highest above ground level spray events within 1 km of border, by year

For 2000-2007, no spray events occurred in 2008 or 2009

Length for 2001 spray events was calculated from the geometry of the lines, length attribute was invalid

2000	Height (meters)	Speed (mph)	Length (meters)
1	160.26	166.47	114.39
2	141.84	150.62	40.78
3	131.84	165.08	51.98
4	117.52	166.80	212.96
5	69.57	153.00	368.82
6	67.75	162.91	281.67
7	66.46	169.34	58.57
8	61.27	161.26	99.17
9	61.27	167.56	161.52
10	60.18	180.05	217.44

2001	Height (meters)	Speed (mph)	Length (meters)
1	113.83	162.83	223.19
2	112.76	155.97	72.84
3	106.91	0.00	180.56
4	101.04	154.28	210.93
5	100.64	0.00	100.58
6	100.31	0.00	60.46
7	93.66	158.10	200.94
8	92.77	160.57	122.52
9	91.82	149.84	278.08
10	91.16	152.49	222.68

2002	Height (meters)	Speed (mph)	Length (meters)
1	139.22	155.30	6.97
2	139.12	155.10	6.95
3	139.00	155.10	6.96
4	138.61	155.50	13.92
5	138.45	154.90	6.91
6	137.60	155.90	7.00
7	134.64	158.00	7.06
8	134.34	158.70	7.09
9	132.24	159.00	14.29
10	131.01	159.70	7.14

2003	Height (meters)	Speed (mph)	Length (meters)
1	73.36	183.80	117.27
2	65.75	177.50	526.51
3	64.02	173.90	7.79
4	62.90	174.00	70.15
5	61.60	180.70	469.76
6	61.52	171.60	23.07
7	59.12	171.80	43.55
8	57.51	174.10	7.81
9	57.49	173.40	209.73
10	57.16	171.70	135.76

2004	Height (meters)	Speed (mph)	Length (meters)
1	138.28	151.00	7.15
2	63.86	174.40	382.57
3	63.56	176.00	94.54
4	60.77	176.20	55.25
5	57.78	170.20	312.31
6	57.50	160.00	200.53
7	57.06	182.50	139.35
8	56.99	181.50	222.18
9	56.63	172.30	29.43
10	56.24	176.30	376.26

2005	Height (meters)	Speed (mph)	Length (meters)
1	107.87	171.40	78.47
2	101.02	166.50	80.56
3	95.62	158.00	226.77
4	83.46	165.70	80.31
5	73.42	182.20	80.25
6	67.75	157.90	68.73
7	67.29	174.00	57.10
8	66.67	176.30	148.49
9	66.57	169.20	41.81
10	66.12	177.20	174.67

2006	Height (meters)	Speed (mph)	Length (meters)
1	86.94	172.00	292.41
2	72.93	148.20	145.32
3	72.17	151.60	33.26
4	60.56	184.50	128.81
5	59.80	156.40	346.13
6	58.74	177.40	211.24
7	57.00	179.20	248.61
8	55.49	170.90	272.29
9	54.36	185.70	326.47
10	54.19	179.50	273.01

2007	Height (meters)	Speed (mph)	Length (meters)
1	122.16	160.60	269.94
2	107.30	149.40	12.78
3	106.47	167.20	317.53
4	77.41	163.40	70.54
5	70.97	179.80	625.06
6	69.66	177.20	294.92
7	66.70	169.90	80.09
8	62.10	184.10	51.24
9	59.12	165.30	696.00
10	58.21	149.30	228.16

Table 10. Spray events with heights over 77 meters: highest and closest to the border											
For 2000 to 2007, note there was only a single spray event over 77 meters in 2004 and 2006.											
		Spray Line Attributes									
Year	Type	Height above ground level (Metres)	Distance to Border (Metres)	Line ID/ SEG	ASCII_Name/ File Name	Date	Ground Speed (mph)	Application rate	Appl. rate units	Length (Metres)	Aircraft
2000	Highest	160.260	947	3143	i130kdac	13-Sep-00	166.470	87.230003	gallons/minute	114.385	T-65
2000	Closest	141.840	922	3667	i130kdac	13-Sep-00	150.620	86.82	gallons/minute	40.78	T-65
2001	Highest	113.83	674	1956	l151k1bc	15-Dec-01	162.830	81.800	gallons/minute	223.19	T-65
2001	Closest	112.76	571	2010	l151efbc	15-Dec-01	155.970	77.660	gallons/minute	72.85	T-65
2002	Highest	139.22	585	671	I222A#DC.B99	22-Sep-02	155.30	0.000	gallons/acre	6.966	T-65
2002	Closest	122.63	479	1058	I092JDAC.B99	9-Sep-02	151.00	2.300	gallons/acre	186.803	T-65
2004	Highest	138.28	209	135	D0240QBC	2-Apr-04	151.00	1.600	gallons/hectare	7.147	AT802
2005	Highest	107.87	704	13872	C155L~CC.B99	15-Mar-05	171.40	1.600	gallons/hectare	78.473	AT802
2005	Closest	95.62	464	13841	C155L~CC.B99	15-Mar-05	158.00	1.600	gallons/hectare	226.773	AT802
2006	Highest	87	1145	6857	L246JJAC.B01	24-Dec-06	172.00	5.900	gallons/hectare	292.409	T-65
2007	Highest	122.16	964	3519	A087DJAC.B99	8-Jan-07	160.60	7.000	gallons/hectare	269.942	T-65
2007	Closest	106.47	904	3522	A087DJAC.B99	8-Jan-07	167.20	6.900	gallons/hectare	317.531	T-65

6. Application Rate

6.1 A summary of the counts of spray lines within the relevant area for each year and within defined ranges by application rate (VOLUME attribute in GIS data tables) is shown in Table 11. Data for 2000 and 2001 are recorded as units per minute (not units per area as was done for the others years) and spray rate for 2004 was recorded in mixed units. No clear break was identifiable between those events recorded in gallons per acre and those recorded in gallons per hectare for 2004. As was done by Ecuador, we have excluded the years 2000, 2001 and 2004.[7]

[7] Ecuador Reply, Vol. I, Chap. 2, para. 2.141.

Table 11. Spray rate (volume) recorded for spray events within 1 km of border									
For 2000-2007, no spray events occurred in 2008 or 2009									
Excluding years 2000, 2001, and 2004									
Number of events	2000	2001	**2002**	**2003**	2004	**2005**	**2006**	**2007**	**All Years**
Total by year	x	x	**1,328**	**146**	x	**575**	**177**	**209**	**2,435**
Lower than 23.65 liters/hectare	x	x	755	96	x	418	127	126	1,522
Higher than 23.65 and lower than 24.83	x	x	332	34	x	92	42	52	552
Higher than 24.83 liters/hectare	x	x	241	16	x	65	8	31	361
Average liters/hectare	x	x	23.77	23.50	x	19.45	23.11	23.49	22.67
Highest value in liters/hectare	x	x	28.05	26.12	x	28.39	26.50	26.87	28.39

6.2 As noted above, there were spray events with values of zero recorded for the spray rate attribute in the years for which usable data were recorded. In 2002 there were 940 such records, in 2003 there were 10 and in 2005 there were 14. These 964 spray events were discarded for the summary statistics resulting in a total of 2,435 spray events with usable spray rate attribute records within the relevant area.

6.3 At the request of the Government of Colombia, we calculated summary values based on a threshold of 23.65 liters/hectare. Out of the total of 2,435 spray events within the relevant area, 1,522 were below the threshold of 23.65 liters/hectare and 913 were above this threshold. Of those that recorded a value above 23.65 liters/hectare, 552 or 60.5% were only above it by a margin of up to 5% (i.e. up to 24.83 liters/hectare). The highest value recorded for a spray event within the relevant area was 28.39 liters/hectare, exceeding the 23.65 liters/hectare threshold by 20.04%.

6.4 In analyzing the spray events for application rate, we noticed that for the year 2005, there is a distinct break between two sets of values for the VOLUME (application rate) attribute. It appears there are mixed units for this year for this attribute and that both gallons per acre or gallons per hectare have been recorded. Table 12 shows the spray lines above and below the apparent split between measurement units. The values of 1.9 and below were assumed to be in gallons per acre and the values of 5.4 and above were assumed to in gallons per hectare.

6.5 By way of comparison, in 2006 the range of values for volume was from 5.4 to 7.0, described by the Department of State document as gallons per hectare. In

2003, the range of values for volume is from 2.2 to 2.8, described by the Department of State document as gallons per acre.

6.6 This data, corrected for the assumed mixed units, was used in this analysis of spray rate. This is a more conservative approach as the values all increase when converted from gallons per acre to gallons per hectare.

Table 12. Volume (application rate) values, 2005.
For spray events within 1 km of the border.

OBJECTID	SEG	FILE_NAME	LINE	START_TIME	ALTITUDE	SPEED	VOLUME	AREA	LENGTH	MONTH_	SWATH	AIRCRAFT
37	4041	K225YGAC.B99	26	18:21:34:16	339	201.5	7.5000	0.4668	89.959	511	85	OV-10
89	4350	K235X{AC.B99	7	14:12:43:77	368	212.300003	7.4000	0.6984	134.478	511	85	OV-10
13	3707	K225I2AC.B99	25	13:21:30:90	336	201.800003	7.4000	0.514299	99.321	511	85	OV-10
38	4042	K225YGAC.B99	26	18:21:35:52	336	200.899993	7.3000	0.460799	89.184	511	85	OV-10
82	4341	K235X{AC.B99	3	14:08:53:76	362	212.399993	7.3000	0.383799	73.487	511	85	OV-10
28	3847	K225VSAC.B99	36	18:27:23:97	309	207.399993	7.3000	1.302099	251.986	511	85	OV-10
36	4040	K225YGAC.B99	26	18:21:25:79	345	205.300003	7.3000	0.313899	60.402	511	85	OV-10
62	4246	K235VSAC.B99	2	14:09:19:24	388	210.899993	7.2000	0.6545	126.915	511	85	OV-10
163	2606	J225ZHAC.B99	26	7:59:44:13	311	206.100006	7.1000	0.343699	66.393	510	85	OV-10
[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
There were 589 total spray events for 2004, this table shows only highest and lowest as ranked by volume (application rate) and a section showing the apparent break in units from gallons per acre to gallons per hectare												
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
588	784	L085NQAC.B99	12	23:42:14:90	107	164.800003	5.6000	0.3551	68.986	512	85	AT802
513	147	L025BVAC.B99	6	10:59:18:04	101	166.199996	5.6000	0.2079	39.897	512	85	AT802
515	149	L025BVAC.B99	6	10:59:20:69	105	166.399993	5.6000	0.485799	93.798	512	85	AT802
128	1066	J125VUCC.B99	30	13:38:37:50	335	204.699996	5.5000	0.331999	64.099	510	85	OV-10
158	2130	J225T$AC.B99	32	8:04:42:44	319	208.899993	5.4000	1.0599	204.659	510	85	OV-10
587	783	L085NQAC.B99	12	23:42:04:17	102	164.800003	5.4000	0.202299	39.414	512	85	AT802
225	11344	C115P5AC.B99	1	9:01:49:86	139	166.5	1.9000	2.9275	565.742	503	85	AT802
451	5694	I265VGBC.B99	4	19:59:59:30	318	205.699996	1.9000	0.0476	9.216	509	85	OV-10
186	10200	C115M0AC.B99	9	19:05:41:47	147	170.899993	1.8000	0.106899	20.961	503	85	AT802
442	5685	I265VGBC.B99	1	19:58:29:70	327	207.800003	1.8000	0.1444	27.886	509	85	OV-10
170	6288	C095K~CC.B99	9	23:50:55:00	144	162.300003	1.8000	3.5675	690.09	503	85	AT802
205	10642	[illegible]	12	19:08:16:65	141	168.899993	1.8000	0.36	69.547	503	85	AT802
There were 589 total spray events for 2004, this table shows only highest and lowest as ranked by volume (application rate) and a section showing the apparent break in units from gallons per acre to gallons per hectare												
149	1323	J135Y_AC.B99	23	18:43:37:20	307	203.399993	0.0000	0.0942	18.21	510	85	OV-10
144	1278	J135VMAC.B99	22	8:43:55:70	310	207.800003	0.0000	0.1444	27.918	510	85	OV-10
139	1264	J135VMAC.B99	22	8:43:35:10	307	204.100006	0.0000	0.094599	18.266	510	85	OV-10
143	1274	J135VMAC.B99	22	8:43:38:90	311	204	0.0000	0.094499	18.303	510	85	OV-10
138	1263	J135VMAC.B99	22	8:43:34:70	307	204.100006	0.0000	0.1419	27.37	510	85	OV-10
140	1265	J135VMAC.B99	22	8:43:35:50	307	204	0.0000	0.094499	18.238	510	85	OV-10
151	1325	J135Y_AC.B99	23	18:43:40:80	307	201.800003	0.0000	0.0935	18.023	510	85	OV-10
137	1259	J135VMAC.B99	22	8:43:33:80	307	203.899993	0.0000	0.094499	18.243	510	85	OV-10
135	1252	J135VMAC.B99	22	8:43:32:10	308	203.100006	0.0000	0.094099	18.363	510	85	OV-10
136	1258	J135VMAC.B99	22	8:43:33:50	307	203.800003	0.0000	0.0944	18.214	510	85	OV-10

Note: not all attribute columns are shown for these spray events and not all spray events are shown for this year.

6.7 An average value of liters/hectare was calculated for each of the years with valid records for application rate. The overall average for the years 2002-2003 and 2005-2007 is 22.67 liters/hectare.

6.8 The top ten spray events by highest application rate in each of the relevant years (2002, 2003, 2005, 2006, and 2007) are shown in Table 13 along with each event's value for speed and height above ground level. For those spray events with the same application rate, they are further sorted by distance to the border.

6.9 At the request of the Government of Colombia, we evaluated all the spray lines with an application rate over 23.65 liters/hectare to determine which of these was the closest to the border for each year. Using the measurement tools in ESRI's ArcGIS software, and a heads-up visual proximity assessment, the spray line (over 23.65 liters/hectare) that was closest to the Colombia-Ecuador border for each year was identified. More than one spray line was selected when several were about the same distance away from the border.

6.10 The two extreme spray lines for each year, i.e., the highest application rate within the relevant area from Table 13 and the line closest to the border of those over 23.65 liters/hectare as determined above, were given to Dr. Andrew Hewitt for drift modeling. The selected spray events along with their key attributes are shown in Table 14. In some cases where the highest application rate is exactly the same, or very nearly so, for multiple events, the spray event that is closest to the border has been chosen.

Table 13. Ten highest application rate spray events within 1 km of border, by year

For 2002, 2003, 2005, 2006 and 2007

2002	Application Rate (liters/ hectare)	Speed (mph)	Height (meters)	2003	Application Rate (liters/ hectare)	Speed (mph)	Height (meters)	2005	Application Rate (liters/ hectare)	Speed (mph)	Height (meters)
1	28.05	205.40	35.61	1	26.18	174.00	53.39	1	28.39	201.50	28.39
2	28.05	206.40	48.13	2	26.18	173.50	48.66	2	28.01	212.30	28.01
3	28.05	208.90	33.64	3	26.18	177.70	47.83	3	28.01	201.80	28.01
4	27.11	212.90	58.33	4	26.18	176.80	35.63	4	27.63	200.90	27.63
5	27.11	218.70	54.76	5	25.24	174.00	62.90	5	27.63	212.40	27.63
6	27.11	212.30	49.20	6	25.24	171.80	59.12	6	27.63	207.40	27.63
7	27.11	213.60	48.36	7	25.24	170.60	54.88	7	27.63	205.30	27.63
8	27.11	210.90	48.21	8	25.24	172.30	54.57	8	27.25	210.90	27.25
9	27.11	206.40	45.52	9	25.24	172.50	54.50	9	26.87	206.10	26.87
10	27.11	205.10	45.52	10	25.24	159.30	46.79	10	26.50	206.30	26.50

2006	Application Rate (liters/ hectare)	Speed (mph)	Height (meters)	2007	Application Rate (liters/ hectare)	Speed (mph)	Height (meters)
1	26.50	175.60	41.71	1	26.87	185.00	43.61
2	26.12	151.60	72.17	2	26.50	160.30	30.28
3	26.12	180.90	42.33	3	26.50	173.70	38.27
4	26.12	185.90	29.77	4	26.50	175.00	40.45
5	25.74	178.30	53.54	5	26.50	160.60	122.16
6	25.36	180.80	47.38	6	26.50	165.30	59.12
7	25.36	142.70	32.98	7	26.50	183.20	42.68
8	25.36	140.70	23.67	8	26.12	167.20	106.47
9	24.60	173.20	48.00	9	26.12	163.40	77.41
10	24.60	165.40	42.84	10	26.12	174.50	54.03

Table 14. Spray events with application rates over 23.65 liters/hectare: highest and closest to the border												
For 2002, 2003, 2005, 2006 and 2007												
For the years 2006 and 2007, events were chosen that are close to the highest (0.1 gallons per hectare less than the highest) but are closer to the border than the highest events.												
		Spray Line Attributes										
Year	Type	Appli-cation rate	Appl. rate units	Rate in liters/ hectare	Distance to Border (Metres)	Line ID/ SEG	ASCII_Name/ File Name	Date	Height above ground level (Metres)	Ground Speed (mph)	Length (Metres)	Aircraft
2002	Highest	3	gallons/acre	28.05	704	155	J032R9CC.B99	3-Oct-02	35.610	205.40	584.50	OV-10
2002	Closest	2.6	gallons/acre	24.31	52	697	I222A#EC.B99	22-Sep-02	41.000	156.50	196.08	T-65
2003	Highest	2.800	gallons/acre	26.18	71	319	B2432YAC.B99	24-Feb-03	53.390	174.00	98.54	AT802
2003	Closest	2.600	gallons/acre	24.31	12	54	B05356AC.B99	5-Feb-03	51.460	166.60	246.25	AT802
2005	Highest	7.500	gallons/hectare	28.39	710	4041	K225YGAC.B99	22-Nov-05	33.63	201.50	90.10	OV-10
2005	Closest	6.700	gallons/hectare	25.36	277	4250	K235VSAC.B99	23-Nov-05	50.68	211.70	112.70	OV-10
2006	Highest & Closest	6.900	gallons/hectare	26.12	430	3899	L196AJCC.B99	19-Dec-06	42.33	180.90	48.48	T-65
2007	Highest	7.000	gallons/hectare	26.50	552	1651	B027NVAC.B99	2-Feb-07	30.28	160.30	64.64	AT802
2007	Closest	6.500	gallons/hectare	24.60	407	862	B027FEAC.B99	2-Feb-07	23.32	166.60	141.71	AT802

7. Statement of Qualifications

7.1 International Mapping has performed geographical analysis and mapping for many cases before the Court and before other international courts and tribunals. A short list of recent cases before the Court to which International Mapping has contributed work includes:

- ☐ *Pulp Mills on the River Uruguay: Argentina v. Uruguay* (work for Uruguay),
- ☐ *Territorial and Maritime Dispute between Nicaragua and Honduras in the Caribbean Sea: Nicaragua v. Honduras* (work for Honduras),
- ☐ *Application of the International Convention on the Elimination of All Forms of Racial Discrimination: Georgia v. Russian Federation* (work for Georgia), and
- ☐ *Land and Maritime Boundary between Cameroon and Nigeria: Cameroon v. Nigeria: Equatorial Guinea intervening* (work for Nigeria).

7.2 In addition, International Mapping recently worked for the Government of Bangladesh at the International Tribunal on the Law of the Seas in the *Dispute concerning delimitation of the maritime boundary between Bangladesh and Myanmar in the Bay of Bengal* in 2011 and for the Interim Government of South Sudan in the *Abyei Arbitration* at the Permanent Court of Arbitration at the Hague in 2009.

7.3 The analyses contained in this report were performed based on standard geographical and statistical methods. All geographical analysis and data preparation were done in ESRI ArcGIS software with careful attention to maintaining geographic accuracy. Buffers were created using geodetic calculations. Distances were measured on projected UTM zone 17 and UTM zone 18 maps with WGS 84 datum.

This concludes our report.

Dated: 19 December 2011

Alex Tait
Vice President
International Mapping Associates, Inc.
Ellicott City, Maryland, USA

Annex 6

Dr B.M. Evans, Ph.D., *Expert Report by Dr. Barry M. Evans*, Ph.D., December 2011

EXPERT REPORT BY
BARRY M. EVANS, Ph.D.

Prepared for the Government of Colombia

Before The International Court Of Justice

CASE CONCERNING

AERIAL HERBICIDE SPRAYING (ECUADOR v. COLOMBIA)

1. Summary of Completed Analyses and Opinions

1.1 The work described herein was accomplished under a service contract with the Colombian Ministry of Foreign Affairs. My qualifications for undertaking this work are set out in an addendum to this report. Under the contract, various analyses were performed for the purposes of evaluating changes in vegetation health/vigor, north and south of the rivers that serve as the border between Ecuador and Colombia, that have or have not occurred as a result of spraying that took place between the years 2000-2003, under the Program for the Eradication of Illicit Crops by Aerial Spraying with Glyphosate (hereafter, PECIG), conducted within the framework of bilateral cooperation between Colombia and the United State against drug trafficking. These analyses were primarily based on an evaluation of features and conditions near several geographic locations visible on a series of satellite images obtained for the purpose of these analyses. As part of this work, analyses were completed for four separate areas along the river. For the purposes of this report, these sites are further identified as follows:

Site 1: Puerto Mestanza, September 2002 to January 2003

Site 2: Cofan Area, September 2002 to January 2003

Site 3: San Francisco I and II Area, September 2002 to October 2002

Site 4: Salinas Area, December 2000 to February 2001

Based on my review and analysis of various satellite images (as described in detail below), which were acquired by various Earth-orbiting systems between the years 2000 and 2003 for the four sites in northern Ecuador, I have reached the following conclusions:

1.2 While significant changes in vegetation cover and condition may be observed in the Republic of Colombia in 2002 to 2003 near the Mestanza farm at Puerto Mestanza – some of which changes coincide very closely with locations and times associated with PECIG spraying that took place in Colombia during 2002 according to available spray data – there are no similar changes reflected on the Ecuadorian side of the border on the Mestanza farm or in the surrounding area.

1.3 While significant changes in vegetation cover and condition may be observed in the Republic of Colombia in late 2002 near the Cofán-Bermejo Ecological Reserve – some of which changes coincide very closely with locations and times associated with PECIG spraying that took place in Colombia during August, September and October of 2002 according to available spray data – there are no similar changes reflected on the Ecuadorian side in the area encompassed by the Cofán-Bermejo Ecological Reserve.

1.4 While significant changes in vegetation cover and condition may be observed in the Republic of Colombia in late 2002 near San Francisco I and II – some of which changes coincide very closely with locations and times associated with PECIG spraying that took place in Colombia during September and October of 2002 according to available spray data – there are no similar changes reflected on the Ecuadorian side in the vicinity of San Francisco I and II. Those relatively minor changes in vegetation condition that did occur are believed to be entirely consistent with normal cultivation activities such as clearing, planting and harvesting.

1.5 While significant changes in vegetation cover and condition may be observed in the Republic of Colombia in late 2000 and early 2001 near Salinas – some of which changes coincide very closely with locations and times associated with PECIG spraying that took place in Colombia during that time period according to available spray data – there are no similar changes reflected on the Ecuadorian side in the vicinity of Salinas. Those relatively minor changes in vegetation condition that did occur are believed to be entirely consistent with normal cultivation activities such as clearing, planting and harvesting.

2. Knowledge of the Dispute and Related Factors

2.1 During the period 2000 through 2007, it is my understanding that aerial spraying of an herbicide mixture containing glyphosate was carried out in areas of southern Colombia near the border of Ecuador as part of the government-sponsored PECIG program. This spraying was performed for the purpose of eradicating illicit coca plants grown in these areas during the same time period. In an application deposited by Ecuador against Colombia at the International Court of Justice, based in The Hague, Ecuador has alleged that damage has been caused within Ecuador, including to inhabitants and the environment within Ecuador through the spraying of chemical herbicides.

2.2 Prior to being asked to serve as an expert to the Republic of Colombia in the above case, I worked as an expert in the "Arias vs. DynCorp" litigation before the United States District Court for the District of Columbia. In this case, I provided similar satellite image analysis services related to assessing aerial herbicide spraying. However, in the Arias vs. Dyncorp case, services were only provided for a small area encompassing the Mestanza farm (Puerto Mestanza) described in Sections 3.13 through 3.37 of the present report.

2.3 The work described herein was accomplished under a service contract with the Colombian Ministry of Foreign Affairs. Under this contract, I was requested by the Ministry to provide expert scientific and technical advice in the field of satellite data/image analysis in support of Colombia's defense related to the application deposited by Ecuador against Colombia at the International Court of Justice as described above. Various analyses were performed for the purposes of evaluating changes in vegetation health/vigor north and south of the rivers that serve as the border between Ecuador and Colombia that have or have not occurred as a result of PECIG spraying that took place between the years 2000-2003. These analyses were primarily based on an evaluation of features and conditions near several geographic locations visible on a series of satellite images obtained for the purpose of these analyses. As part of this work, analyses were completed for four separate areas along the river. These areas were selected based on the location of communities in Ecuador within which various individuals claiming to have witnessed alleged damage related to the herbicide spraying lived, the proximity of these communities to areas in Colombia where aerial spraying occurred, the dates during which damages were alleged by witnesses to have occurred, and the availability of satellite images for the relevant periods covering these areas. For the purposes of this report, these sites (and these time periods for which various analyses were conducted) are further identified as follows:

Site 1: Puerto Mestanza (September 2002 to January 2003)

Site 2: Cofan Area (September 2002 to January 2003)

Site 3: San Francisco I & II Area (September 2002 to October 2002)

Site 4: Salinas Area (December 2000 to February 2001)

2.4 To support my work activities outlined above, a number of documents and other materials were provided to me by other parties associated with Colombia's defense in the above-mentioned matter. These documents and materials include the following:

The following satellite images were provided by International Mapping in a format that could be viewed by me in ArcView© GIS (Geographic Information System) software:

- Color infrared rendition of Landsat image dated December 11, 2000
- Color infrared rendition of SPOT image dated February 17, 2001
- Color infrared rendition of Landsat image dated September 12, 2002
- Color infrared rendition of SPOT image dated September 22, 2002
- Color infrared rendition of SPOT image dated October 7, 2002
- Color infrared rendition of Landsat image dated October 14, 2002
- Color infrared rendition of SPOT image dated January 19, 2003
- NDVI rendition of Landsat image dated December 11, 2000
- NDVI rendition of SPOT image dated February 17, 2001
- NDVI rendition of Landsat image dated September 12, 2002
- NDVI rendition of SPOT image dated September 22, 2002
- NDVI rendition of SPOT image dated October 7, 2002
- NDVI rendition of Landsat image dated October 14, 2002
- NDVI rendition of SPOT image dated January 19, 2003

Other documents provided included:

1. Various GIS files showing such features as the date and location of aerial spray lines carried out as part of the PECIG program, community locations in Ecuador, as well as the locations of other features such as the Cofán-Bermejo Ecological Reserve
2. A copy of testimony provided by Mr. Victor Mestanza to Engineer Roger Mera, Ministry of the Environment on October 14, 2002 (ANNEX 237 to Ecuador's Memorial dated April 28, 2009)

3. Copies of witness declarations provided by unknown residents of the Cofán-Bermejo Ecological Reserve to Dr. José María Barrazueta Toledo of the Lago Agrio Canton in January and February of 2009 (Witnesses 26, 27, 29 and 31) (ANNEXES 210, 211, 213 and 215 to Ecuador's Memorial dated April 28, 2009).

4. Copies of witness declarations provided by unknown residents of San Francisco I and II to Dr. José María Barrazueta Toledo of the Lago Agrio Canton in January and February of 2009 (Witnesses 11, 12, 13, 14, 18 and 19) (ANNEXES 199, 200, 201, 202, 204 and 205 to Ecuador's Memorial dated April 28, 2009).

5. Copies of witness declarations provided by unknown residents of Salinas to Dr. José María Barrazueta Toledo of the Lago Agrio Canton in January and February of 2009 (Witnesses 1, 2, 3, 4, 5, 6 and 7) (ANNEXES 189, 190, 191, 192, 193, 194 and 195 to Ecuador's Memorial dated April 28, 2009).

6. A copy of the document "Response to Report "Spray Drift Modeling of Conditions of Application for Coca Crops in Colombia" by D.K. Giles", prepared by Andrew Hewitt, Ph.D.

7. A copy of the document "Aerial Spray Drift Modeling of Plan Colombia Applications", prepared by Andrew J. Hewitt, Ph.D.

8. A copy of the document "Case Concerning Aerial Herbicide Spraying (Ecuador v. Colombia)", prepared by Keith R. Solomon.

In addition, the following technical documents from the scientific literature are referenced in the report:

- Lillesand, T.M. and R.W. Kiefer, 2000. Remote sensing and image interpretation. John Wiley and Sons, New York, 736 pp.

- Myneni, R. B., F. G. Hall, P.J. Sellers, and A.L. Marshak ,1995. The interpretation of spectral vegetation indexes, *IEEE Transactions on Geoscience and Remote Sensing*, **33**, 481-486).

3. <u>Discussion of Opinions Related to Vegetative Changes near the Border in 2000 - 03</u>

A. Initial Background Work

3.1 My initial activity for the purposes of preparing the present report, following receipt of my instructions, involved discussions with staff from International Mapping (consultants retained by the Government of Colombia) in order to identify satellite imagery which could be of assistance in relation to specific dates and locations at which I understand it is alleged that harm from spraying was suffered within Ecuadorian territory. From discussions with International Mapping, it was learned that digital map records in the form of GIS (digital map) files were available which indicate the date and times of each specific spray event carried out as part of the PECIG spraying program. These GIS files depict such events as "spray lines" that are identified as to date and other relevant acquisition information in the database associated with each file. Copies of these files were provided to enable viewing of these records on my own computer. At this same time, International Mapping also provided me with a copy of a GIS file that showed the locations of communities where individuals identified in various witness statements purported to reside.

3.2 International Mapping, as part of its activities on behalf of the Government of Colombia, had searched numerous public and private archives for the purpose of identifying potentially usable satellite images that could be analyzed to assess the presence/extent of vegetation damages in both Colombia and Ecuador that may or may not have occurred as a result of PECIG aerial spray events. In conducting this search, International Mapping staff attempted to identify images from various satellites that had been acquired before and after the date of specific recorded aerial spray events. Subsequent to identifying potentially usable images based on locations and dates, a determination was also made as to whether available images were usable based on the presence or absence of cloud cover which might obscure vegetation and other features on the ground. Based upon its preliminary review, International Mapping had identified a number of satellite images that might support my subsequent analyses. In collaboration with International Mapping, I conducted an additional review of these images to identify specific satellite images that could be used to determine the effects (and/or the non-effects) in both the Republic of Colombia and Ecuador of PECIG aerial coca eradication operations at several locations along the Ecuador-Colombia border on a number of specific dates or periods during which exposure to the spray mixture used in the spraying program is alleged to have occurred, and as to which the records of spray flights indicated that there had been spraying in the immediate vicinity. In addition to cloud conditions as described above, consideration was also given to the availability of images acquired before and after specific reported spray events since the comparison of "before" and "after" conditions depicted on such images was a critical part of determining whether vegetation changes potentially caused by nearby aerial spraying activities had occurred.

3.3 In relation to the western sector of the border, covering the province of Narino in Colombia, insufficient images were available in relation to the relevant dates identified due to heavy cloud cover. This is a common weather phenomenon in this part of the world. As to the province of Putumayo, there were relatively few images available for the relevant region and time span, and some of those that were available were likewise unusable due to heavy cloud cover. In some cases, individual cloud-free images for specific dates were available, but a corresponding "before" or "after" image that would allow comparative analysis as described earlier was not available. However, given the above limitations and considerations, we were able to identify and obtain for review, the following satellite images that revealed specific locations of interest in the relevant periods identified:

1. December 11, 2000 (Landsat)
2. February 17, 2001 (SPOT)
3. September 12, 2002 (Landsat)

4. September 22, 2002 (SPOT)
5. October 7, 2002 (SPOT)
6. October 14, 2002 (Landsat)
7. January 19, 2003 (SPOT)
8. February 19, 2003 (SPOT)

3.4 The identified satellites (Landsat and SPOT) collect high-resolution imagery in a standardized format covering many parts of the land surface of the world. These satellites are examples of a number of non-military, commercial satellites that have been developed and used by government agencies around the world since 1972 to collect digital data (imagery) to support mapping and natural resource evaluations. These satellites are typically positioned in fixed orbits to allow the capture of data during daylight hours (*i.e.,* they are positioned at fixed altitudes above the Earth, and travel around the globe in pre-determined flight paths). Data collection is accomplished with various on-board sensors that have the ability to capture reflected and emitted energy from land surfaces in specific portions of the electromagnetic spectrum, including the visible, near-infrared, and far-infrared portions. When viewed as "images" in printed form or on computer screens, these data can be used to highlight different features on the surface of the Earth.

3.5 Not all commercial satellites are similar in terms of the data they collect and the spatial resolution at which data are collected. The Landsat series of satellites, first launched in 1972, has undergone several sensor re-configurations over the last four decades. The Landsat 7 system (from which images were acquired for use in the analyses described in this report) has a sensor that collects digital data in the visible and near-infrared portions of the electromagnetic spectrum from 6 separate channels at a typical spatial resolution of about 30 meters[1]. The SPOT satellites (first launched by the French Space Agency in 1986) also have similar "multi-spectral" sensors that collect data in separate channels. The SPOT 4 satellite (from which images were used for this report) has a sensor that acquires visible and near-infrared data at a spatial resolution of 20 meters. This higher resolution in the visible and near- infrared channels, when compared with Landsat 7 data, typically allows for better "definition" of features on SPOT satellite images.

3.6 International Mapping also searched other known and available satellite sources (GeoEye and Digital Globe) for additional images of the subject areas, but found none within the relevant date range for the specific areas that encompass the geographic locations of interest.

3.7 Copies of the digital image data for the specific dates identified above were obtained and provided to me by International Mapping for use in my subsequent analyses described in this report. The viewing of various satellite images on a computer is typically done by displaying various "channels" of information representing different portions of the electromagnetic (color) spectrum on different "layers" or "color guns" (*i.e.,* red, green and blue) in much the same way that transmitted data are presented on a color television. For example, if data from the red, blue and green channels of a given satellite system are displayed on the red, blue and green layers of a computer screen, then a "natural color" image is created (*i.e.,* it looks more like a photograph taken with a hand-held or aircraft-borne camera). This is the kind of image that one typically sees on web-based applications such as Google Earth (see www.google.com/earth/).

3.8 For the current analysis, however, which is focused on vegetation and vegetative changes, a "color infrared" image was created by putting data from the near-infrared channel of each

[1] Landsat 7 also has two other data channels having different spatial resolutions that were not used to support any analyses performed as part of this report.

satellite on the red layer so that a particular kind of red-tinted image was created that highlighted differences in vegetation type and condition on the ground. This approach has long been recognized as a standardized approach for vegetation mapping and analysis (Lillesand and Kiefer, 2000). With this type of image, vegetation is represented in various hues of red, with healthier vegetation being "brighter" in color. Bare, exposed soil typically shows up as various shades of light to dark blue-green on such images. Therefore, as vegetative cover decreases in a given area, there is a corresponding decrease in "redness" and an increase in various "blue-green" tones in the image. For my use in the analyses described in this report, International Mapping staff created these color infrared images based on consultations with me on the specific manner in which these images were to be processed so that I could view them on my computer correctly.

3.9 To supplement these color infrared images for some of the site analyses, additional processing was done by International Mapping to create "normalized difference vegetation index" (NDVI) images from the above satellite data. This index is calculated using the "visible" and "near infrared" channels of satellite data, and results in new digital data values ranging from -1 to +1. With this index, values close to -1 generally correspond to water; values close to zero (-0.1 to 0.1) generally correspond to barren areas of rock, sand or snow; values between 0.2 to 0.4 generally represent shrubs and grassland; and values greater than 0.4 usually indicate temperate and tropical rainforests (Myneni, R. B., F. G. Hall, P.J. Sellers, and A.L. Marshak, 1995). For the analysis described in this report, NDVI images showing "vegetated" versus "non-vegetated" areas were used to supplement the color infrared images to aid in the evaluation of spray effects.

3.10 For the purposes of the analyses described later in this report, NDVI images were created using both ArcGIS© and ERDAS Imagine© image processing software, which are two of the most widely-used GIS/image processing software packages of their type in the world. In each case, standard "NDVI" tools were used to create images that converted the values ranging from -1 to + 1 as described above to values ranging from 1-200 (i.e., values from -1 to 0 were respresented by values of 1-100, and values greater than 0 were represented by values from 101-200). In viewing these images on-screen, the values from 1-200 are separated in discrete color ranges in order to highlight certain degrees of vegetation/non-vegetation (see later discussion in Section 3.31).

B. Analysis of Relevant Images

3.11 The images described above were each reviewed carefully by me to determine what they revealed: (1) about the vegetation on both sides of the border between Colombia and Ecuador and (2) about conditions and features (especially related to vegetation) associated with each of the four sites previously identified.

3.12 Analyses for each of these sites are provided below. A more site-specific analysis is provided for the Mestanza site (Site 1: Puerto Mestanza) since it is substantially smaller in terms of geographic area than the other sites, and the precise location in which it is alleged by Mr. Victor Mestanza that damage was caused can be ascertained with greater accuracy. Less "site-specific" comments on the other locations are provided since less is known about the exact locations where various witnesses live in these cases. Therefore, it was necessary to extend the geographic size of the "study areas" surrounding these sites in order to provide a reasonable degree of assurance that these areas included the residences and farmed areas to which those witnesses make reference.

Site 1: Mestanza Farm (Puerto Mestanza)

3.13 The first site analyzed was the "Mestanza Farm"; I am instructed that this is a plot of land apparently owned by Victor Mestanza and occupied by him and several members of his family. Figure 1 depicts what I understand to be the approximate location of this site (shown by the red boundary line). The satellite image shown in the background is the 2011-vintage image provided by default when using Google Earth (see http://www.google.com/earth/).

Figure 1. Mestanza Family Farm with approximate property boundary shown in red.

3.14 The next step in my analysis was to determine if I could conduct a "before and after" review of the areas allegedly sprayed with herbicide near the Mestanza farm. In Memorial

Annex 237, Mr. Mestanza alleges that spraying took place in November of 2000, January of 2002, September of 2002, and October of 2002.

3.15 Based on the limited dates of the satellite images available, it was determined that analysis would be pointless for the alleged spraying in November of 2000 or January of 2002. More specifically, as to November 2000, an analysis of the spray line data revealed that no aerial herbicide applications were conducted anywhere within the vicinity of Puerto Mestanza in November of 2000. In fact, the closest spraying in Colombia was 20 kilometers away to the west, and this did not occur until late December of 2000. The next closest set of spray lines were over 50 km to the east. Therefore, since the spray line records show that no aerial spraying occurred in the vicinity of the Mestanza farm in November 2000, no analysis for this date was conducted.

3.16 For the damage allegedly suffered as a result of spraying conducted in Colombia in January 2002, the two images identified that were closest to this event in terms of their dates were Landsat images acquired in September 2001 and September 2002. These two images, however, were far too removed in terms of months before and after the relevant date of January 2002 to be useful since, given the large gap in time, short-term vegetation changes due to aerial spraying or other causes (e.g., routine planting and harvesting activities) could not be adequately evaluated.

3.17 However, for the PECIG spraying that occurred near the Mestanza farm in September and October 2002, there were the potentially useful satellite images taken (as noted above) on September 12, 2002, September 22, 2002, October 7, 2002, October 14, 2002 and January 19, 2003.

3.18 As indicated earlier, I have been provided with the GIS data for the individual spray events that took place as part of PECIG, including those closest to the Mestanza farm during the relevant period in the fall of 2002. As I reviewed the September and October 2002 images and the January 2003 image, I superimposed on certain of these images, as appropriate, the "spray lines", to determine if the effects of the spraying could be seen in Colombia and/or on the Mestanza farm in Ecuador[2]. The process of evaluating this area in a step-by-step manner is described below.

3.19 Figure 2 shows the September 12, 2002 Landsat image. Superimposed on this image in yellow are spray lines indicating aerial spraying that had taken place in September of 2002 up till the date on which the satellite image was acquired. More specifically, for those spray lines shown in Figure 2, aerial applications had occurred on September 4, 6 and 8 of 2002. Because of these application dates, one would not expect to see the full effects in Colombian territory of the early September herbicide applications on the September 12 image because PECIG uses a glyphosate mixture that I understand takes a number of days or even weeks to kill the illicit coca plants on which it is applied. Thus, although this image may depict some early indications of the effects of the spraying in Colombia, most of the effects from the early September spraying operations become more evident in the following weeks (as described below). The September 12 image, therefore, provides a useful "before" image of the border area in Colombia and Ecuador near the Mestanza farm -- prior to any impacts of the Fall 2002 PECIG spraying operations.

[2] These "spray lines" were created by the GPS equipment on board each spray plane to reveal exactly where the herbicide mixture was sprayed in Colombia.

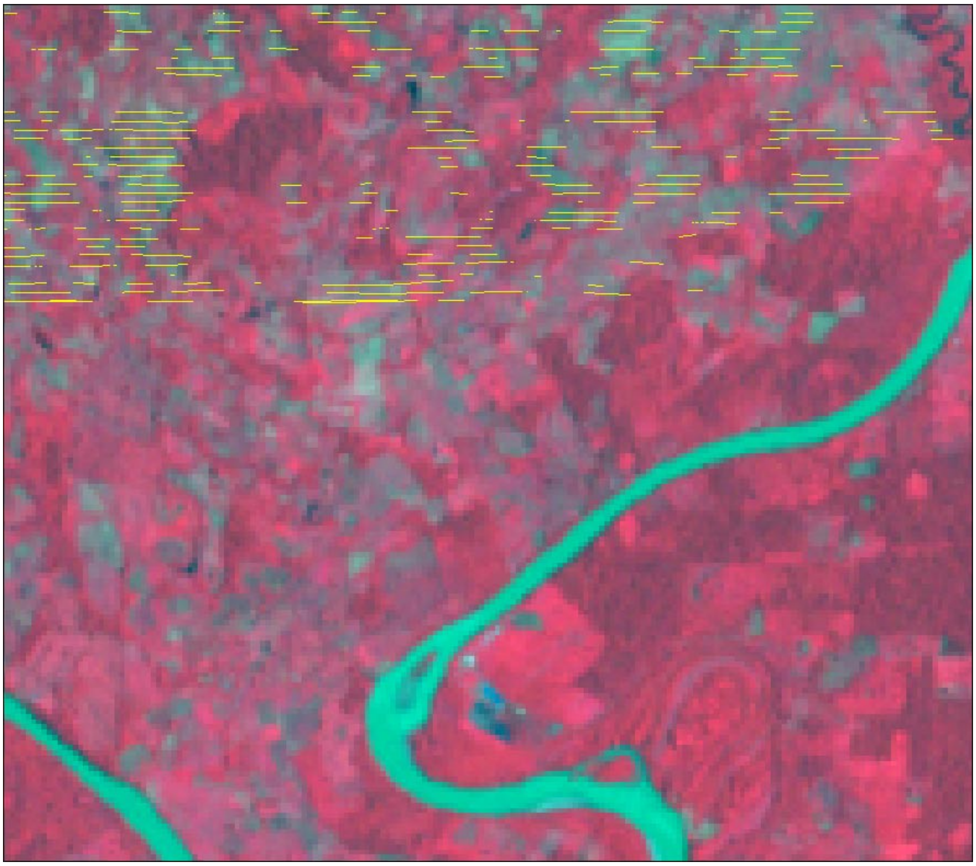


Figure 2. September 12, 2002 (Landsat) image with September spray lines for aerial applications completed up to the date of the satellite image.

3.20 In reviewing the September 12, 2002 image, I made a number of observations with respect to vegetative conditions in the vicinity of the Puerto Mestanza site identified in Figure 1, as well as in Colombian territory across the border river. These observations, as well as comments on the appearance of vegetation types and conditions on color infrared images, are summarized below:

1. On color infrared images, forested or wooded areas typically have a darker, "duller" red hue (see example areas denoted by "A" in Figure 3). Areas with lower-lying "grassy"

vegetation (including pastures) or cultivated plants such as corn and other small-grains appear in hues of "brighter" reds or pinks, as do areas with relatively shorter, broad-leaved plants such as plantains. In this case, areas with smaller plants or sparser vegetative cover (i.e., leaf cover) typically appear in lighter pink tones (see example areas labeled "B" in Figure 3), whereas areas with relatively taller, thicker growth usually appear in more "lush" reds (see example areas labeled "C" in Figure 3). In contrast, areas devoid of leaf cover appear in varying shades of light to dark blue-green (indicating exposed soil), with lighter areas typically being relatively drier, and darker areas being relatively wetter and/or having more "non-leafy" woody matter at the surface (see example areas labeled "D" in Figure 3). Areas that appear somewhat between "B" and "D" in color (i.e., somewhat "purplish") are typically a mixture of sparse vegetation and bare soil (see example areas labeled "E" in Figure 3).

2. Based on my observations, it appears that a significantly larger percentage of the Colombia side of the border (in comparison to nearby areas in Ecuador) had been cleared of forest (which would appear like the examples labeled "A" in Figure 3) and was in various stages of cultivation as suggested by the various shades of red, pink and blue-green hues visible in the image. Some areas similar to those labeled "B" and "E" in Figure 3 could be coca fields or other cultivated plants in the early stages of growth when there is mostly bare ground around the small plants, which would *not* appear on a satellite image as thicker, healthier vegetative growth for many months or more (such as those example areas labeled "C" in Figure 3). Finally, the areas which from their color on the image appear to be bare could be the result of recent harvesting, recent removal of vegetation via burning/clearing, recent plowing/planting, or the successful eradication of

coca fields by aerial or manual eradication. From a satellite's perspective, these latter areas would all appear to be lacking significant vegetative leaf cover (hence, they would appear less "red" and more "blue-green" in tone).

3. It appears from the satellite image taken on September 12, 2002 that the Mestanza property in Ecuador includes a number of areas of differing types and density of vegetation. However, the image does not reveal any large areas lacking vegetation such as those seen in Colombia. The different colors on the Mestanza property (particularly the brighter reds shown in Figure 3) suggest that at the time of the image (September 2002) there were various types of crops being grown in the vicinity of Puerto Mestanza.

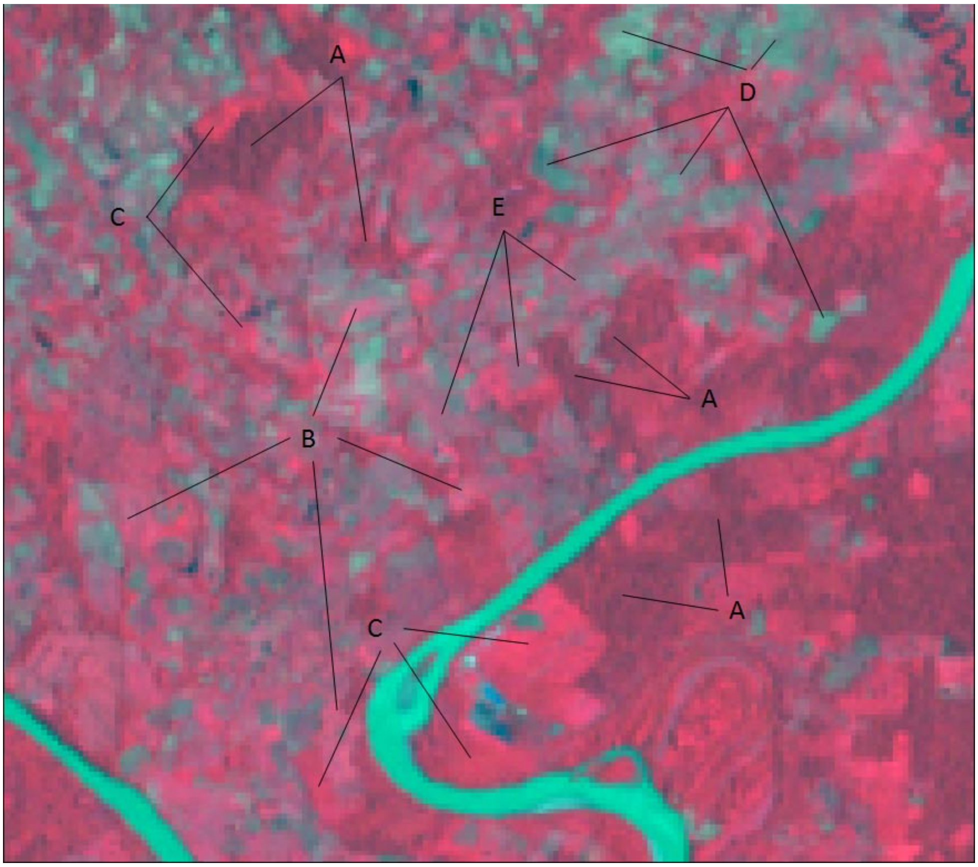


Figure 3. September 12, 2002 (Landsat) satellite image with annotations.

3.21 Using the same September 12, 2002 image, one can see the area where fish ponds are located on the Mestanza farm, which I have marked with the letter "V" on the image shown in Figure 4. I have also marked with the letter "W" the area where a road and a number of homes were built along the river at Puerto Mestanza. And I have marked with the letters "X" and "Y", two small areas which appear to be devoid of vegetation at the time this satellite image was acquired. These areas are good examples of how a color infrared satellite image shows a patch of bare land (or land with very little vegetation). On the basis solely of my analysis of the satellite images, I am unable to express any firm conclusions as to why these patches of land were bare, as the blue-green coloring might indicate recent planting/harvesting activities or might be areas that the Mestanzas had kept cleared for other reasons. However, given the date of the image, the dates of the spraying in September that had occurred prior to this date (i.e., September 4-8), the distance of these spray lines from the Mestanza property (about 1.7 kilometers), and the amount of time which I understand is typically required for glyphosate to have an effect on plants sprayed (from a number of days to weeks), it is extremely likely that these areas were devoid of vegetation for reasons unrelated to the aerial spraying. This assumption is strongly supported by the obvious lack of stress to vegetation surrounding each of the patches as indicated by the bright red hues. Further, the various satellite images covering this area show that these areas remained bare in several different years. Moreover, this assumption is also confirmed by the findings of Hewitt in his report "Aerial Spray Drift Modeling of Plan Colombia Applications", for the spray line of September 8, 2002, in Colombian territory, closest to the Mestanza farm. That spray line was at a distance of 1696 meters from the Ecuadorian bank on the border river, and the resulting deposit at that distance was only 0.6537 g/ha (i.e., practically zero), as a result of which, vegetation cover could not have been affected.

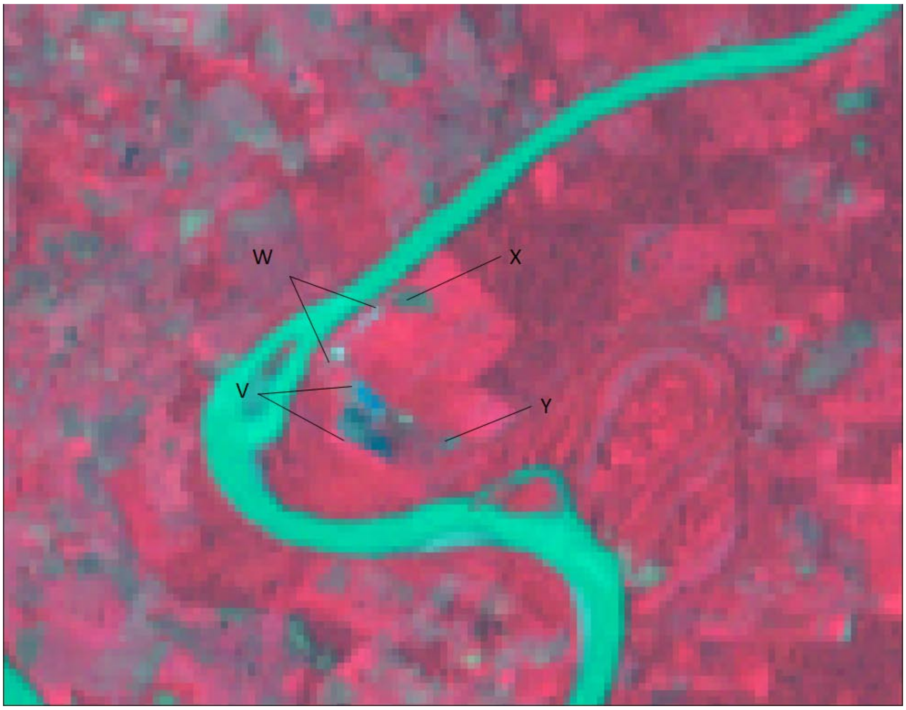


Figure 4. September 12, 2002 (Landsat) image, showing Features on Mestanza Farm

3.22 Figures 5a, 5b and 5c all show the next image dated September 22, 2002, acquired by the SPOT satellite. On Figure 5b, I have superimposed the same spray lines created by the planes that flew eradication missions in Colombia within about 5 kilometers of the Mestanza farm in early September 2002 as are depicted on Figure 2 (there were no further spray events during September 2002 in the region shown). While the full effects in Colombia of the September spraying were likely not yet evident, extensive vegetative loss is apparent in the areas directly under the spray lines in Colombian territory. In this image, many of these areas appear to have become more "whitish" in hue (i.e., very light blue-greens), suggesting an increase in exposed soil and loss of leaf cover as compared to 10 days prior (see example areas labeled as "A"). In general, there appears to be far less "red" underneath the sprayed areas, indicating a substantial decrease in vegetative foliage. See, in particular, the area I have marked with the letter "B" in the figure which illustrates a fairly dramatic demarcation between a vegetated area not sprayed (below) and a sprayed area immediately above it.

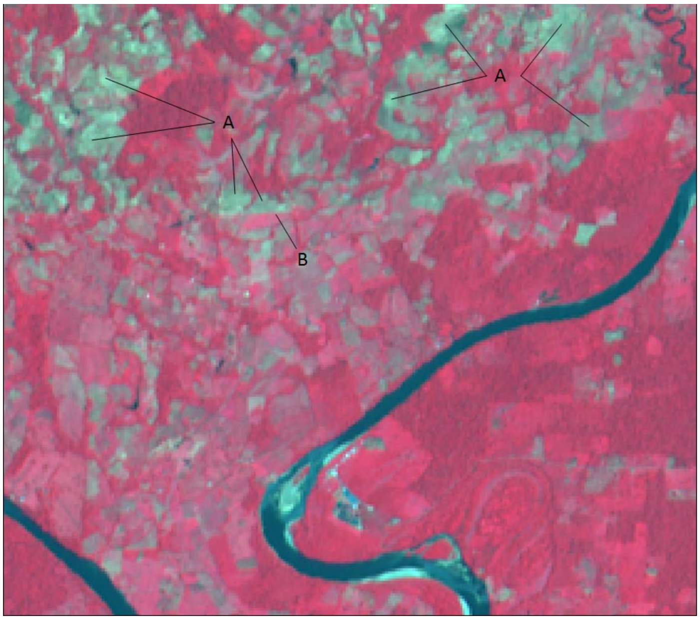


Figure 5a. September 22, 2002 (SPOT) image

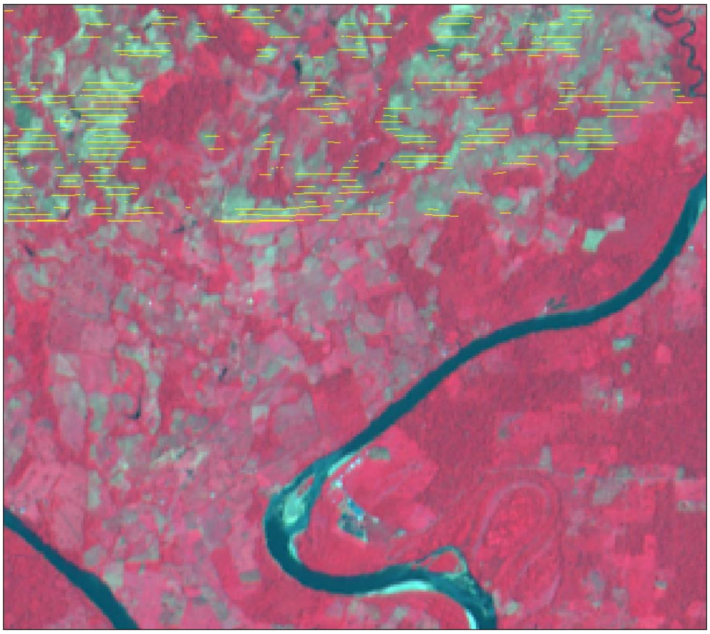


Figure 5b. September 22, 2002 (SPOT) image (with September spray lines)

3.23 In contrast, no such changes in vegetation are seen in the close-up of the Mestanza farm (corresponding to the close-up of the September 12, 2002 image shown in Figure 4) shown in Figure 5c. When viewing the image in this figure, one can see the same two bare spots (*i.e.*, areas "X" and "Y," the same area of the fish ponds ("V"), and the same area of houses along the river ("W")) as well as other color variations on the Mestanza farm corresponding to different crops or plant types, which have not changed in any significant degree from the September 12 image.

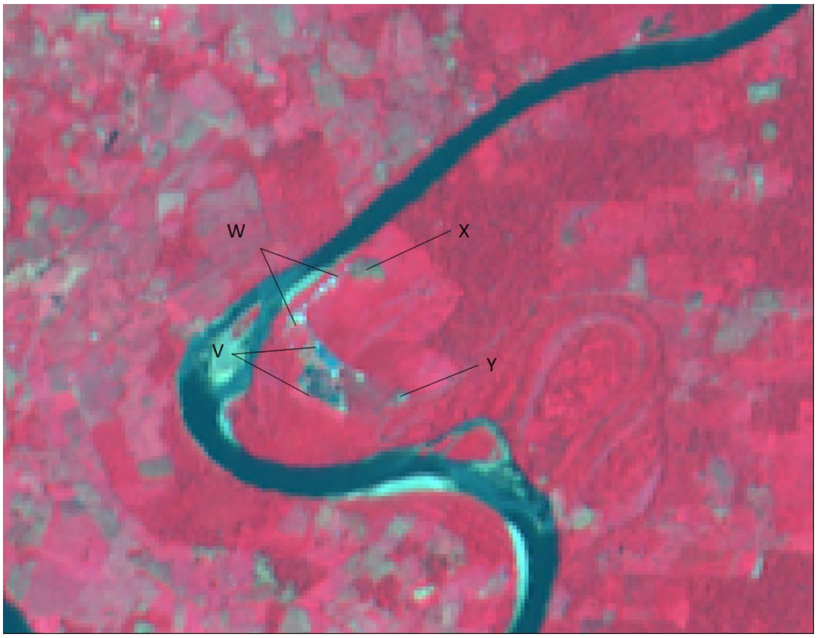


Figure 5c. Sept. 22, 2002 (SPOT) image focused on Mestanza farm

3.24 Figures 6a, 6b and 6c all show the next image acquired by the SPOT satellite on October 7, 2002. In Figure 6b, I have superimposed lines onto the October 7, 2002 SPOT image indicating those spray events which had taken place in October of 2002 up to the date of the image (specifically, October 3 and 7). (Note: the dark area in the center of the image is a shadow cast by an overhead cloud).

3.25 As of the date of this image, the effects of the September PECIG spraying operations within Colombia are particularly evident due to the distinct contrast in vegetative cover between the upper and lower parts of the image. Indeed, there is apparent a clear demarcation within Colombian territory that appears as a "virtual" line between areas in which spraying had taken place in September and areas where it did not (the endpoints of this "virtual" line are denoted by the arrows labeled as "B" in Figure 6a). This difference is highlighted by the relative abundance of vegetative growth below this line (as indicated by the reddish colors) and areas with little vegetative growth (as indicated by the more numerous "blue-green" patches of bare soil above the line).

3.26 In examining the areas previously labeled as "A" in Figure 5a (and also shown in Figure 6a), one can still see a substantial lack of vegetative cover in these areas that would appear to be due to the spraying one month prior. One can also observe in this image the presence of lower-lying vegetation (see example areas labeled as "C" in Figure 6a) and taller, woody vegetation (see example areas labeled as "D" in Figure 6a) immediately adjacent to previously sprayed areas. In these cases, the strong reddish responses indicate relatively healthy, continuous leaf cover that shows no ill effects from nearby spraying activities.

3.27 Looking at the close-up of the Mestanza farm in Figure 6c, there again is no evidence of any similar changes in the vegetative cover as described above. One can again see the same area "V" of fish ponds, the same area "W" of homes along the river, and the same patches of bare land marked as areas "X" and "Y". No significant vegetative changes are visible in any of those areas. Moreover, none of the vegetated areas on the Mestanza farm appear to have experienced any changes in vegetative vigor and/or leaf cover similar to those noticeable on the Colombian side of the river.

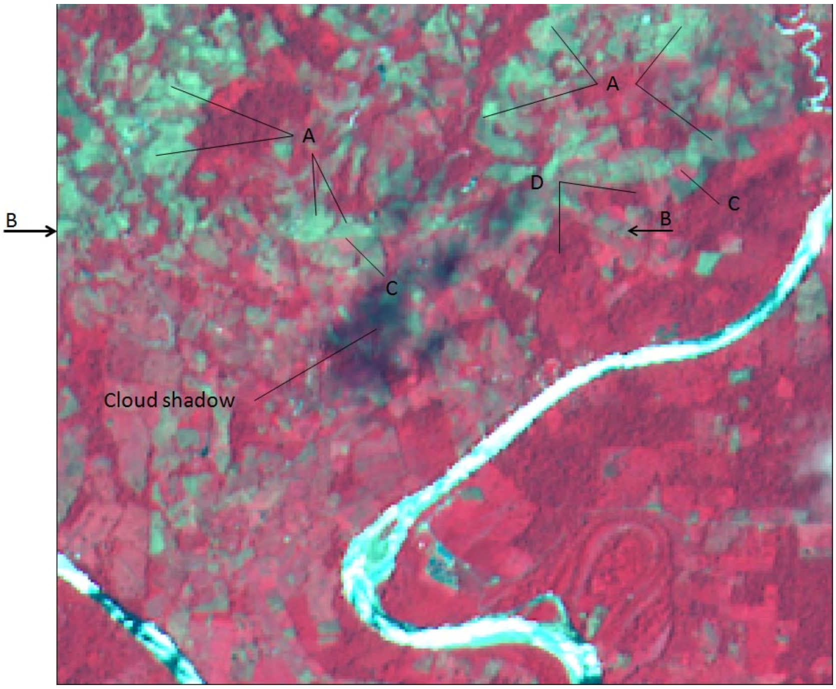


Figure 6a. October 7, 2002 (SPOT) image.

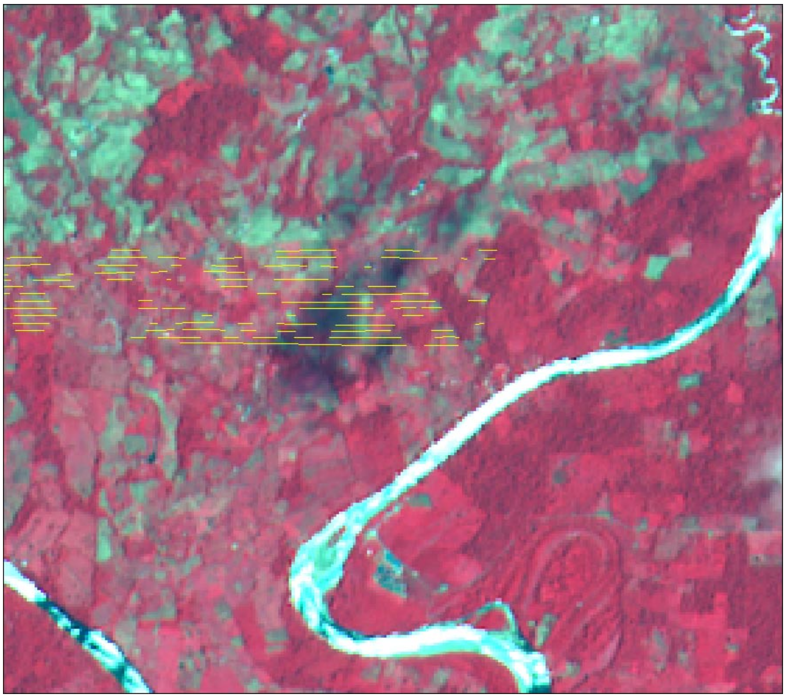


Figure 6b. October 7, 2002 (SPOT) (with early October spray lines).

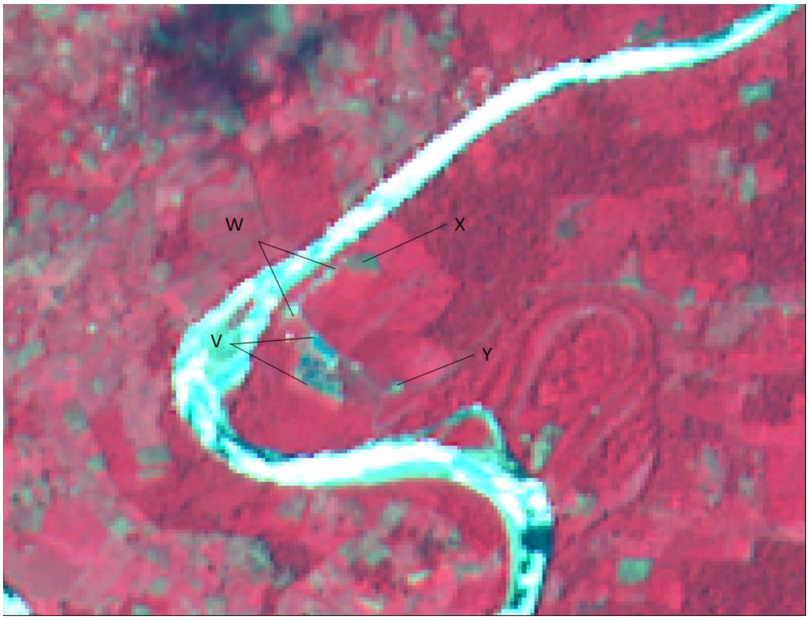


Figure 6c. October 7, 2002 (SPOT) image focused on Mestanza farm.

3.28 Figures 7a, 7b and 7c are all from the next image acquired by the Landsat satellite on October 14, 2002. On Figure 7b, I have superimposed spray lines in yellow to indicate spray events that took place in Colombia in October 2002 after the date of the previous image (October 7, 2002) and on or before October 14, 2002. Because of the closeness in time of the images, one would not expect to see markedly greater effects on Colombia's side of the border of the spraying prior to October 7, 2002 on the October 14, 2002 image. However, some effects are clearly already present under the earlier October 2002 spray lines shown previously in Figure 6b. That is, there appears to be less vegetative cover than that shown a week prior as indicated by fewer "red" tones (indicating foliage) and more light "blue-green" tones (indicating exposed soil). There are still areas exhibiting some foliage (see example areas labeled as "A" in Figure 7a), but I understand that this is expected since maximum defoliation after glyphosate application is typically not evident until some weeks after spraying. However, most of the areas under the spray lines are beginning to take on the characteristic light blue-green tones indicative of defoliated areas with exposed soil (see example areas labeled as “B” in Figure 7a) as seen in areas to the north affected by the September 2002 spray activities. Also, as shown in the figures, the effects in Colombia of the September 2002 spraying are still quite visible as exposed soil is evident throughout (as indicated by the predominant light blue-green tones) and little re-vegetation (as would be suggested by an increasing amount of reddish tones) has occurred in the intervening month.

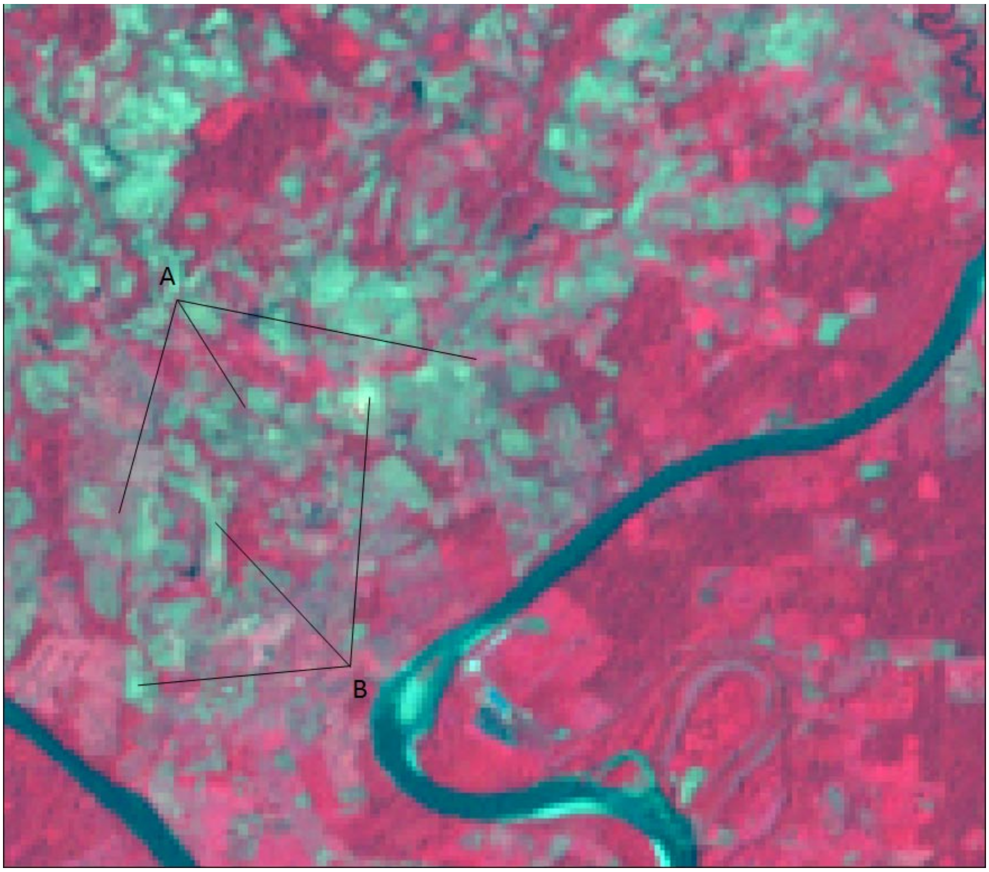


Figure 7a. October 14, 2002 (Landsat) image

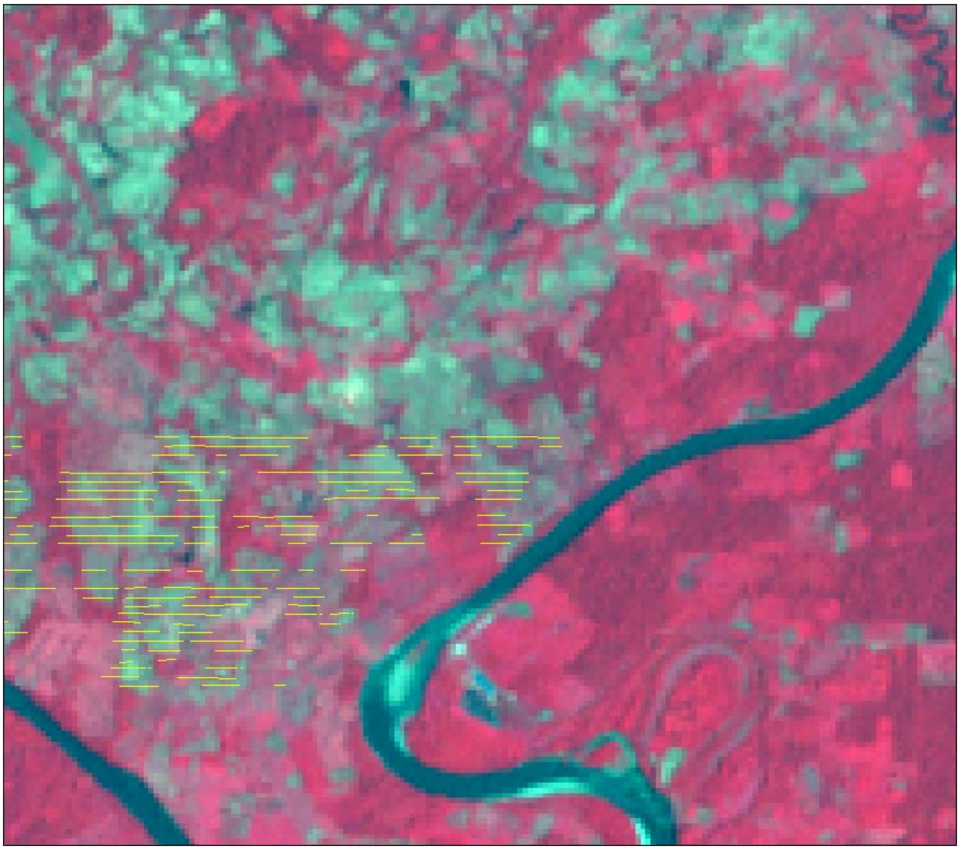


Figure 7b. October 14, 2002 (Landsat) Image (with later October spray lines)

3.29 An even more revealing contrast may be seen by comparing the same October 14, 2002 Landsat image (Figure 7b) with the earlier September 12, 2002 Landsat image (Figure 3), which was taken before most of the effects of the spraying later that month became visible. To demonstrate the "before and after" disclosed in these two Figures, I have displayed them both again on the following page. As is evident from these images, there appears to be no change at all in the condition of the vegetation on the Mestanza property during this same time period.

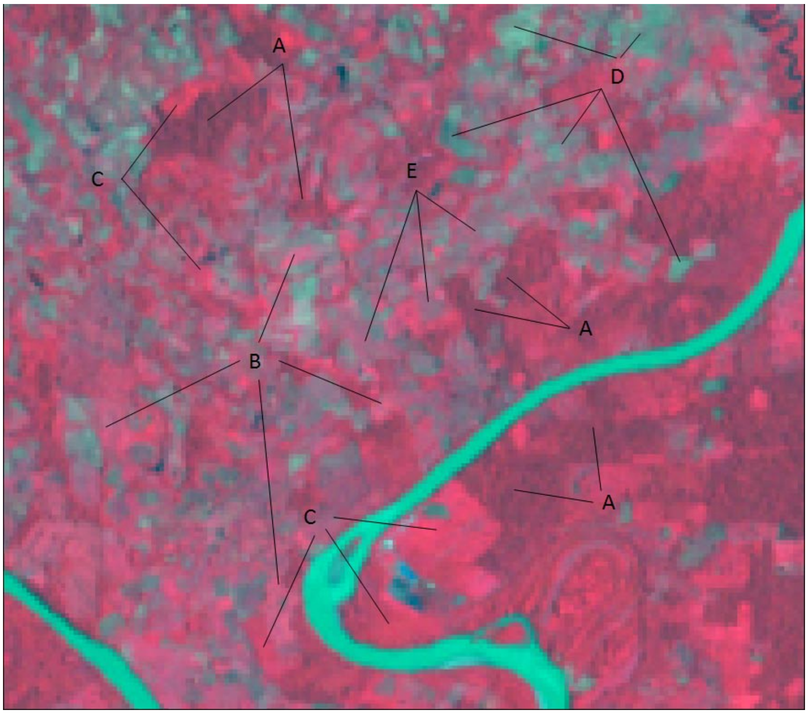


Figure 3. September 12, 2002 Landsat image

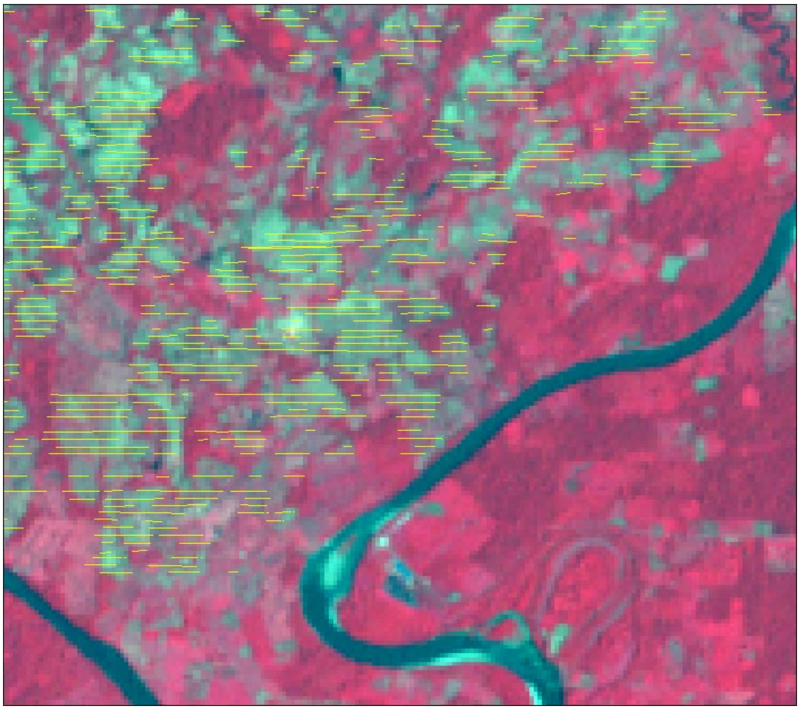


Figure 7b. October 14, 2002 (Landsat) image (with all September and October spray lines)

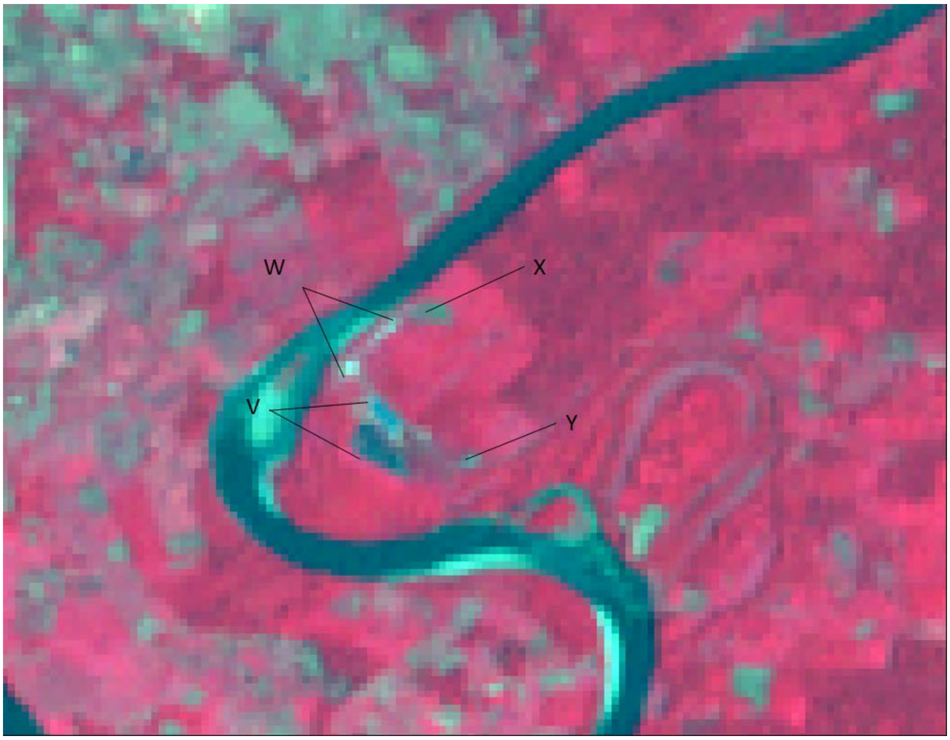


Figure 7c. October 14, 2002 (Landsat) image focused on Mestanza farm

3.30 Focusing on the Mestanza farm on the same October 14, 2002 image (Figure 7c above), one again sees the same fish pond area ("V"), the same area where houses are located along the river ("W"), the same areas "X" and "X". No significant changes in the vegetative cover around these areas, or anywhere else on the Mestanza farm, is visible. It should be noted here that Victor Mestanza has claimed that there was "clear evidence of the death of woodlands, orito and sugarcane" after aerial spray events on "Monday 7th and Thursday 10th of October of this year" (i.e., October of 2002) (see page 2 of Annex 237 to Ecuador's Memorial). However, none of the images, as described above, show any evidence of defoliation or decline in vegetation health. Additionally, none of the September or October images reveal any area near the Mestanza farm (or elsewhere) where "drifting" herbicide has destroyed trees, crops or any other vegetation between the site of the spraying and the Mestanza farm. If any damage from drifting herbicide did occur, in accordance with my understanding of the effects of glyphosate and the mechanism of drift, I would have expected to see evidence of "creeping defoliation", appearing as a change in color of the vegetation in the relevant area, leading up to the Mestanza property from the north in more or less a straight swath from where the spraying occurred in Colombia. Neither of the October 2002 satellite images (Figures 6a-c and 7a-c) reveals any such swaths of vegetative change or destruction when compared to the earlier September 2002 images. This lack of change in vegetation condition is consistent with the findings of Hewitt in his report "Aerial Spray Drift Modeling of Plan Colombia Applications" in which he states that, based on rigorous "worst-case scenario" drift modeling, "Deposition rates generally decreased with greater distance from spray release to the border, generally falling to de minimus levels within a few hundred meters from release by the aircraft". Indeed, Hewitt's findings in the aforementioned report show that for the spray lines of October 7 and 12, 2002 (which were closest to the border river in the vicinity of the Mestanza farm), the lines were at a distance of 891 and 570 meters, respectively, from the Ecuadorian bank of the border river, and the resulting deposition rates were insignificant (i.e., 1.15 g/ha and 2.71 g/ha, respectively).

3.31 Figures 8a, 8b and 8c show the next available image from January 19, 2003, captured by the SPOT satellite. These figures reveal the same areas in Colombia and Ecuador a little over three months after the previous nearby spray activities occurred on October 10, 2002. In this part of the world, vegetation grows very quickly, so even if vegetation was eradicated or harvested, other plants could well have begun to re-grow within a three-month period. In this image, the areas sprayed in Colombia in both September and October 2002 appear to show a range of responses to the defoliant (the spray lines for applications that took place earlier in Colombia in

September and October 2002 are shown in Figure 8a). In some areas on the Colombian side, the vegetation appears to have fully rebounded (see example areas labeled as “A” on Figure 8b) as indicated by a substantial increase in lush, reddish hues (which may be re- planted coca, weeds or other plant types); whereas in other areas, vegetation appears to be coming back at a slower rate as indicated by the somewhat muted or duller reddish tones on the image (see example areas labeled as “B”). In contrast, other areas appear still to be devoid of vegetation to varying degrees (see example areas labeled as “C”). These latter areas may have experienced more devastating defoliation in comparison to the other areas, or may have undergone other clearing activities in the interim such as plowing, burning or planting.

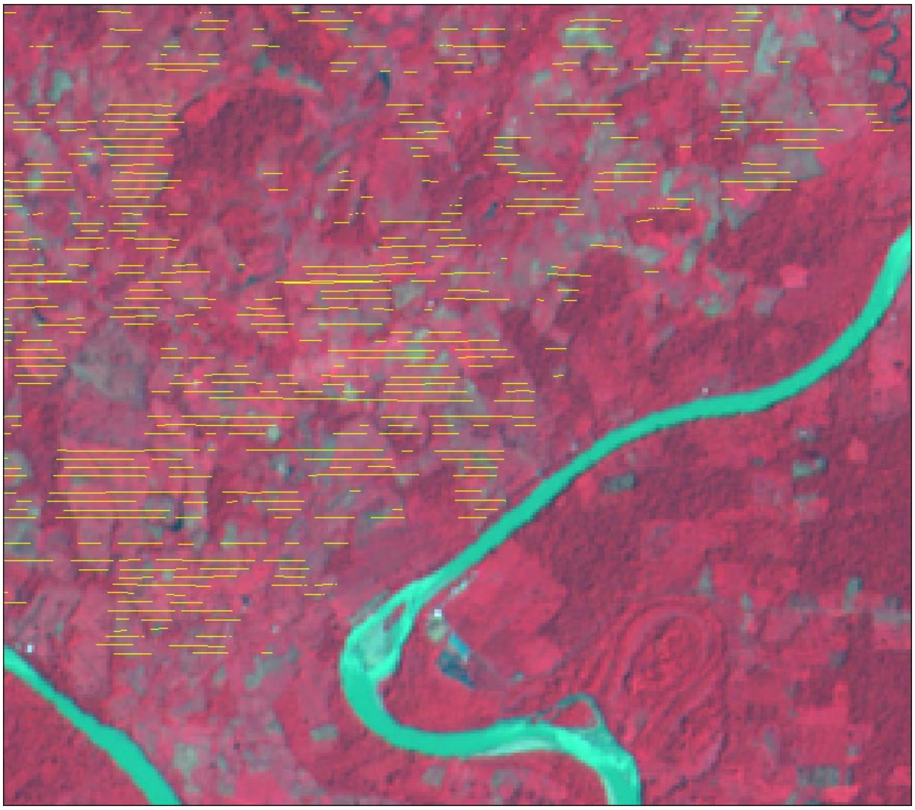


Figure 8a. January 19, 2003 (SPOT) image (with all September and October spray lines).

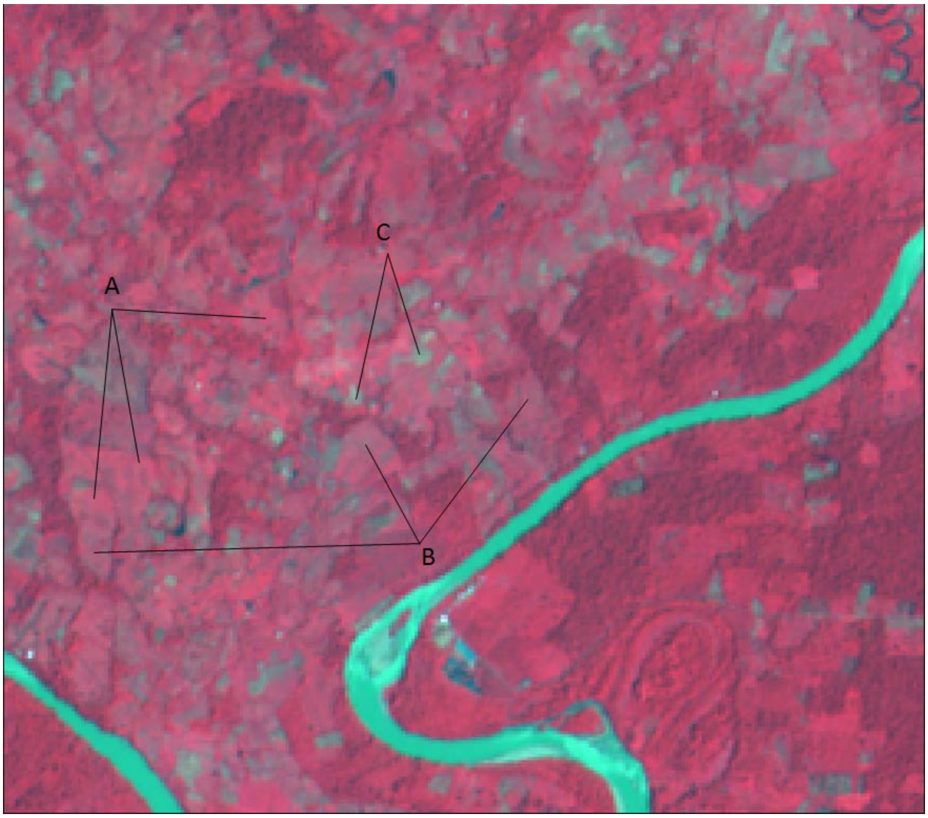


Figure 8b. January 19, 2003 (SPOT) image

3.32 On the Ecuador side of the river, the close-up image shown in Figure 8c (which corresponds to the close-ups shown earlier in Figures 4, 5c, 6c and 7c) again reveals no evidence of impacts due to previous herbicide spraying in Colombia on the Mestanza farm. One change that is obvious is that area "X" appears to have substantially more vegetation than was evident on the earlier satellite images. This could be due to growth of weeds or a newly-planted crop on that plot of land which was bare in 2002. Otherwise, I do not see any significant changes on the Mestanza farm or elsewhere on the Ecuador side of the river border.

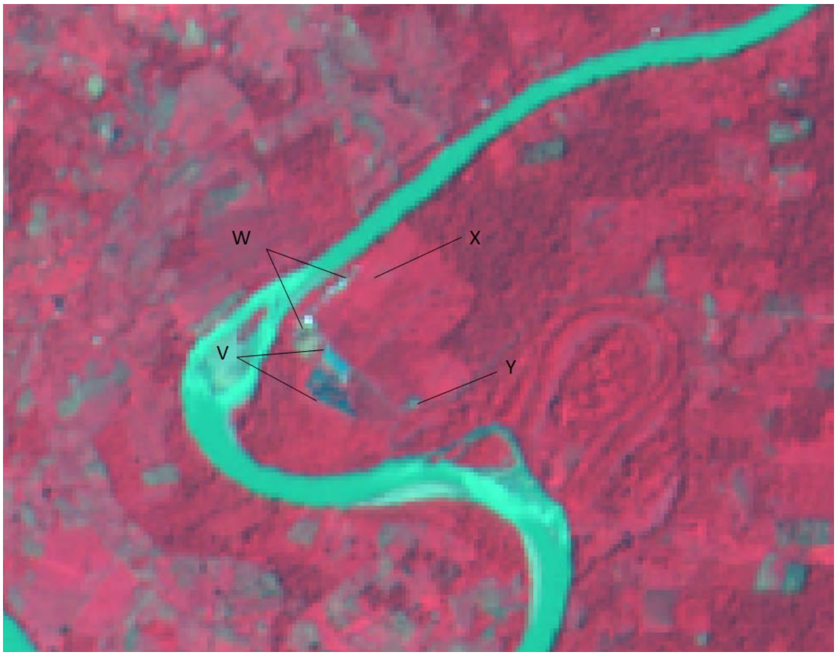


Figure 8c. January 19, 2003 (SPOT) image focused on Mestanza farm

3.33 Figure 9 is a different view of the same October 14, 2002 Landsat satellite image as shown earlier in Figures 7a - 7c, which depicts a larger geographic region (*i.e.,* it appears to be from a "higher-altitude" perspective). Depicted in this figure is a line showing the southern extent of the area in which the September and October 2002 spray activities previously took place in Colombia. This view provides an even better perspective of the considerable contrast between the areas corresponding to the location of the spraying in Colombia, which exhibit lack of vegetation, above the line and the comparatively plush vegetation below it. As explained above, the lack of vegetation in Colombia is not due solely to the illicit growing of coca because farmers do clear the land and plant and harvest other kinds of crops as well. But the coca production and successful coca eradication efforts in Colombia undoubtedly played a major role in the dramatic contrast that is evident in Figure 9.

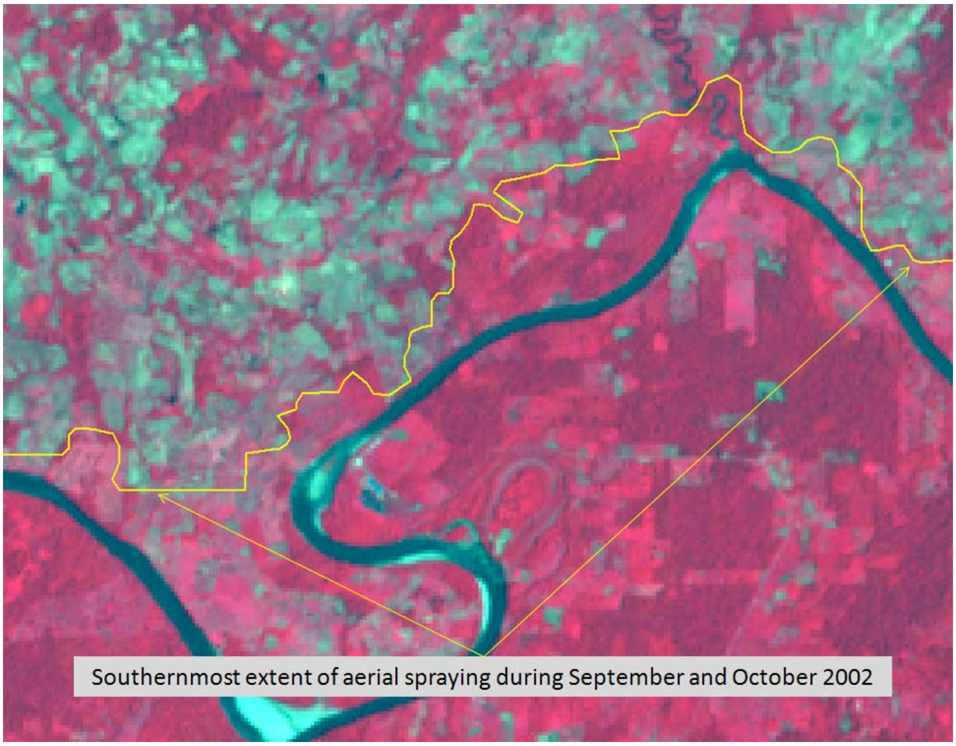


Figure 9. Enlarged "regional" view of October 14, 2002 Landsat image

3.34 In addition to the color infrared images shown in previous figures, NDVI images were also used to supplement the analyses completed for the Mestanza site as described earlier. In these images, areas with high NDVI values that correspond to ground vegetation are shown in hues of green, with darker hues generally indicating denser foliage per unit area. Areas without foliage are shown in colors ranging from dark red to orange to yellow. Dark red and orange areas tend to be water or "non-soil" surfaces such as the San Miguel River and fish ponds on the Mestanza property, and lighter oranges and yellows tend to be "vegetation-free" areas as might result from cleared agricultural areas or areas defoliated by aerial spraying.

3.35 Figure 10 is the NDVI image of the same portion of the September 12, 2002 Landsat image shown in Figure 2, whilst Figure 11 is the NDVI image that corresponds to the portion of the September 22, 2002 SPOT image shown in Figures 5a-5b. Similarly, Figures 12 and 13 correspond to the SPOT and Landsat images from October 7, 2002 and October 14, 2002, shown in Figures 6a-6b and 7a-7b, respectively. Each image shows the spray events which had taken place in the period up to the date of the image in question.

3.36 It is to be noted that the annotations shown on these images are the same as those shown on their corresponding color infrared images. The slight difference in the "brightness" of the colors between the NDVI images derived from the Landsat images and those derived from the SPOT images is due to the fact that, although each satellite type has "visible" and "near infrared" channels that are required for producing NDVI images, the two satellite systems have different sensors that capture slightly different portions of the electromagnetic spectrum, thereby resulting in slightly different "brightness" values.

3.37 As shown in these figures, it can be seen that defoliation due to aerial herbicide spraying on the Colombian side of the border generally trends from north to south due to the sequence in which the September and October 2002 spray events occurred, and that the vegetated and defoliated areas in these images correspond closely with these same areas illustrated in the color infrared images used in the previous figures for each date. Further, it can be seen that during the September-October time frame illustrated by these images, there is no evidence of defoliation occurring on or around the Mestanza property.

3.38 As a result of the above analysis, my expert opinion is that while changing levels of vegetation may be observed in the Republic of Colombia in 2002-2003 in the immediate area of – and in the weeks immediately following – the September and October 2002 PECIG spraying operations, there are no similar changes in vegetation reflected on the Ecuadorian side of the river in the area of the Mestanza farm.

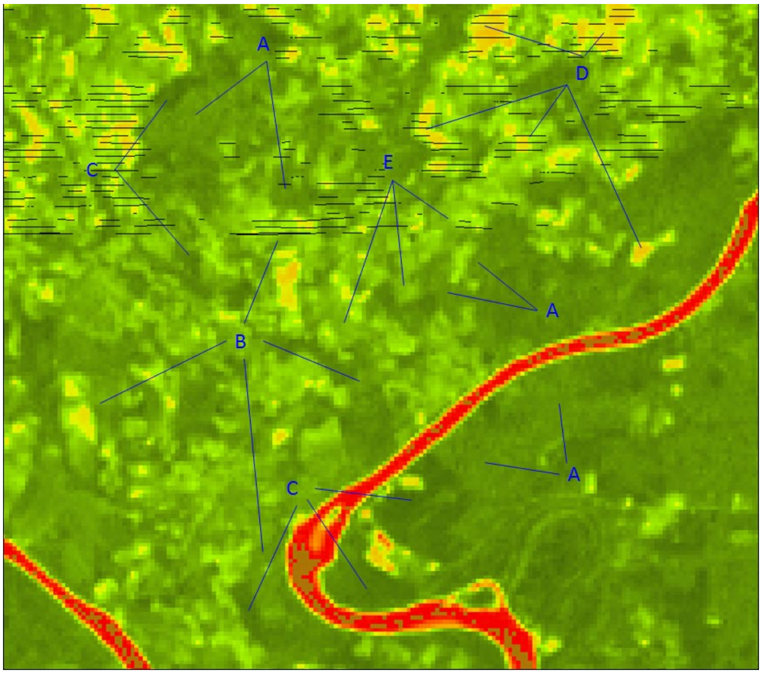


Figure 10. NDVI image for September 12, 2002.

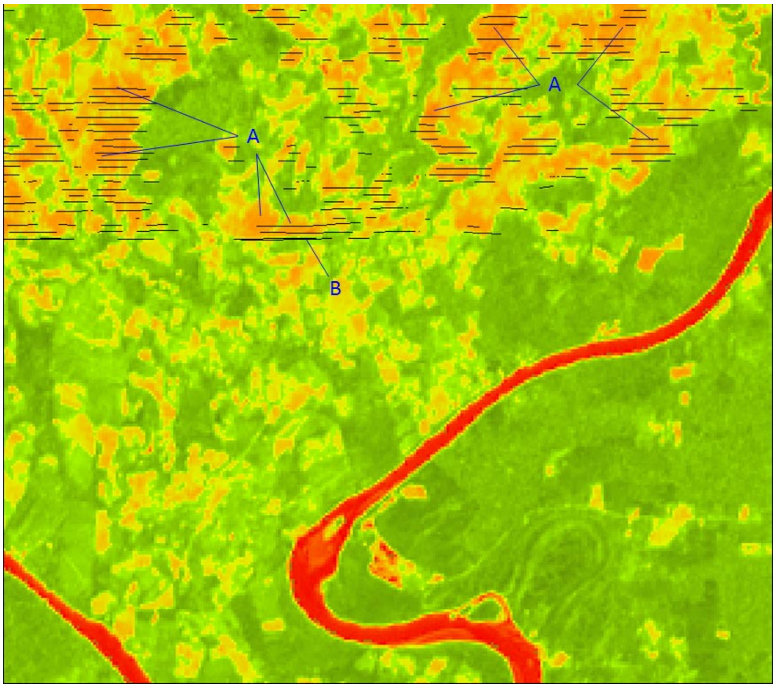


Figure 11. NDVI image for September 22, 2002

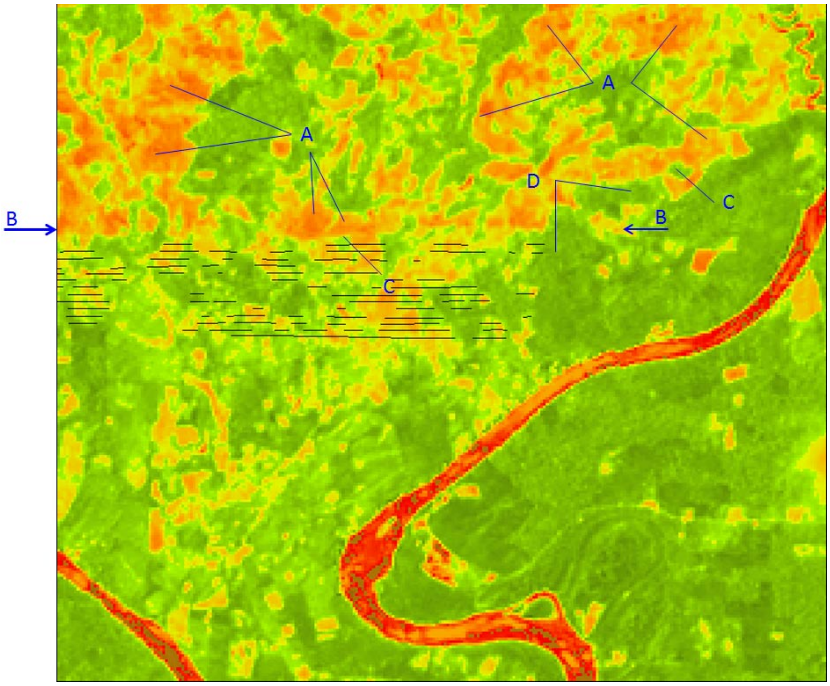


Figure 12. NDVI image for October 7, 2002.

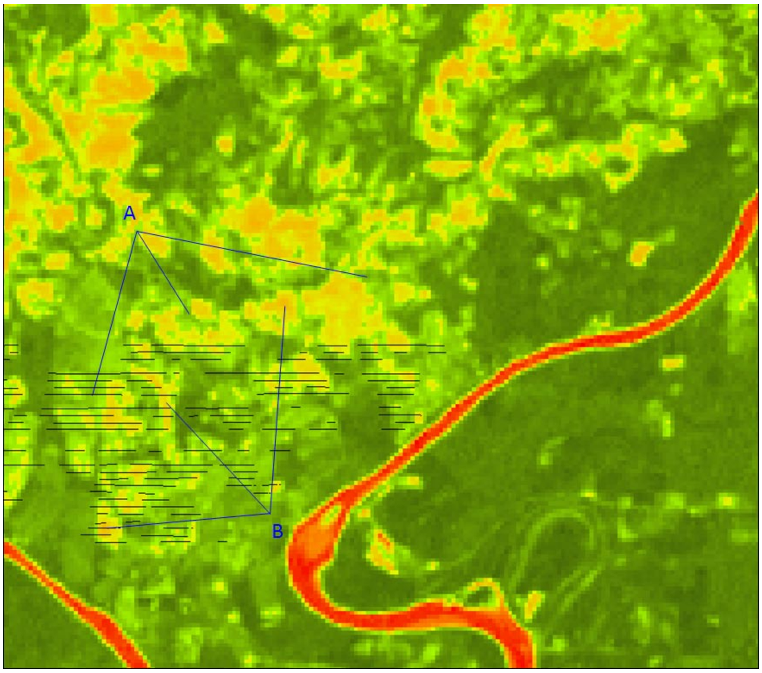


Figure 13. NDVI image for October 14, 2002.

Site 2: Cofán Area

3.39 Since less is known about the exact locations of alleged problems associated with spray events near the Cofán-Bermejo Ecological Reserve, located approximately 40 km to the west of the Mestanza site, a less site-specific analysis was conducted for this area. However, a similar approach was utilized in terms of evaluating conditions on the ground before and after spray events completed in Colombia as part of PECIG via the analysis of satellite images. That is, the satellite images as described previously for the Mestanza site were used to evaluate "before" and "after" conditions for the general area of the Cofán-Bermejo Ecological Reserve. In this case, however two of the images used in the Mestanza site analysis (the September 22, 2002 and January 19, 2003 SPOT images) were not available for the Cofán area (i.e., the images from the SPOT satellite did not extend that far west). However, another SPOT image from February 19, 2003 was used as described later. Therefore, the September 12 (Landsat), October 7 (SPOT), and October 14 (Landsat) images described for the previous site were utilized in this particular analysis, as well as the newer SPOT image from February 19, 2003. The late September 2002 time frame was the period during which the most intensive spraying that was closest to the Cofán-Bermejo Ecological Reserve took place in Colombia.

3.40 Prior to doing the analysis for this site, it was first necessary to define a more specific study area upon which subsequent evaluations could be focused. As described below, this was done based on the spatial extents of the satellite images used, information provided by Cofán witnesses on alleged spray damages, and the dates of aerial spraying that occurred in the vicinity of the Cofán-Bermejo Ecological Reserve.

3.41 As testified by various individuals in the Cofán witness statements (i.e., Witness 26 in Annex 210 to Ecuador's Memorial, Witness 27 in Annex 211, Witness 29 in Annex 213, and Witness 31 in Annex 215), all of these individuals resided within the Cofán-Bermejo Ecological

Reserve during the period within which various damages due to unspecified aerial spraying events are alleged to have occurred. The exact locations where these individuals lived within the Reserve are unknown as such information was not provided in the Annexes mentioned above, nor has such information been otherwise provided to me.

3.42 Figure 14 shows the September 12, 2002 Landsat image that covers the region around the Cofán-Bermejo Ecological Reserve. Shown in black on this image is the boundary of the Reserve itself. Shown in blue are the western and southern limits of the October 7, 2002 SPOT satellite image that was used in the analysis for this site. Also shown in yellow are the spray lines which took place in the general time period covered by the three primary satellite images used (i.e., September 12 up to October 14, 2002). More specifically, these spray lines on Figure 14 indicate spray events that occurred during August and September of 2002 (there was no aerial spraying in this area after September in 2002). The labeled group of spray lines just north of the river that defines the border between Colombia and Ecuador, as well as constituting the northern boundary of the Reserve, show aerial spraying that occurred on September 22 and 26 of 2002. The remainder of the spray lines shown to the north and east are spray events that took place between August 1 and September 22 of 2002.

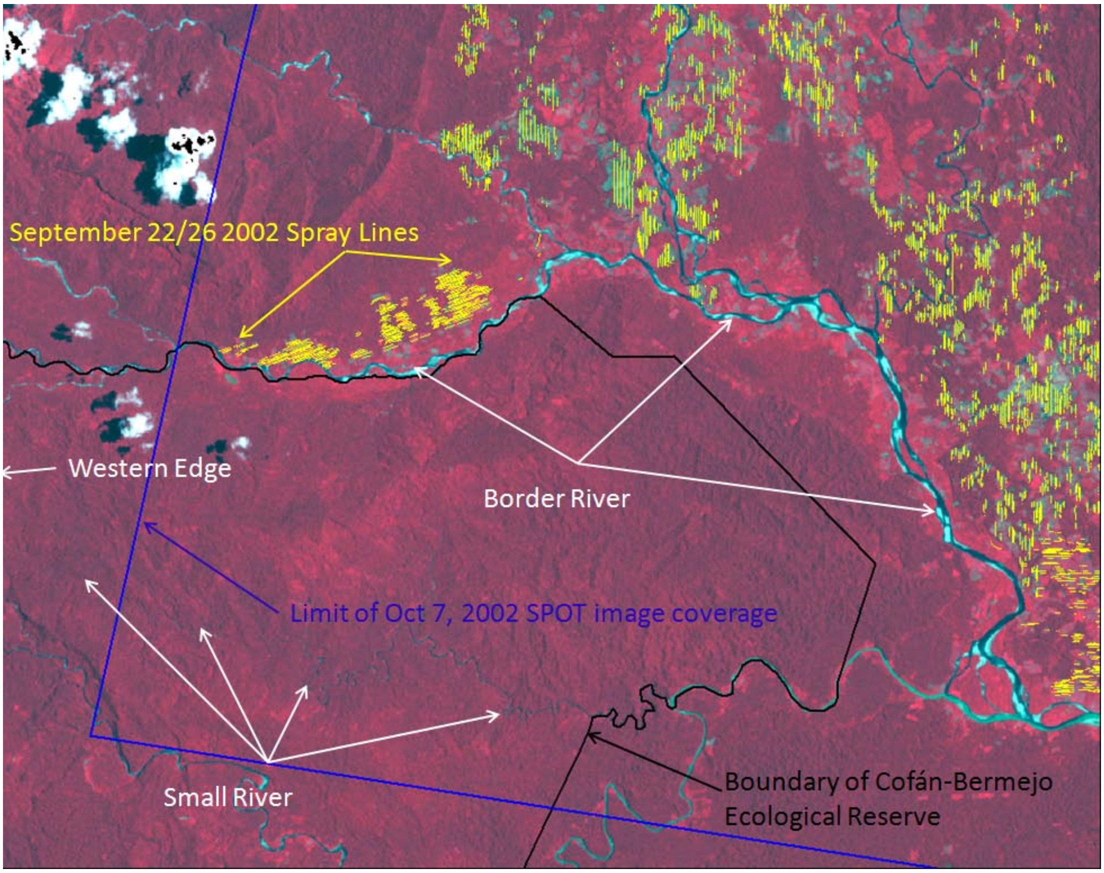


Figure 14. Information pertaining to the Cofán study site.

3.43 Based on the above information, the area upon which my image analysis was focused for the purposes of the "Cofán" site analysis was the geographic limit of the Reserve boundary to the east and north (shown in black in Figure 14), the small river running more or less west-to-east to the south (this small river can be seen more clearly on the image in Figure 16 that is discussed later), and the western edge of the image shown in Figure 14. The area of focus was limited to areas within the Reserve boundary since all of the Cofán witnesses identified above testified that they resided within the Reserve. This study area is presumed to include all of the communities near the river that defines the Colombia-Ecuador border within which the Cofán witnesses resided. However, this cannot be ascertained with absolute accuracy since, as described above, the exact locations where each of the witnesses resided is unknown by me. Although the boundary of the Reserve does extend to the west as shown in Figure 14, the study area boundary identified is assumed to be reasonable give the large geographic area encompassed by it (approximately 16,000 hectares), as well as by the fact that no aerial spray lines were recorded to the west of those identified in the figure as occurring on September 22 and 26 of 2002. This latter group of spray lines includes the nearest sites in Colombia at which aerial spraying occurred during the time period covered by the three satellite images, as well as areas up to approximately 10 kilometers away from the river in Ecuador.

3.44 Shown in Figure 15 is the same Landsat image shown in Figure 14, minus the annotations, that was acquired on September 12, 2002. For comparison purposes, Figure 16 shows the SPOT image acquired on October 7, 2002. For context, the geographic area encompassed by each image is approximately 21 by 27 kilometers or 56,000 hectares. From these color infrared images, it can be seen that many plots of land north of the border in Colombia are devoid of vegetation as indicated by the characteristic light blue-gray hues. Many of these areas are presumed to be the result of aerial herbicide spraying as they are directly under spray lines as illustrated earlier in Figure 14.

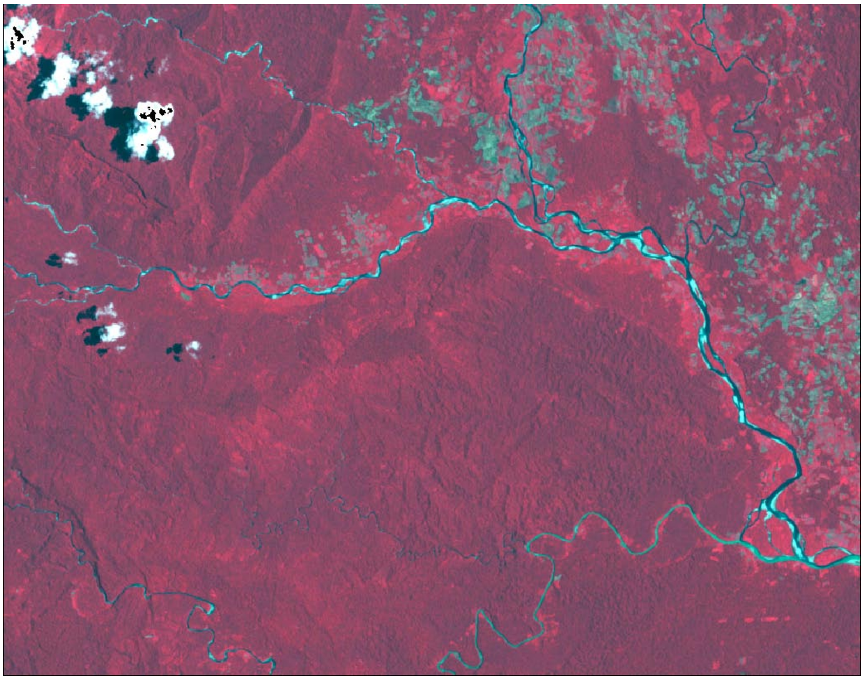


Figure 15. September 12, 2002 Landsat image.

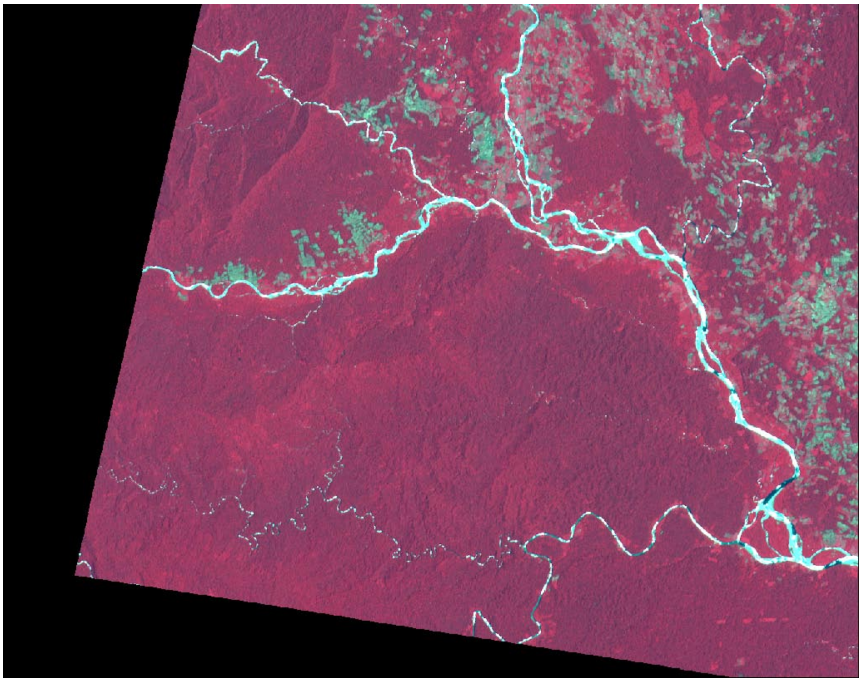


Figure 16. October 7, 2002 SPOT image.

3.45 Upon reviewing the September 12 and October 7 color infrared images shown in Figures 15 and 16, respectively, it was noticed that those areas of Colombia that were sprayed prior to September 12, 2002 showed up more distinctly on the September 12, 2002 Landsat image shown in Figure 15 (i.e., had brighter blue-gray hues) than those areas that were sprayed after September 12. The approximate locations of these groups of spray lines (highlighted in green) are shown in Figure 17. In the September 12 image (Figure 15), more reddish hues indicative of ground vegetation are evident in the image in the areas sprayed prior to September 12, as contrasted with these same areas in the October 7 image (Figure 16). In the later image, from October 7, more evidence of defoliation is present on the Colombian side in areas in which spraying took place after September 12 (i.e., more extensive areas of blue-gray hues), thereby suggesting that the spraying after September 12 was successful in these areas.

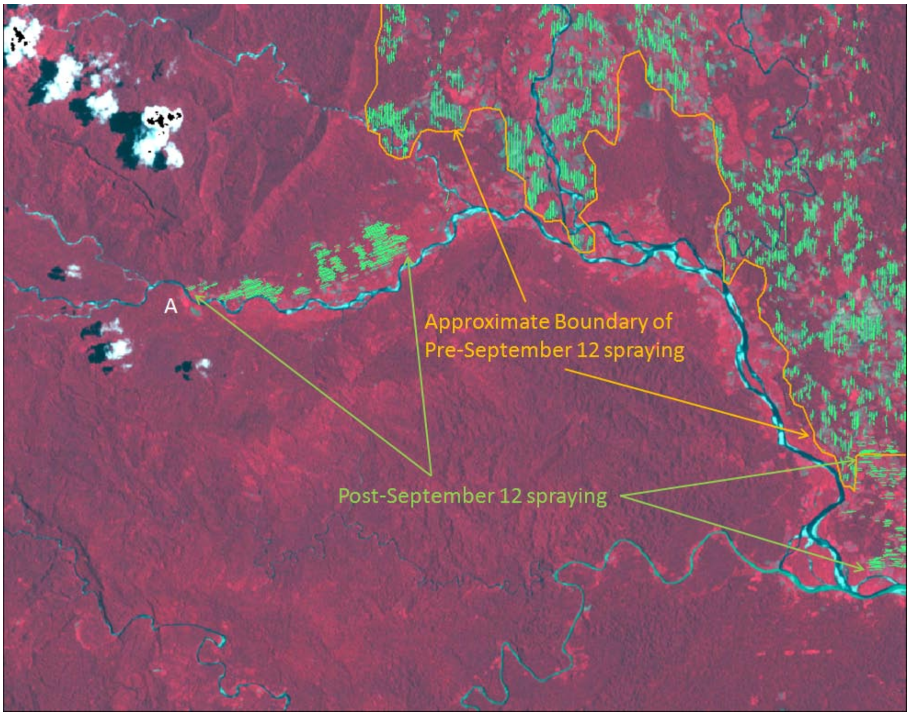


Figure 17. Locations of spray lines for different time periods superimposed on September 12, 2002 Landsat image.

3.46 For comparison purposes, color infrared renditions of the October 14, 2002 Landsat image and the February 19, 2003 SPOT image are shown in Figures 18 and 19, respectively. From these images, one can see that vegetation conditions in Colombia between October 7 and 14 have not changed substantially. However, by February of 2003, many of the areas appearing as "vegetation-free" in the October images are reverting back to a greater degree of vegetative cover similar to the conditions exhibited in September of 2002. (Note that many of the features in this image are obscured by cloud cover).

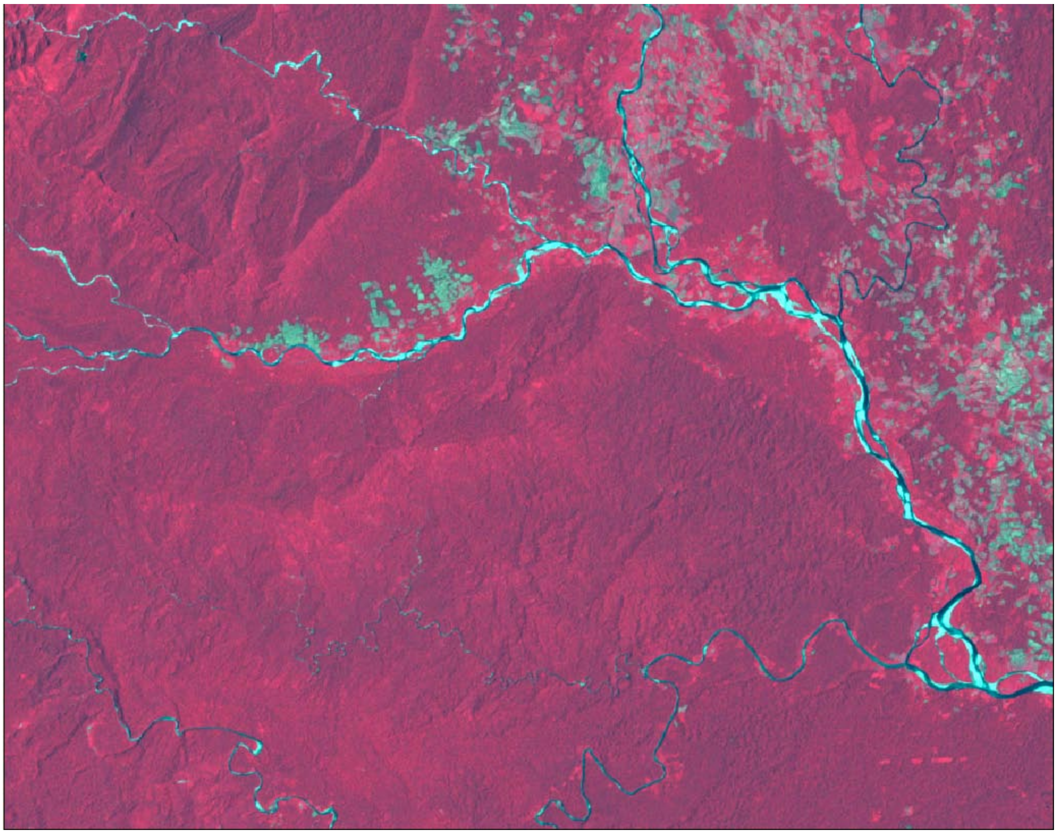


Figure 18. October 14, 2002 Landsat image.

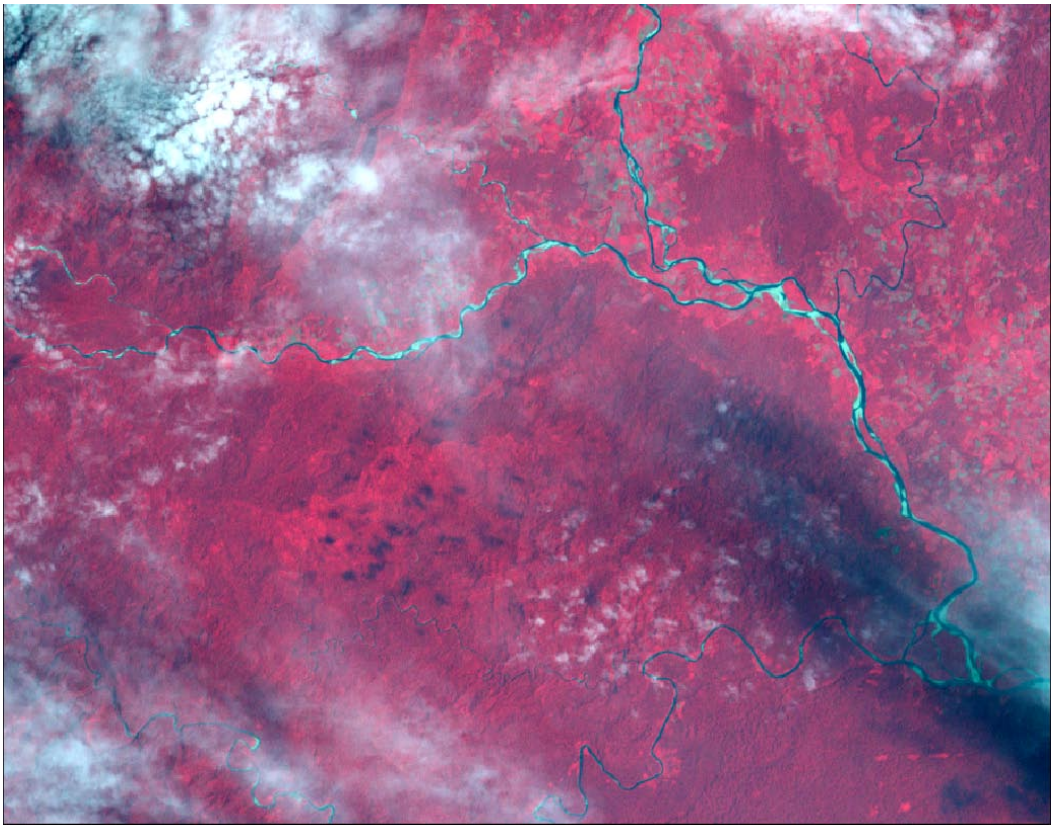


Figure 19. February 19, 2003 SPOT image.

3.47 As part of the analysis of the Cofán study area, a careful "close-up" review was made using the images shown in Figures 15 through 19 of all the land areas within the boundaries of the Cofán study area described earlier to see if there were any changes in vegetation (i.e., from a vegetated to a non-vegetated condition) similar to those seen in Colombia. Based upon this review, no evidence of similar vegetation changes within the entire area of approximately 16,000 hectares could be found, with the exception of one small area located close to the river that separates Ecuador and Colombia. That small area was located in the vicinity of spray lines which had been sprayed in Colombia on September 22, 2002. The general location of this area is indicated by the “A” in Figure 17. Hewitt’s findings in his report “Aerial Spray Drift Modeling of Plan Colombia Applications”, for the spray lines closest to the Ecuadorian bank on the border river in the vicinity of this small area, resulted in the following deposition rates at the Ecuadorian bank of the river, which were close to zero:

Row 22: line of 22 September 2002, Distance to the Ecuadorian bank on the border river: 169 meters, Deposition: 0.633 g/ha
Row 47: line of 22 September 2002, Distance to the Ecuadorian bank on the border river: 123 meters, Deposition: 0.137 g/ha
Row 57: line of 22 September 2002, Distance to the Ecuadorian bank on the border river: 117 meters, Deposition: 0.0673 g/ha
Row 21: line of 22 September 2002, Distance to the Ecuadorian bank on the border river: 86 meters, Deposition: 0.637 g/ha

Therefore, it is not technically possible to attribute the observed vegetation change to the sprayings conducted in Colombia.

3.48 An enlarged view of the area described above is given in Figure 20 which shows conditions as seen on the September 12, 2002 Landsat image as well as indicating the location of the spray lines in late September 2002. In this case, the particular focus of interest is a roughly one-half hectare area, again indicated by the annotation “A”. On this image, the area can be seen to have bright reddish hues indicative of low-lying vegetative cover; whereas in the October 7, 2002 image shown in Figure 21, the hues in this area have changed to shades of blue-gray indicating a change in vegetative cover during the intervening period. This change, however, is very likely due to some other activity such as harvesting or clearing since the vegetation surrounding it continues to exhibit bright reddish hues in the image, which suggests relatively healthy vegetation. This assumption is supported by the fact that areas immediately adjacent to the three westernmost spray lines across the river (see “C” in Figure 21) are still relatively healthy as indicated by the reddish hues, which is in sharp contrast to the defoliated area under these spray lines within Colombia.

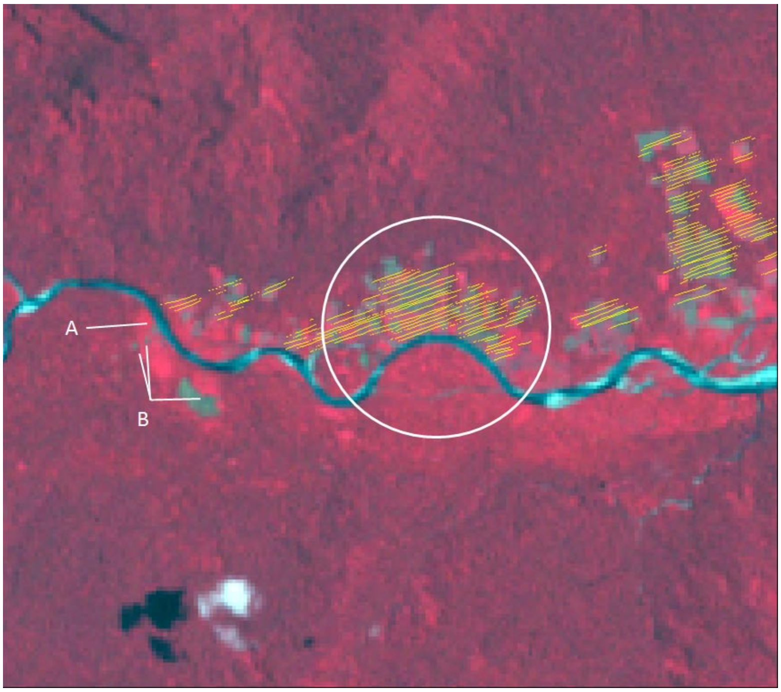


Figure 20. Enlarged portion of September 12, 2002 Landsat image near Site "A".

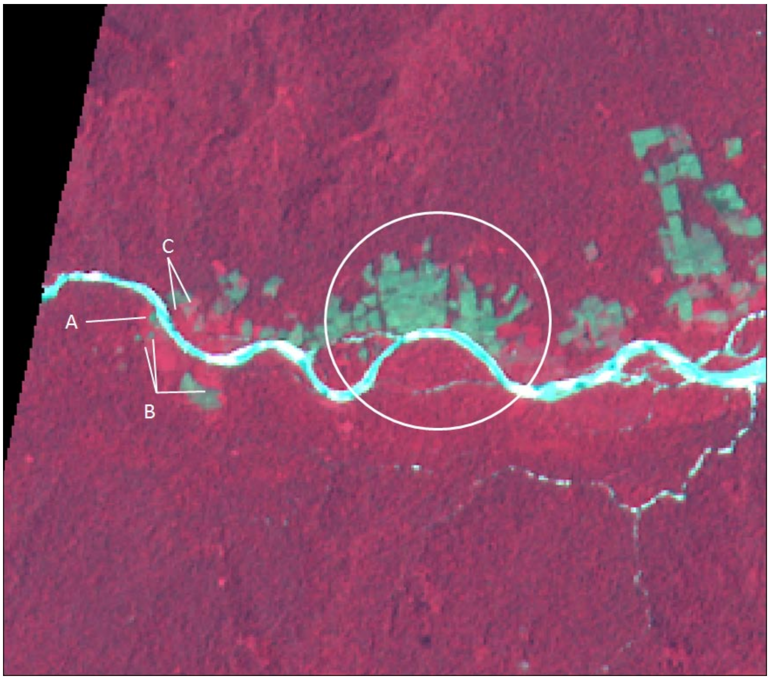


Figure 21. October 7, 2002 SPOT image.

3.49 Area “A” is similar in appearance to three other areas exhibiting blue-gray hues that can be seen nearby as indicated by annotation “B” in Figure 20. As evident from this figure, these latter areas were “vegetation-free” on or before September 12, 2002; therefore the apparent lack of vegetation could not be due to any aerial spraying that occurred on September 22 or 26 of 2002, and is likely due to normal planting/clearing/harvesting activities. Figures 22 and 23 show close-ups of the same area as seen in the previous two figures, as depicted on the October 14, 2002 Landsat image and the February 19, 2003 SPOT image, respectively. As can be seen in Figure 22, the conditions described for site “A” for October 7 are still evident on October 14, 2002. As evident from Figure 23, however, this area appears to have developed vegetative cover by February of 2003.

3.50 Another example of the precise “targeting” nature of aerial herbicide applications in Colombia is illustrated by the white circle in Figures 20 through 23. From the drastic change in vegetative conditions noticeable on the Colombian side from September 12, 2002 to October 7, 2002, one can see how the intensive aerial spraying has essentially obliterated the vegetation (presumably coca plants) in areas underneath the September 22 and 26 spray lines. However, in the forested area south of this spraying, only tens of meters away across the river, there is absolutely no indication of any ill effects from the spraying as would be indicated by a loss of leaves. Such a change would appear on the images as a change from reddish to blue-gray hues as demonstrated in previous image examples. In this case, the relatively lush reddish hues are indicative of healthy vegetation, and the area remains essentially unchanged from September 12, 2002 through February 19, 2003.

3.51 Consequently, in the Cofan study area, no evidence of defoliation caused by aerial herbicide spraying during August and September of 2002 could be found.

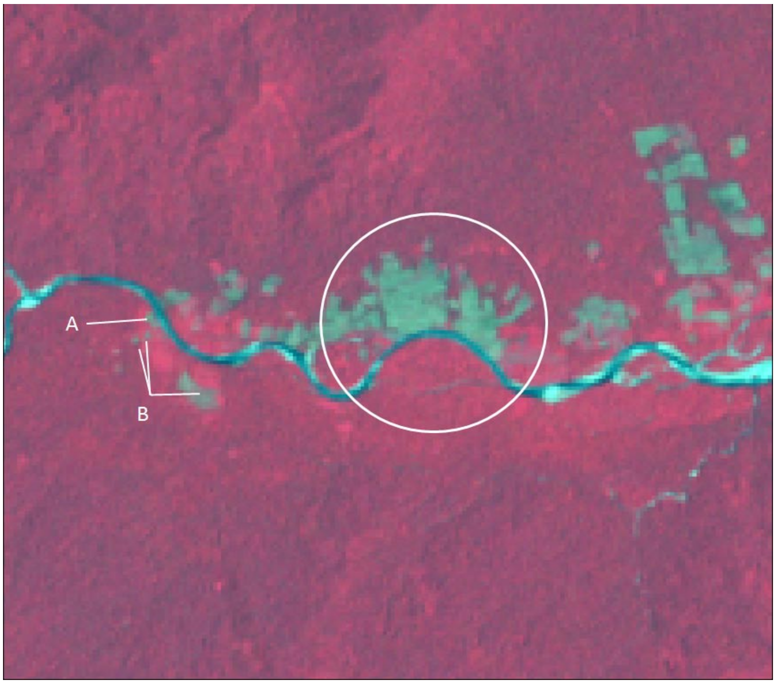


Figure 22. October 14, 2002 Landsat image.

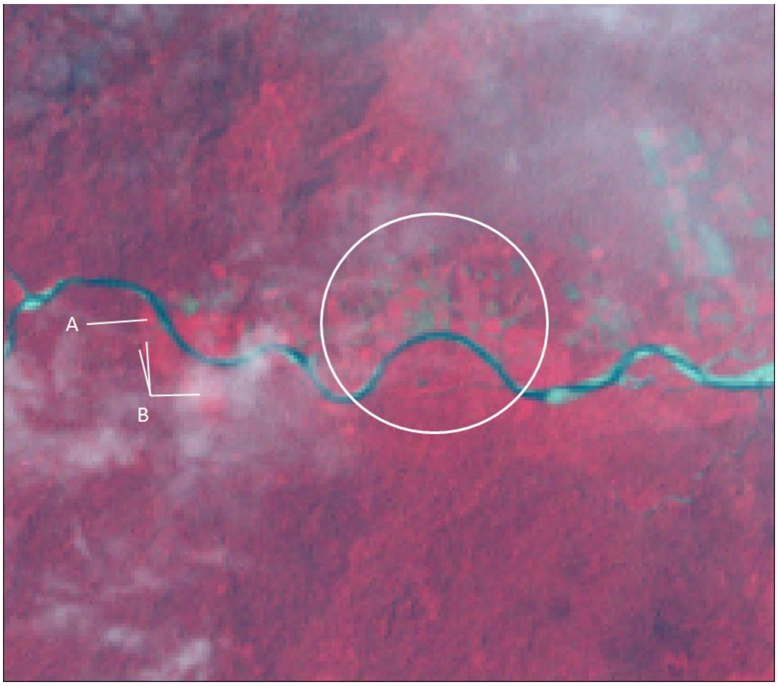


Figure 23. February 19, 2003 SPOT image.

Site 3: San Francisco I & II Area

3.52 I was provided with a GIS map showing the location of the communities of San Francisco I and San Francisco II. In the witness documents given to me, six (6) witnesses living in or around the communities of San Francisco I and II provided testimonies related to alleged aerial spraying activities in Colombia for varying periods of time. Four of these witnesses also provided descriptions of the approximate locations of their homes and/or farms with respect to the border with Colombia. Witness #12 described having a 35-hectare farm about 2 kilometers from the border (Annex 200); Witness #13 described having a 52-hectare farm about 3 kilometers from the border (Annex 201); Witness #14 described having a 55-hectare farm less than 2 kilometers from the border (Annex 202); and Witness #18 described working on a farm about 1 kilometer from the border (Annex 204). Further, I am informed that Witness #11 is the sister of Witness #12, and apparently lives at the same location.

3.53 Based on the above information, a study area on which analytical efforts for this site could be focused was developed. This area, shown in white in Figure 24, is centered on San Francisco I and II (shown as green dots in the figure). The boundary of this area (which is approximately 5,046 hectares in size) extends about 1.8 kilometers south of these two communities, and a little over 4 kilometers on either side. Depending on the exact location, the southern boundary of this area is approximately 4 to 8 kilometers away from the San Miguel River, which serves as the border between Ecuador and Colombia in this region. In creating this area, an attempt was made so far as possible to not include other known communities located close to San Francisco I and II (shown as blue dots in Figure 24).

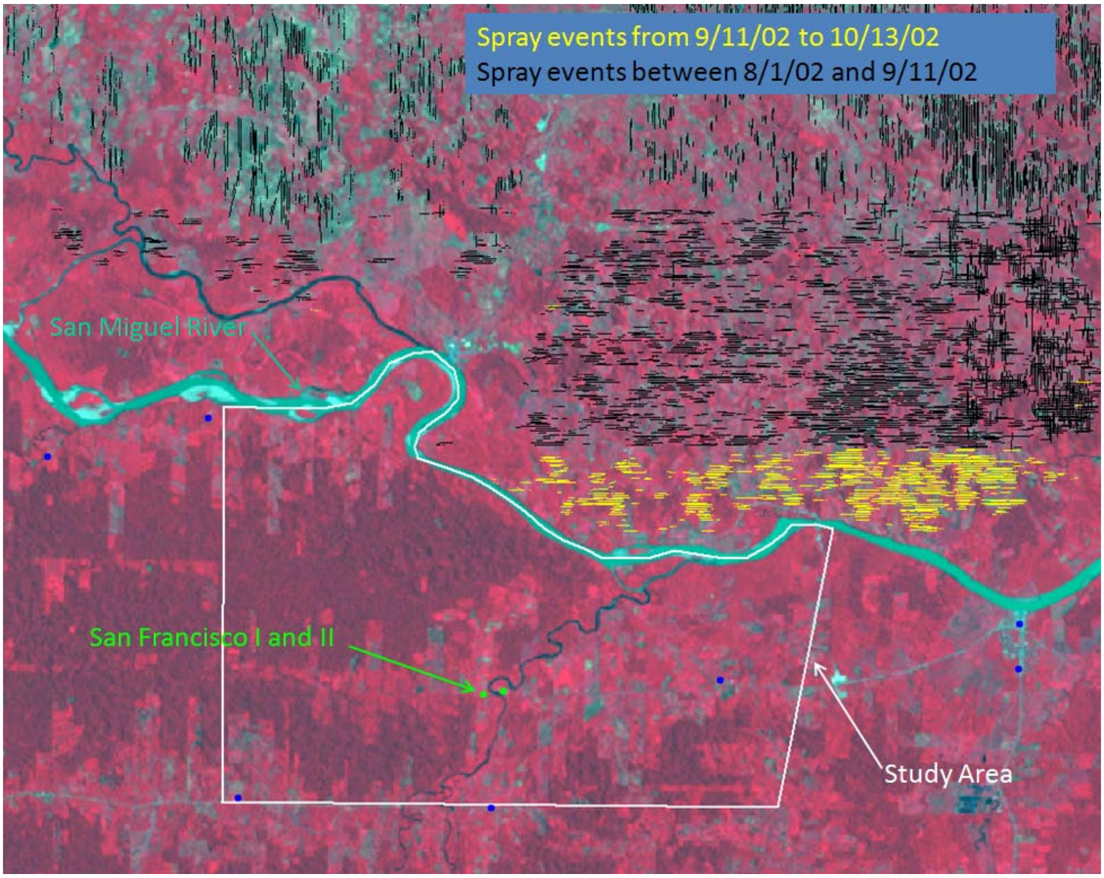


Figure 24. San Francisco study area.

3.54 As described previously, a number of satellite images were evaluated with respect to their utility in depicting vegetation conditions before and after aerial spraying activities that took place to the north of the San Miguel River in Colombia. For this particular area, the only satellite images that were available (and usable given recorded spray dates) include those for September 12, 2002 (Landsat), October 7, 2002 (SPOT), and October 14, 2002 (Landsat). In this case, the January 19 and February 19, 2003 SPOT images used for the two previous sites (Mestanza and Cofán) did not extend out far enough to cover the San Francisco I and II study area; neither were there other SPOT, Landsat or other satellite images available for these or similar dates in time.

3.55 Given the dates of the satellite images available for this area, the aerial spray dates considered for the analysis performed were those events that occurred in nearby areas of Colombia during the period between September 12, 2002 and October 14, 2002. This was done under the assumption that given the typical "cause and effect" lag time between spray events and observed defoliation effects (i.e., days to several weeks), any vegetation effects that might be caused by spraying activities on or about September 12 through early October would be noticeable by the date of the October 14 image.

3.56 Also shown in Figure 24 (in black and yellow) are spray lines representing aerial spray applications that occurred in Colombia as part of PECIG within the vicinity of the study area during 2002. Those lines shown in yellow depict spray applications that took place between September 11 and October 13, 2002 (i.e., one day before the first and last dates of the satellite images). Within this interval, spraying occurred on 15 different days, with the first and last day being September 11 and October 13, respectively. These lines are generally within a few kilometers of the northern edge of the study area depicted in Figure 24. Those lines shown in black depict spray applications that took place between August 1 and September 11, 2002.

3.57 Using the three satellite images described above for this area, an analysis was conducted to identify and quantify vegetation changes that occurred within the study area from September 12 to October 14, 2002. Specifically, the satellite images were analyzed to evaluate the extent of vegetated versus non-vegetated areas based on the presence/absence of reddish and blue-green hues within the color infrared images as described previously for other study sites.

3.58 In the witness documents referenced earlier (Annexes 199, 200, 201, 202, 204 and 205), it was alleged by a number of witness that aerial spraying on the other side of the border resulted in rather rapid and dramatic damages to crops and plants in the area surrounding San Francisco I and II. Examples of such statements by the witnesses include:

- "…shortly after the smoke of the planes visited us for the first time, and every time after that, all the plants dried up." (Witness 11, Annex 199)
- "After the sprayings, the crops dried up. The plants started turning yellow and then black until all was lost." (Witness 12, Annex 200)
- "Approximately two weeks after the spraying, I went to the farm and I saw that the field was dry and yellow. Little by little the plants turned yellow. This was the first time that this had happened to me; the whole harvest was ruined." (Witness 13, Annex 202)
- "The rice and maize were the most affected. Coffee could not produce either. It was incredible, never before had we seen all the plants die at the same time. All of them turning yellow and dry." (Witness14, Annex 202)
- "But, during those days, all the plants were affected, from pasture to fruit trees. Nothing survived." (Witness 18, Annex 204)
- "When the first spraying occurred, I was at my house. In the sky, above the bank of the river, there were two planes and two helicopters. Shortly after they sprayed, all the plants died." (Witness 19, Annex 205)

3.59 If one were to assume that the above allegations as to the effects of the spraying were true, then one would expect to see evidence of such vegetation losses in the area surrounding San Francisco I and II shortly after nearby aerial spraying operations in Colombia were completed. So for example, during the period September 12, 2002 to October 14, 2002, one would expect to see an extensive portion of the landscape visible on the satellite images change from bright, reddish hues (indicative of lush ground vegetation) to various shades of blue-green (indicative of defoliation and plant loss). As described below, a satellite image analysis of this type was performed to see if evidence of such vegetation change occurred.

3.60 In the first phase of this analysis, the color infrared satellite images from September 12 to October 14, 2002 were visually inspected to identify parcels of land on the order of one-half hectare and larger where changes in vegetation condition had occurred. This included changes from both a vegetated to non-vegetated condition (as would be reflected by shifts from reddish hues to blue-green hues), as well as from a non-vegetated to a vegetated condition (as indicated by a reverse shift in hues). Upon having completing this analysis, it was found that a number of changes in both directions could be identified within the study area.

3.61 Figures 25 through 27 show an enlarged view of the study area presented earlier in Figure 24 with underlying satellite images for September 12, 2002, October 7, 2002, and October 14, 2002, respectively. Note the quite dramatic defoliation effects evident in the latter two images in Colombia across the river from the study area in Ecuador (where such effects are not evident) that were presumably caused by aerial herbicide applications completed in August and early September of 2002. Note also that the SPOT image available for October 7 did not extend far enough to cover the entire study area. This, however, did not affect the analysis in this case since the conclusions are primarily based on the vegetation differences evident between September 12 and October 14.

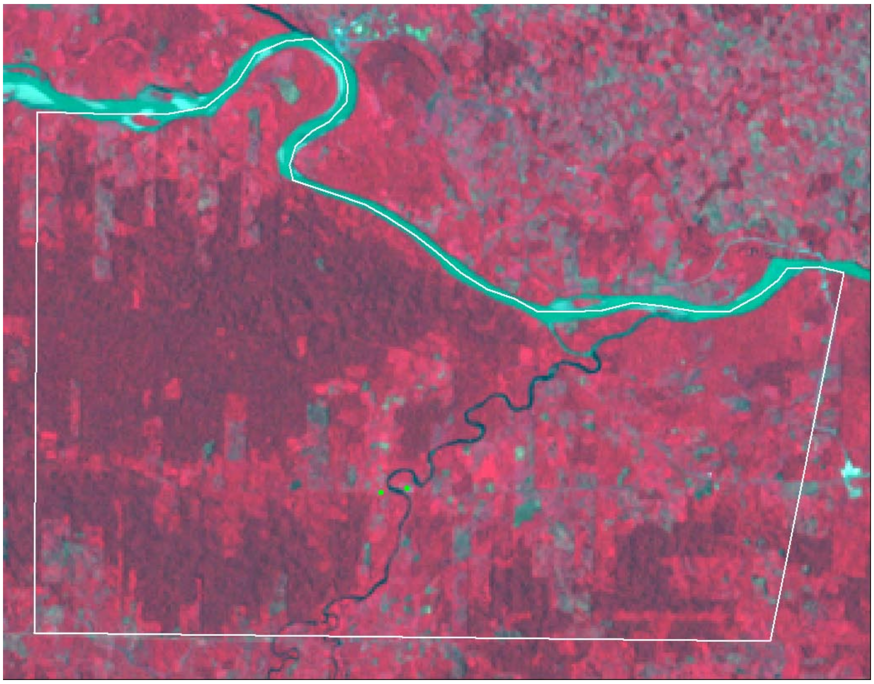


Figure 25. Study area on September 12, 2002 Landsat image.

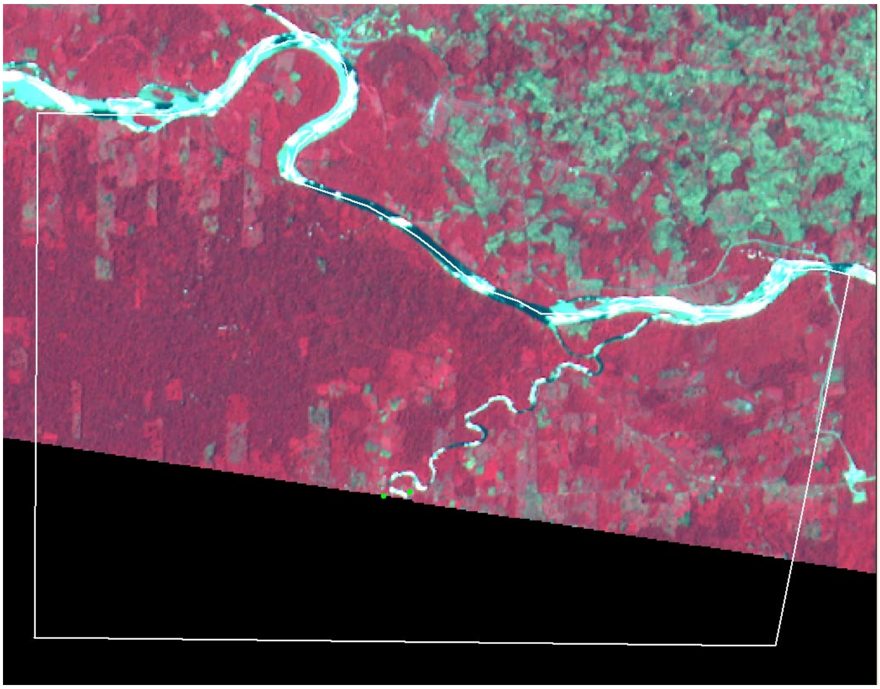


Figure 26. Study area on October 7, 2002 SPOT image.

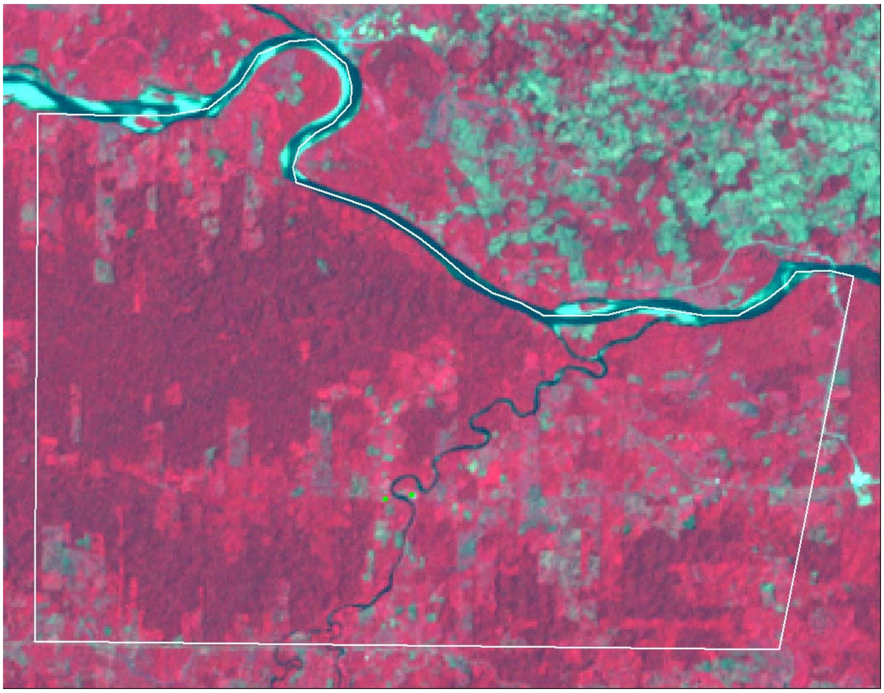


Figure 27. Study area on October 14, 2002 Landsat image.

3.62 Figure 28 shows the last image (from October 14) with additional graphics summarizing the results of the “vegetated vs. non-vegetated” analysis outlined above. In this instance, the black dots represent parcels of land where conditions have changed from vegetated to non-vegetated during the period from September 12 to October 14, 2002; whereas white dots represent parcels where the opposite change has occurred during the same period. In all, 58 “parcels” had changed from vegetated to non-vegetated, and 30 had changed from non-vegetated to vegetated. The results of this initial analysis strongly suggest that the dramatic changes alleged to have occurred by residents in the area (see Section 3.58) did not occur; particularly since vegetation changes are typically expected to occur in this region due to normal crop cultivation activities as described in a later section. To further quantify such changes in the study area, a supplemental approach involving the use of NDVI images as described in Sections 3.9 and 3-10 (and used for the Site 1 analysis) was also conducted.

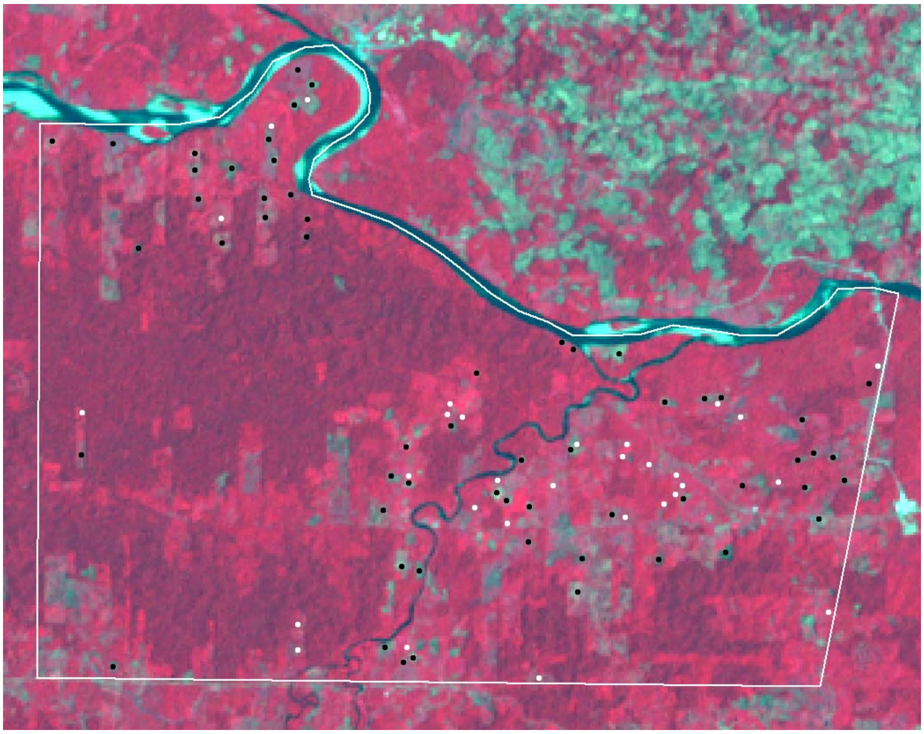


Figure 28. Parcels where vegetation changes have occurred (black = vegetated to non-vegetated, white = non-vegetated to vegetated). Image shown is Landsat from October 14, 2002.

3.63 As described previously, NDVI images are calculated to range from -1 to +1, with values greater than 0.2 corresponding to vegetation, and values less than 0.2 signifying non-vegetated surfaces (see Sections 3.9 and 3.10). Figures 29 and 30 depict NDVI images derived from the September 12, 2002 and October 14, 2002 Landsat images, respectively. (Note: the middle October 7 image was not used in this case since a full image is needed to perform the analysis detailed below).

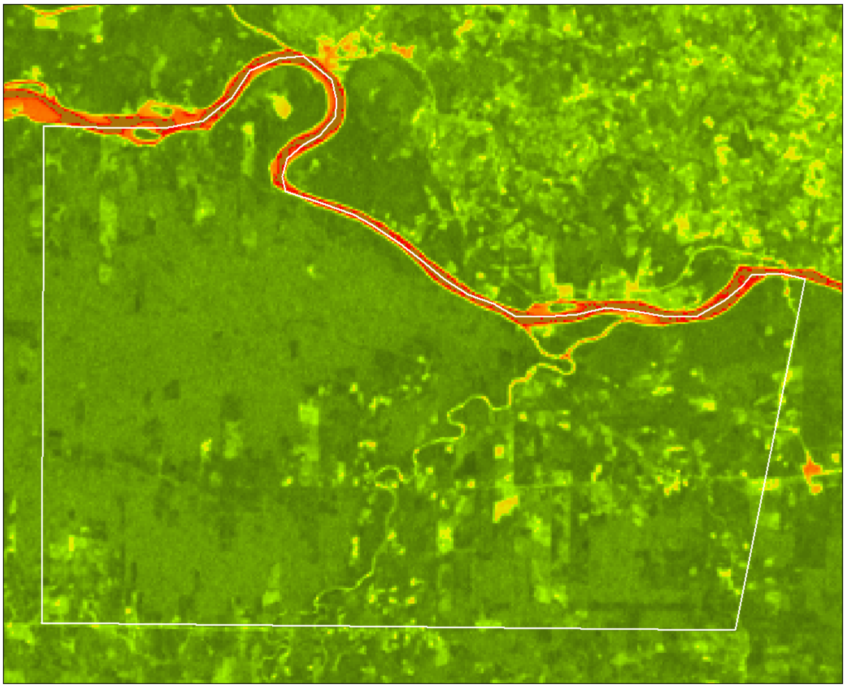


Figure 29. NDVI image derived from September 12, 2002 Landsat.

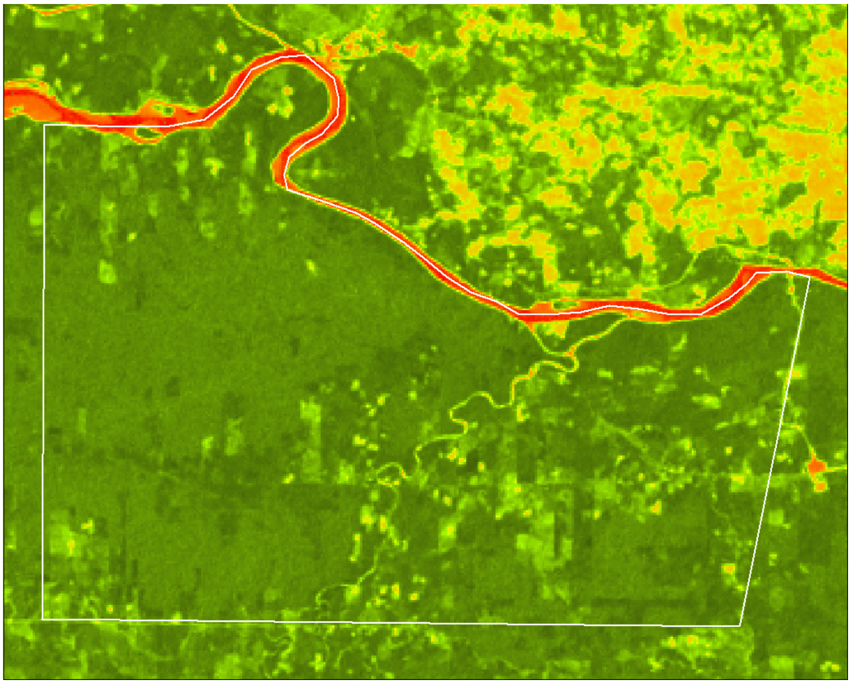


Figure 30. NDVI image derived from October 14, 2002 Landsat.

3.64 For the purposes of trying to better quantify vegetation changes in the study area, these two NDVI images were simplified to create two new "vegetation" maps that only show vegetated versus non-vegetated surfaces. This was done by re-classifying all NDVI values greater than or equal to 0.2 for each image date to be equal to "1", and all values less than 0.2 to be equal to "2". A new "difference" map was then generated by tracking how the above values had changed from the earlier map to the later one. The four possible change combinations include: 1) no change - type 1 (i.e., non-vegetated areas remain non-vegetated), 2) no change - type 2 (i.e., vegetated areas remain vegetated), 3) change from vegetated to non-vegetated, and 4) change from non-vegetated to vegetated. This new map effectively describes the magnitude of the vegetation changes that occurred between September 12 and October 14.

3.65 Figures 31 and 32 show the digital "vegetation" maps that contain only values of 1 and 2 as described above, and Figure 33 shows the "difference" map that was derived by comparing the values in the later-dated map to those in the earlier-dated map. In Figures 31 and 32, values of "1" (indicating vegetation) are shown in green, and non-vegetated values (2) are shown in light brown. In Figure 33, areas that remained vegetated from September 12, 2002 to October 14, 2002 are shown in light green; non-vegetated areas that did not change from one date to the next are shown in brown; areas that changed from non-vegetated to vegetated are shown in blue, and areas that changed from vegetated to non-vegetated are shown in yellow. (Note that "brown areas" in Figure 33 and "light brown" areas in Figures 31 and 32 along the northern edge of the study area are actually the San Miguel River).

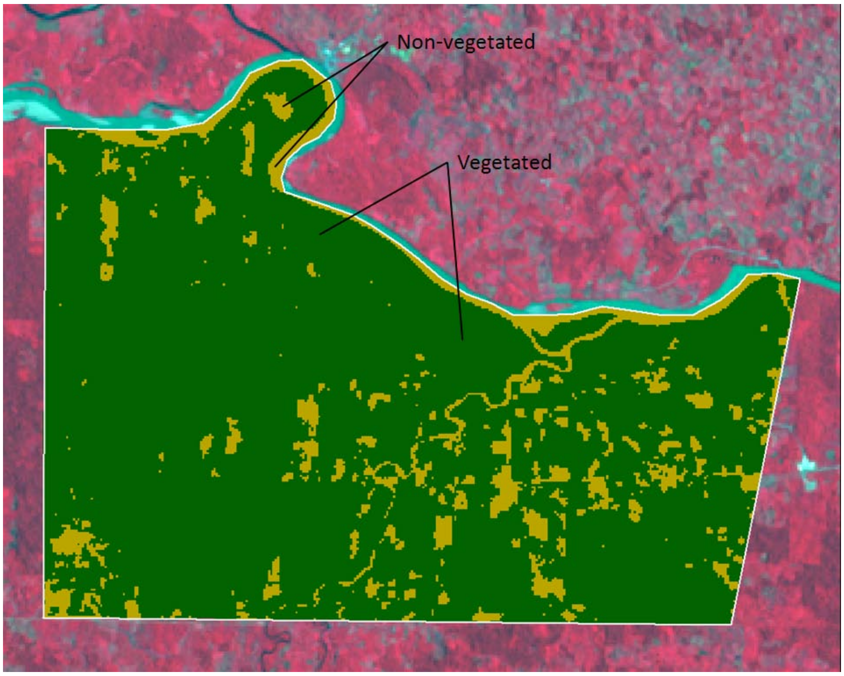


Figure 31. Vegetation map for September 12, 2002 (from Landsat)

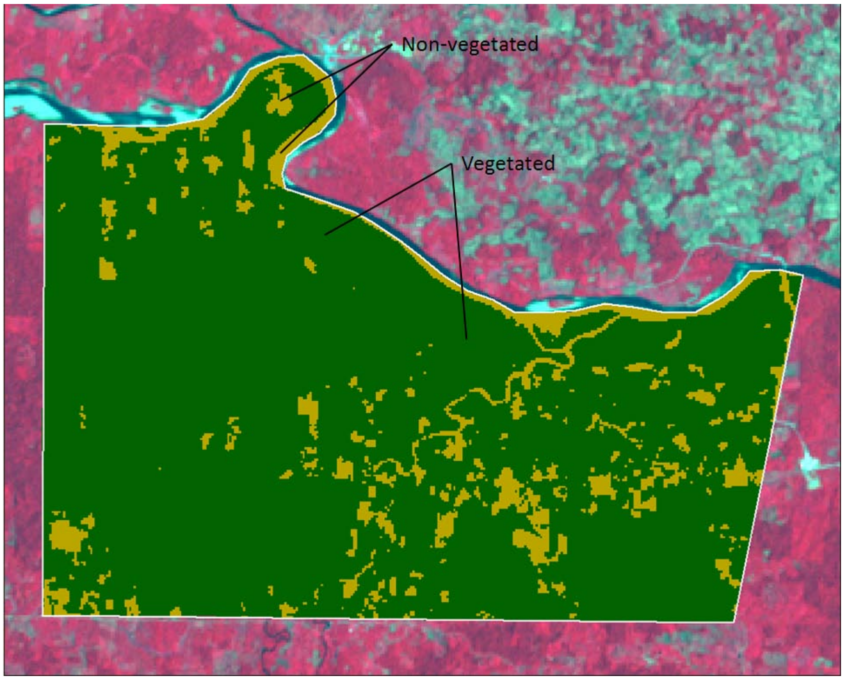


Figure 32. Vegetation map from October 14, 2002 (from Landsat)

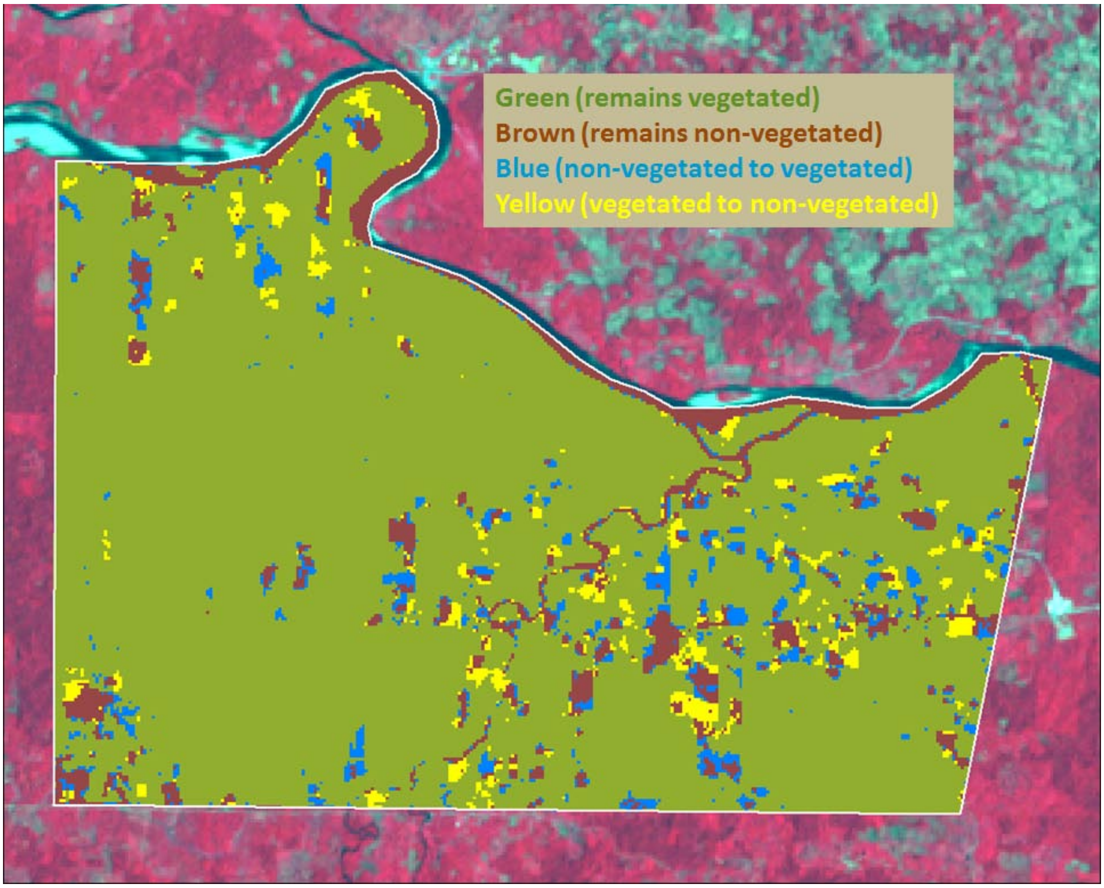


Figure 33. Vegetation changes between September 12 and October 14 of 2002.

3.66 From the maps shown in Figures 31 and 32, it was determined that the study area was about 88.4% vegetated (and 11.6% non-vegetated) on September 12, and about 89.2% vegetated (and 10.8% non-vegetated) on October 14. From the map in Figure 33, it was determined that about 3.1% of the study area had changed from vegetated to non-vegetated during the September12 to October 14 period, and that about 3.9% of the area had changed from non-vegetated to vegetated.

3.67 The primary conclusion drawn from the above two analyses is that the vegetation composition changed very little in the study area over the one-month interval between September 12, 2002 and October 14, 2002. However, this was also a period when extensive aerial herbicide applications were occurring across the river in Colombia. In fact, the amount of ground vegetation in the study area appeared to be slightly greater around October 14 than a month earlier.

3.68 Given their regularity and location, those changes that did occur, in my opinion, were much more likely a result of typical cultivation practices (e.g., harvesting, planting, clearing, plant growth, etc.) than due to aerial spraying activities in Colombia. If such spraying had caused the types of damages alleged to have occurred by witnesses living in the area (as recounted in Section 3.58), then a significant change in vegetation condition (i.e., a shift from "vegetated" to "non-vegetated") should have been evident during the time period discussed above. This, in fact, did not occur as the vegetation composition remained essentially unchanged between the two dates. Moreover, as described earlier in the analysis performed for the Mestanza farm (Site 1), there is no evidence of a "moving front" of defoliation that would have been caused by drifting herbicides. In fact, the vegetation surrounding all the land parcels that had changed from vegetated to non-vegetated without exception appears to be quite healthy**.**

3.69 In his report "Aerial Spray Drift Modeling of Plan Colombia", Hewitt also modeled the spray lines closest to the border, or to the Ecuadorian bank on the border river, with regard to the purported locations of the witnesses. In 2000, the distance of the two lines to the Ecuadorian bank of the border river in the study area were 1,817 meters and 1,960 meters (i.e., nearly two kilometers away), and the resulting deposition rates were practically zero: 0.01 g/ha and 0.01 g/ha (Table of Model Results, rows 69 and 71), respectively. In 2001, there were two spray lines identified at distances of 955 meters and 1500 meters from the Ecuadorian bank on the border river, with deposition values of 0.033 g/ha and 0.1 g/ha, respectively (i.e., nearly zero). In 2002, the two lines closest to the Ecuadorian bank on the border river were at distances of 467 meters and 547 meters, with deposition values of 0.75 g/ha and 0.41 g/ha, respectively; again nearly zero. Therefore, given the analytical results above, it is technically impossible to attribute the effects alleged by the Ecuadorian witnesses to the spraying in Colombian territory, and the results corroborate my opinion to the effect that the few changes observed on the images in the San Francisco study area were much more likely a result of typical cultivation practices.

Site 4: Salinas Area

3.70 As was done for the San Francisco study area (Site 3), a study area for the geographic area surrounding Salinas was defined on the basis of witness statements regarding the locations of their homes/farms within this area and the extent of available satellite images. (Due to different locations given for Salinas on various map sources, two alternative locations for this community [referred to as Salinas I and II] are described in the text and identified on figures relating to this study area). In this case, since the analysis was focused on aerial spraying activities in Colombia that were completed at the end of 2000 and the beginning of 2001, the two available satellite images that were used are a Landsat image acquired on December 11, 2000 and a SPOT image acquired on February 17, 2001. As shown later, the western edge of the study area was limited to the western edge of the SPOT image since it did not extend as far to the west as the earlier Landsat image. For the purposes of this analysis, these two images were used to evaluate vegetation conditions in the study area "before" and "after" aerial spray activities that occurred between the two image dates.

3.71 In the witness statements for the seven individuals identifying themselves as residing in Salinas, six gave descriptions of where they lived or farmed. All six said that they had lived or farmed "near" or "on the banks of" the San Miguel River (Witness 1, Annex 189; Witness 2, Annex 190; Witness 3, Annex 191; Witness 5, Annex 193; Witness 6, Annex 194; and Witness 7, Annex 194). Given these statements, a study area extending about 2 km south of the river and out to the western edge of the February 17, 2001 SPOT image was defined. The northern limit was the San Miguel River, and the eastern limit was extended out to about 3 km east of Salinas II. This study area is illustrated in Figure 34. Also illustrated in Figure 34 are the two alternative locations of Salinas (shown in green), as well as spray lines (shown in yellow) representing aerial herbicide applications in Colombia between the image dates of December 11, 2000 and February 17, 2001. In this instance, spray events in the relevant region within Colombia during this period, as shown on Figure 34, occurred on December 22, 23, 26, 27, 30 and 31, and on January 1 and 2. As was done for the San Francisco study area, the focus of this particular analysis was to evaluate changes in vegetative condition that occurred within this study area that coincided with spray activities completed between the two image dates.

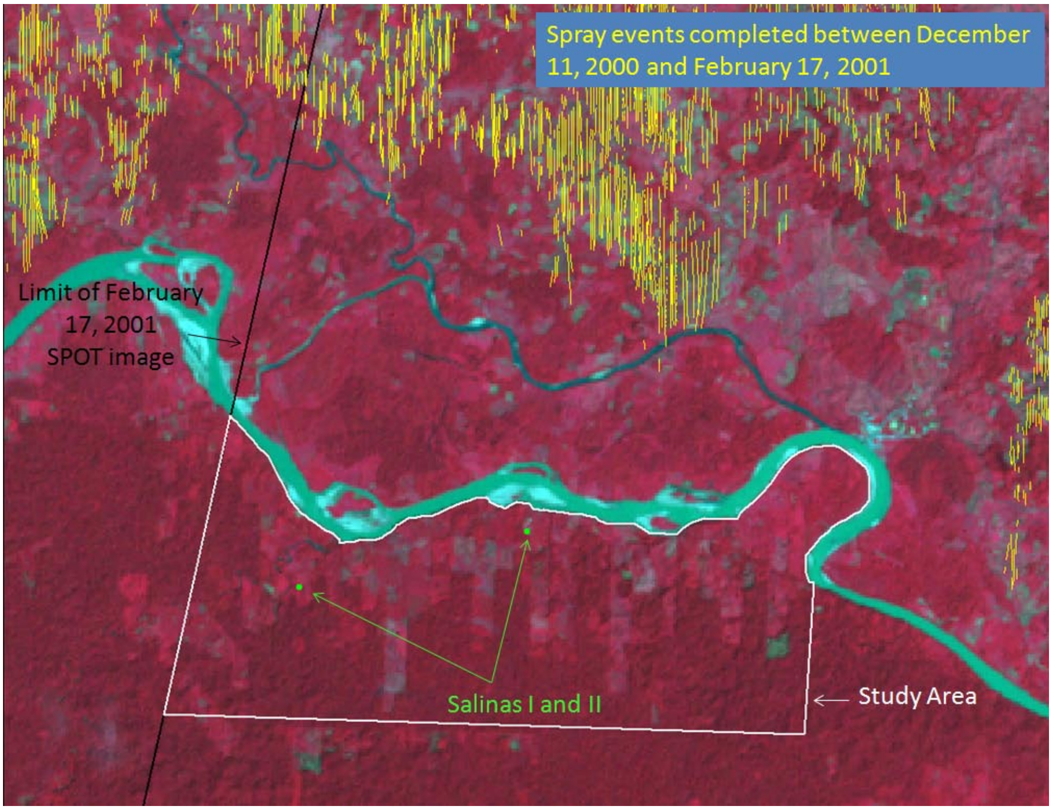


Figure 34. Salinas study area with relevant spray lines.

3.72 For comparison purposes, enlarged portions of the satellite images for December 11, 2000 (Landsat) and February 17, 2001 (SPOT) are shown in Figures 35 and 36. As can be seen from these figures, fairly dramatic changes in vegetation on the Colombian side of the border, as indicated by the light blue-green hues north of the border in Colombia (see example areas identified as “A” in Figure 36) are apparent, and these very closely correspond to the locations in which aerial herbicide applications took place in December 2000 and January 2001.

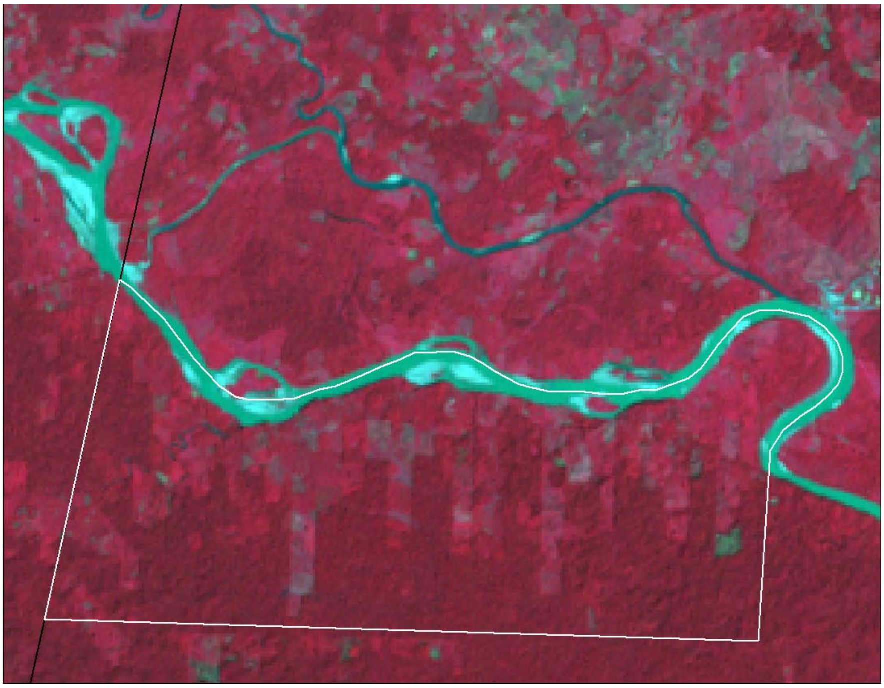


Figure 35. December 11, 2000 (Landsat) image.

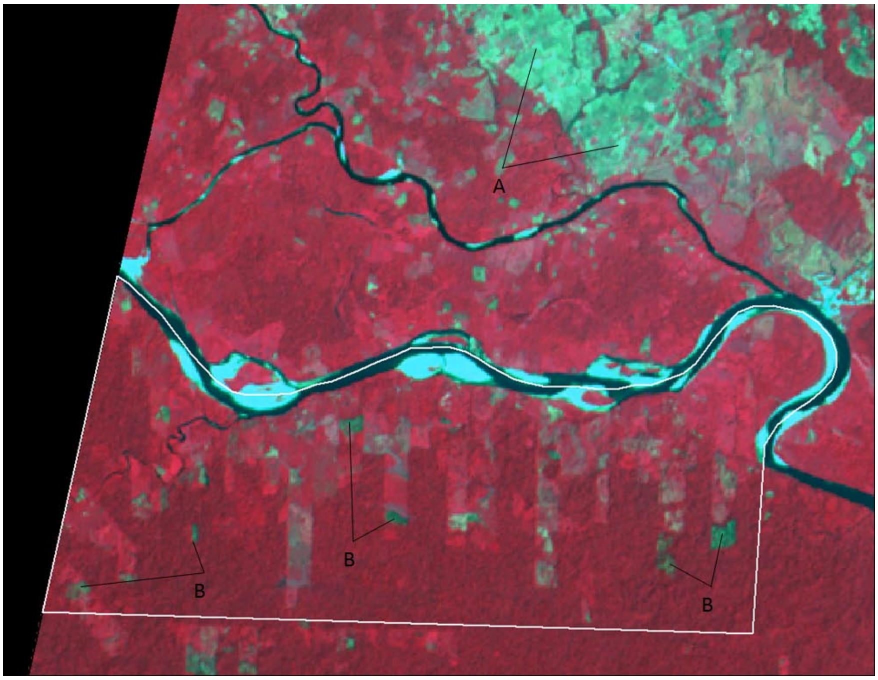


Figure 36. February 17, 2001 (SPOT) image.

3.73 As was done with the previous study area (San Francisco I and II), an image analysis was conducted to identify and quantify vegetation changes that occurred within the study area between the times of the two image dates. Specifically, the satellite images were analyzed to evaluate the extent of vegetated versus non-vegetated areas based on the presence/absence of reddish and blue-green hues within the color infrared images. Figure 37 shows the results of this analysis. As with the previous site, the black dots represent parcels of land where conditions changed from vegetated to non-vegetated during the period from December 11, 2000 to February 17, 2001; whereas white dots depict parcels where conditions changed from non-vegetated to vegetated.

3.74 As shown in Figure 37, vegetation changes occurred in both directions, as would be expected in an area with dynamic cultivation activities. In fact, some of the larger "non-vegetated" areas (see examples labeled "B" in Figure 36) are almost assuredly areas with trees and taller shrubs that have been cleared of vegetation for future crop cultivation. This type of "shifting" agriculture is very typical of tropical and semi-tropical regions where the need exists to "rotate" and "rest" cultivated areas due to poor soil fertility. In the examples cited, the color and very regular boundaries, are very characteristic of such cleared areas on color infrared images, on which large masses of brown-colored brush, branches and tree trunks show up as a very dark blue-green. (Such examples of "shifting agriculture" are also evident in images shown previously for the San Francisco area in 2002 [see Figures 25 through 27]). Of the 37 parcels identified, 23 changed from vegetated to non-vegetated, whilst the remaining 14 shifted from non-vegetated to vegetated during the same time period. To further quantify these changes, additional analyses were completed using NDVI images as was done for the San Francisco site.

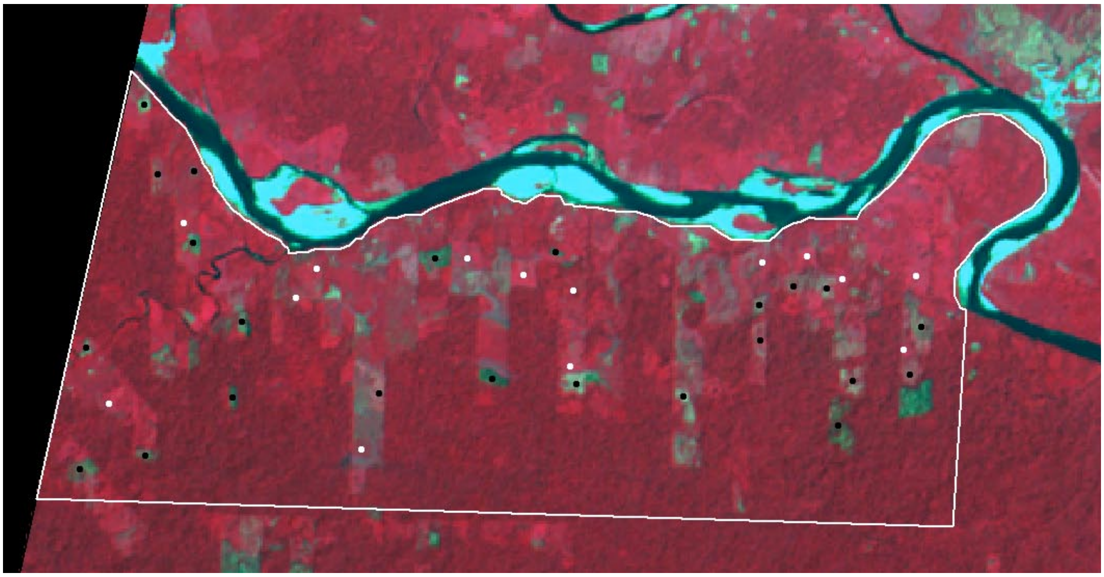


Figure 37. Vegetation changes between December 11, 2000 and February 17, 2001 (black = vegetated to non-vegetated, white = non-vegetated to vegetated).

3.75 Similar to the exercise performed for the San Francisco site, NDVI images derived from the December 11, 2000 Landsat and February 17, 2001 SPOT images were used to create vegetation maps for those two time periods. These maps are shown in Figures 38 and 39, respectively. Also, similar to the figure prepared for the San Francisco study area, Figure 40 shows a "vegetation change" map based on the changes that occurred between December 11, 2000 and February, 17, 2001. From the maps shown in Figures 38 and 39, it was determined that the study area was about 95.6% vegetated (and 4.4% non-vegetated) on December 11, 2000; and about 95.8% vegetated (and 4.2% non-vegetated) on February 17, 2001. From the "vegetation difference" map shown in Figure 40, it was determined that about 3.2% of the study area had changed from vegetated to non-vegetated between the two dates, and that about 3.4% of the area had changed from non-vegetated to vegetated.

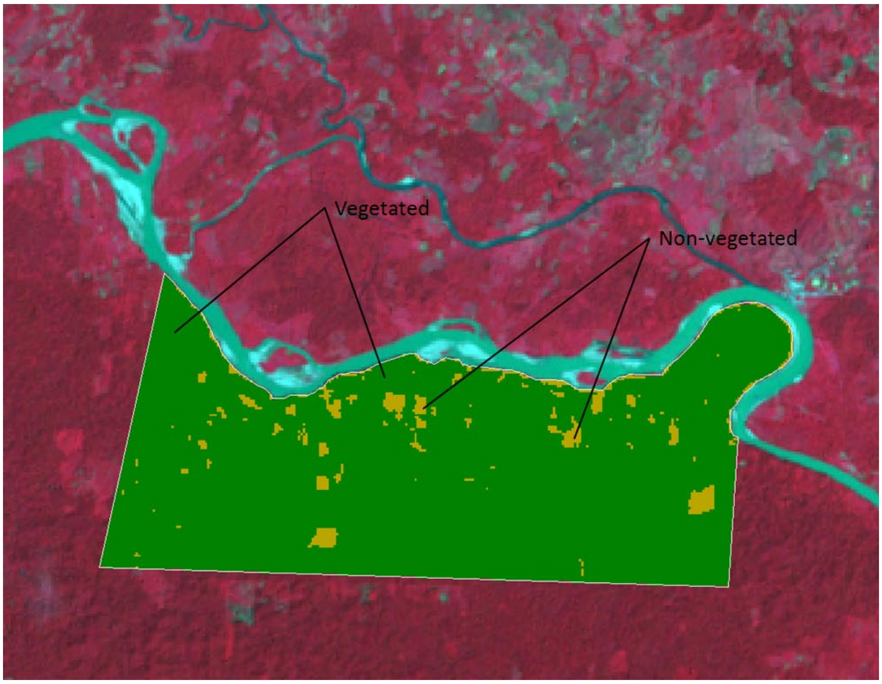


Figure 38. Vegetation map derived from December 11, 2000 Landsat image.

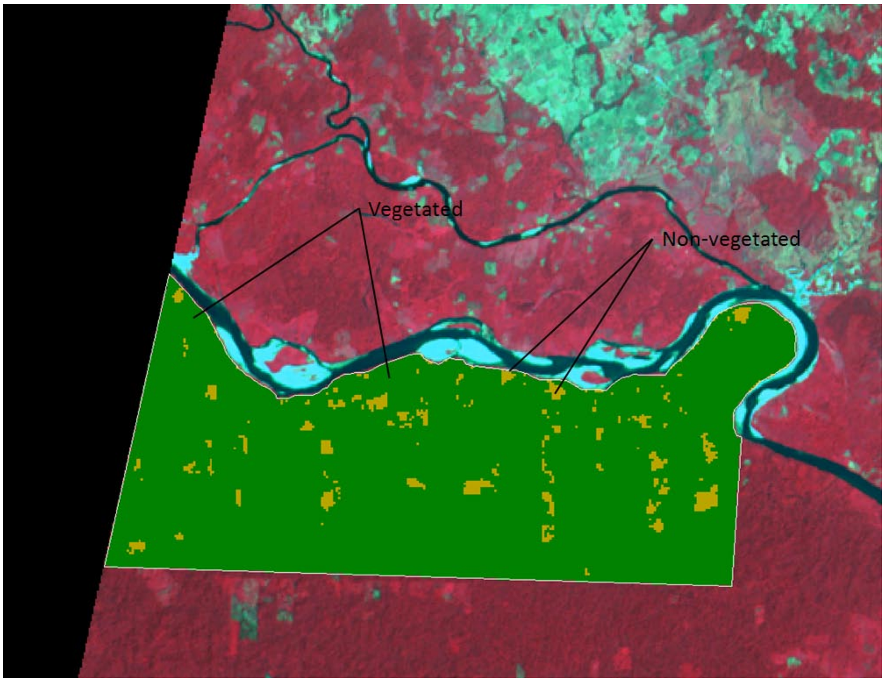


Figure 39. Vegetation map derived from February 17, 2001 SPOT image.

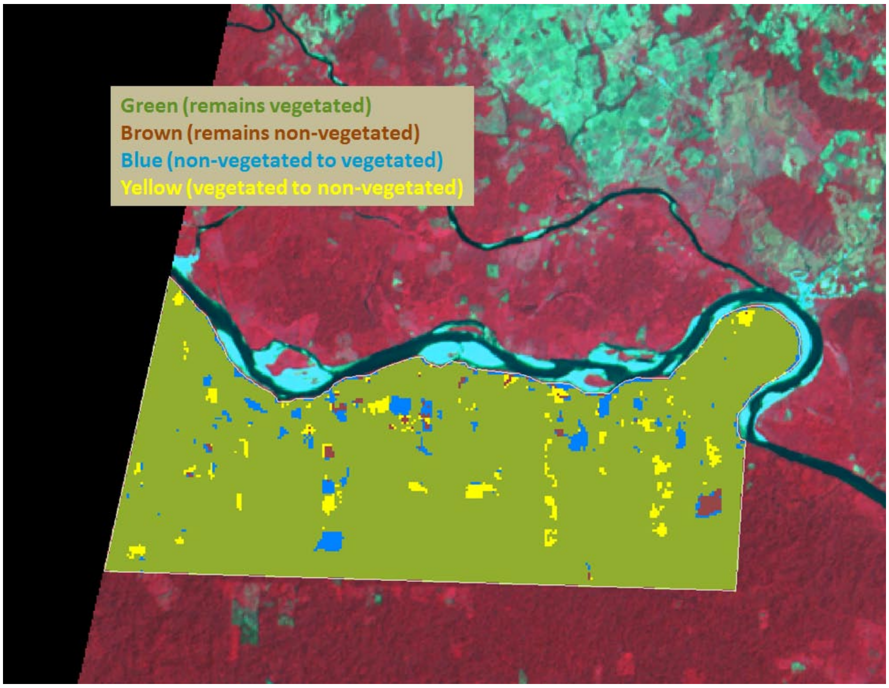


Figure 40. Vegetation changes between December 11, 2000 and February 17, 2001.

3.76 In the witness statements described earlier (see Section 3.71), various claims were made by residents of Salinas of significant vegetation and crop damages resulting from aerial herbicide applications across the border in Colombia. Examples of these claims include:

- "Soon after the spraying, my crops started turning yellow and dying. The tallest fruit trees, such as the *zapote*, were the first ones to be affected. These tall trees were the first to dry up at the top. They did not die completely although they did dry up, and no longer produced fruit. The plantain trees were also destroyed quickly. The plantain, planted next to my house, which is a few meters from the river, died first. The plant was undernourished, falling to one side, and the fruit started to die. My coffee also had spots.

The plantain finally turned black. The pastures were also lost, the grass turned yellow and died." (Witness 1, Annex 189)

- "The first spraying destroyed everything. The plantain leaves turned yellow, they started to bend until they fell off. The plantain and yucca dried up faster than the coffee." (Witness 2, Annex 190)
- "Fifteen days after the spraying, I observed that the crops were turning yellow. Plantain, rice, yucca, and maize. Everything was lost." (Witness 3, Annex 191)
- "On my farm I had planted about twelve hectares of pasture land, plantain, yucca, coffee, and cacao. The spraying completely ruined all of it. A few days after the spraying, the plants started to turn yellow and then they turned black and died. I had never experienced anything like that. I tried to save the crop with fertilizers but it did not work, and we lost everything." (Witness4, Annex 192)

3.77 Although the statements made above would suggest that rather dramatic changes in vegetation condition occurred in the areas surrounding Salinas I and II after nearby aerial herbicide applications on the Colombian side of the river, no such changes were evident based upon my vegetation analyses outlined above. Based on these analyses, my primary conclusion is that very little change in vegetation condition occurred within Ecuador between the two dates analyzed (i.e., December 11, 2000 and February 17, 2001). Those changes that did occur appeared to occur more or less equally in both directions (i.e., from vegetated to non-vegetated, and vice versa), and there was also no evidence of damage to vegetation surrounding any of the "areas of change" described above as would be expected from a "moving front" of drifting herbicides from across the border. Consequently, it is my opinion that the changes identified in the Salinas study area were merely a result of normal agricultural activities.

3.78 In his report "Aerial Spray Drift Modeling of Plan Colombia Applications", Hewitt also modeled the relevant spray lines. In 2000, two lines were identified at distances of 3,890 meters (nearly four kilometers) and 2,062 (over two kilometers) from the Ecuadorian bank on the border river. The deposition values were 0.01 g/ha and 0.099, respectively (i.e., nearly zero). In 2001, there were two lines at distances to the Ecuadorian bank on the border river of 3,131 meters (over three kilometers) and 2,750 meters (nearly three kilometers), with deposition values of 0.106 g/ha and 0.167 g/ha, respectively (again, close to zero). In 2002, there were two lines at distances to the Ecuadorian bank on the border river of 2,498 meters (nearly two and a half kilometers) and 1,760 meters (nearly two kilometers), with deposition values of 0.11 g/ha and 0.015 g/ha, respectively. These values would indicate that it is technically impossible to attribute the effects alleged by the Ecuadorian witnesses to the sprayings in Colombian territory, which is further confirmed by my observations on the satellite images.

4. <u>Discussion Regarding the Heights of Trees Near Aerial Spray Sites in Colombia</u>

4.1 I understand that it has been alleged by various parties in Ecuador that herbicides sprayed as part of PECIG have drifted southward across bordering rivers into areas of Ecuador immediately downwind of PECIG spray sites, thereby causing injury to plants, animals and humans in these areas. This is so in spite of my understanding that meteorological conditions in the region indicate that for most of the year the winds blow in a south-to-north direction (i.e., from Ecuador to Colombia), and that the winds are mild. Given the claim that such drifting has occurred, the presence and extent of vegetation (which would impede the movement of herbicides) between such spray sites and locations where injury claims have been made is very relevant. As indicated by Hewitt in his report ("Response to Report "Spray Drift Modeling of Conditions of Application for Coca Crops in Colombia" by D.K. Giles"), forested areas serve as very effective filters for any drifting that might occur as a result of aerial spraying, and should be considered in drift modeling conducted as part of any evaluation of the potential effects of aerial spraying. As also indicated by Hewitt in the same report, the drift modeling performed by D.K. Giles did not consider the presence of forested land (as illustrated in later figures) between aerial spray sites in Colombia and areas across the border in Ecuador. I was asked to conduct an analysis of tree heights along the San Miguel River between Colombia and Ecuador.

4.2 As described below, relatively high-resolution satellite images are required in order to adequately characterize the approximate heights of different types of trees, shrubs and similar plants in a given landscape setting. For this particular assessment, adequate satellite images were not available for the Cofán study area (Site 2). In this case, only the older Landsat and SPOT images with spatial resolutions of 30 and 20 meters, respectively, were available. Consequently, assessments of tree/vegetation height could only be performed for the other three sites as described below.

Site 1: Puerto Mestanza

4.3 Based on an evaluation of high-resolution satellite images available via Google Earth (dated October 26, 2006) that were close in date to when aerial herbicide applications in Colombia occurred (2000 to 2007), I estimated the heights of the trees and other vegetation across the river from Puerto Mestanza in Colombia. (Note: high-resolution satellite images necessary to perform this type of calculation were not available via Google Earth prior to October 26, 2006). I did this using a standard height estimation technique utilized in image interpretation. That is, I first identified a number of one-story structures in Puerto Mestanza that were visible on the Google image and assumed that each had an average height of about 4 meters. I then measured the lengths of shadows cast by various trees along the river and at various locations in the image, and subsequently inferred tree height by using simple geometric relationships. (For example, if a structure 4 meters high cast a 2-meter shadow, then a tree casting a 16-meter shadow could be estimated to be approximately four times as high [i.e., 16 meters high]). In using this approach, the time of day during which the satellite image was originally acquired is irrelevant since it is the relationship between shadow heights that is used to estimate the height of any feature within the image, and this relationship holds true regardless of the time of day as long as such measurements are made on the same image.

4.4 The results of my observations and are set out in Figure 41. In this figure, the delineated areas represent different patches of vegetation on the landscape that are composed of vegetation that vary in plant density and height. The labeling scheme is as follows:

1: Areas of dense trees with heights varying between about 6 – 30 meters.

2: Areas of dense trees with heights varying between about 3 – 15 meters.

3: Areas of less dense trees with heights varying between about 3 – 15 meters.

4: Areas with dense mix of trees and shrubs with plant heights varying between about 2 – 30 meters.

5: Areas with mix of scattered trees and shrubs of varying height

Areas without labels are generally those that have low-lying vegetation or have been cleared for cultivation, or where trees have been removed for unknown purposes. For comparison purposes, illustrated in yellow in Figure 42 are the spray lines for aerial herbicide applications that occurred during the year 2002 within the area mapped in Figure 41.

4.5 As illustrated by these figures, there are a number of patches of vegetation having trees and plants of considerable height that were located between the locations in Colombia that received aerial herbicide applications and areas in the vicinity of Puerto Mestanza across the river in Ecuador.

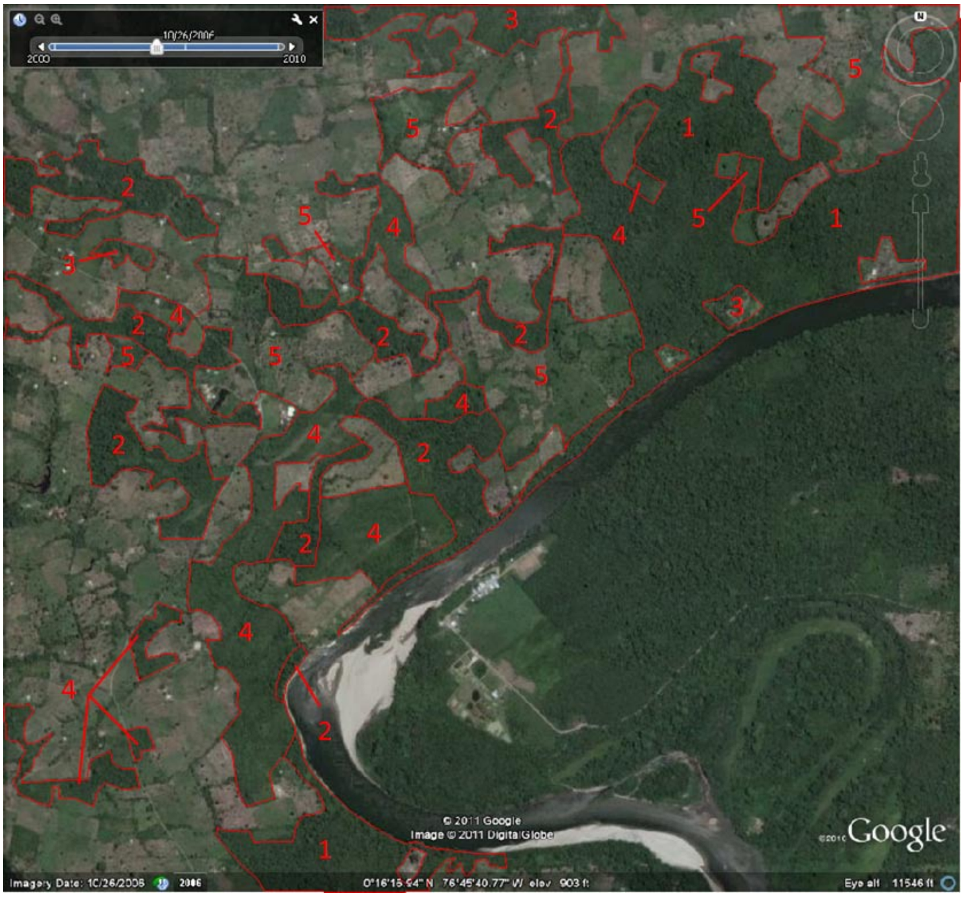


Figure 41. Vegetation map derived from October 26, 2006 satellite image.

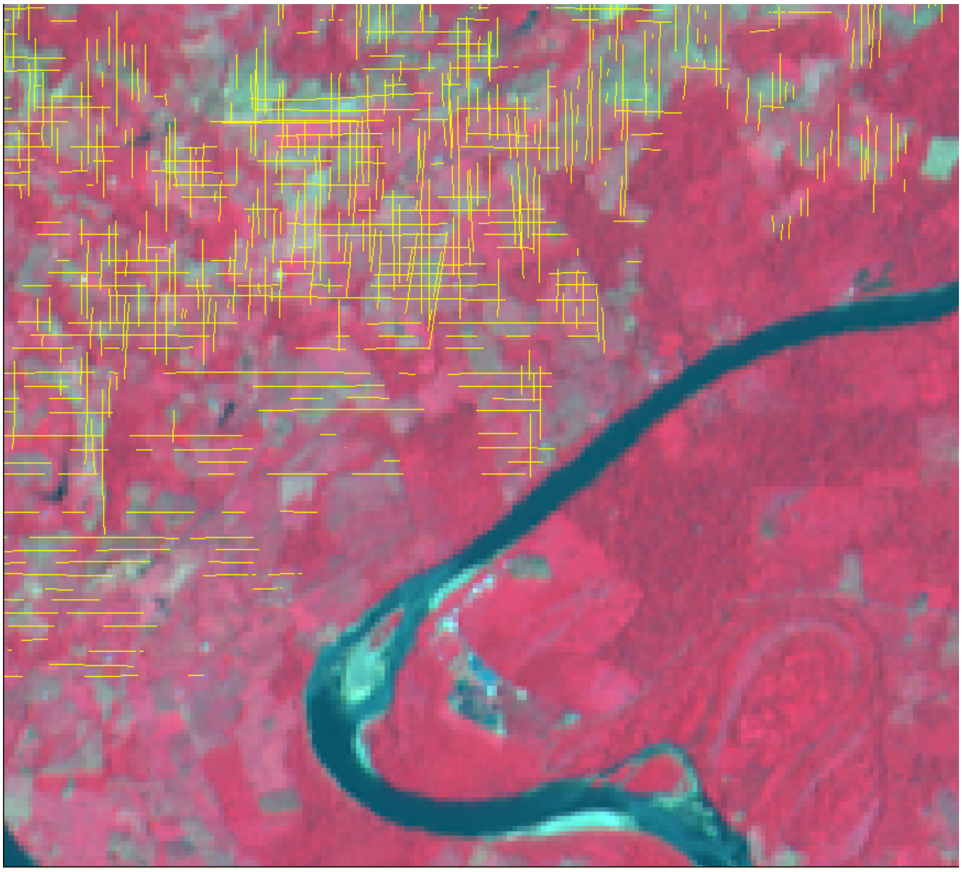


Figure 42. Aerial spray lines (shown in yellow) for the year 2002.

Sites 3 and 4: San Francisco I and II, and Salinas I and II

4.6 Because both of these study areas were adjacent, and even overlapped to a certain extent, these two areas were combined for the purpose of characterizing vegetation height. Similar to the exercise undertaken for Site 1 above, an analysis of satellite images provided via Google Earth was performed to characterize the relative heights of vegetation in the areas between both San Francisco I and II and Salinas I and II, and areas across the river in Colombia where aerial herbicide applications occurred. However, due to the much larger geographic areas covered by these two study areas in comparison to that of Site 1 (Puerto Mestanza), a less detailed vegetation map was prepared in this instance. More specifically, a more generalized vegetation map was prepared using information gleaned from the Google Earth images in combination with information derived from the NDVI map created from the September 12, 2002 Landsat image (a portion of which was shown previously in Figure 10).

4.7 As described earlier in Sections 3.9 and 3.10, NDVI images contain a range of values that reflect both abundance/lack of vegetation as well as the relative size and types of plants (e.g., low-lying grasses/shrubs versus taller plants such as trees). For the purposes of this analysis, the information contained in this image was used to map the location of patches of taller vegetation (i.e., trees and similar plants generally ranging in height from meters to tens of meters) in the vicinity of San Francisco (I and II) and Salinas (I and II). This was essentially done via the following steps:

1) A number of "sample areas" containing taller vegetation were identified on more recent, higher-resolution satellite images from 2006 and 2007 available via Google Earth.

2) Areas corresponding to the "sample areas" identified above were located on the September 12, 2002 Landsat image.

3) The range of NDVI values corresponding to these "sample areas" were identified and isolated within the total range of values in the image.

4) Based on the above information, patches of taller vegetation were identified and mapped across the entire image.

4.8 Shown in Figure 43 is the vegetation map for the area around both study sites that resulted from the exercise outlined above. In this map, vegetation generally ranging in height from meters to tens of meters is represented by the green patches. On this map, the two study areas are shown in red, and spray lines corresponding to aerial herbicide applications completed in 2000, 2001 and 2002 are shown in blue. Also shown in Figures 44 through 47 are enlargements of the vegetation maps for the two sites with their corresponding portions of the September 12, 2002 Landsat image.

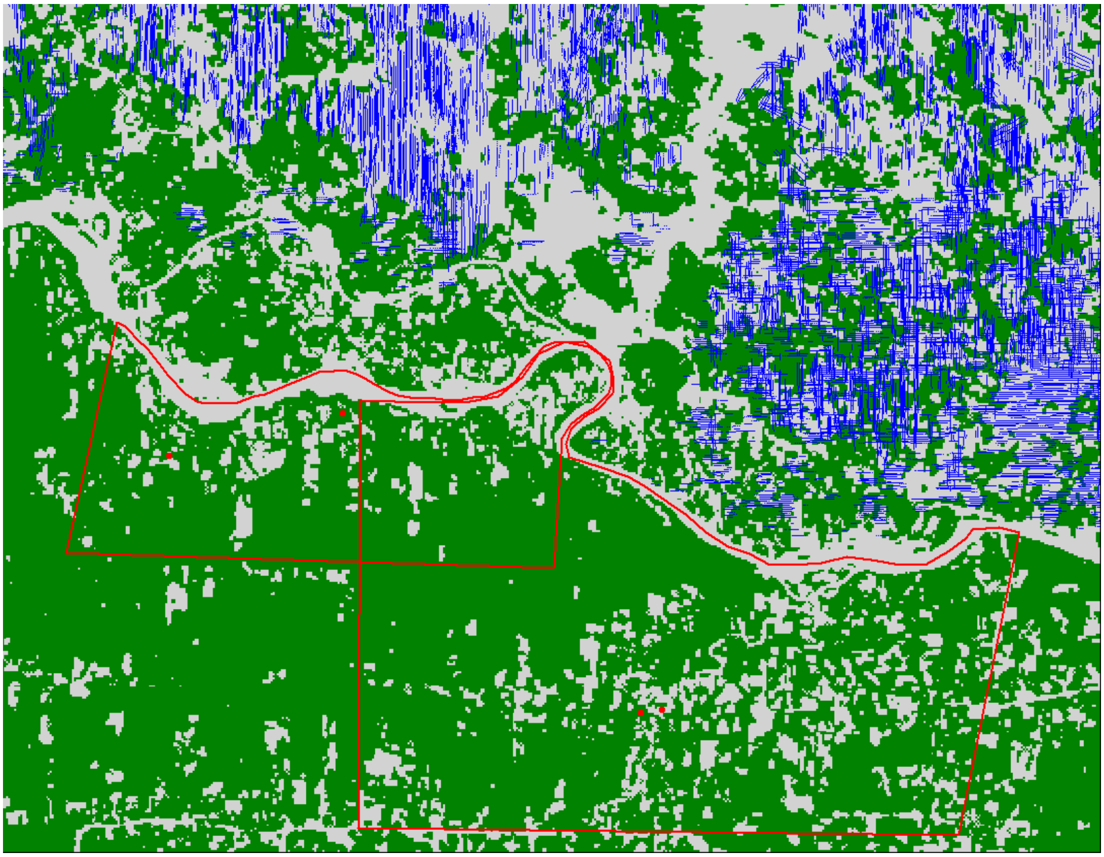


Figure 43. Map showing taller vegetation (green), the two study areas (red), and aerial spray lines (blue) from 2000, 2001, and 2002.

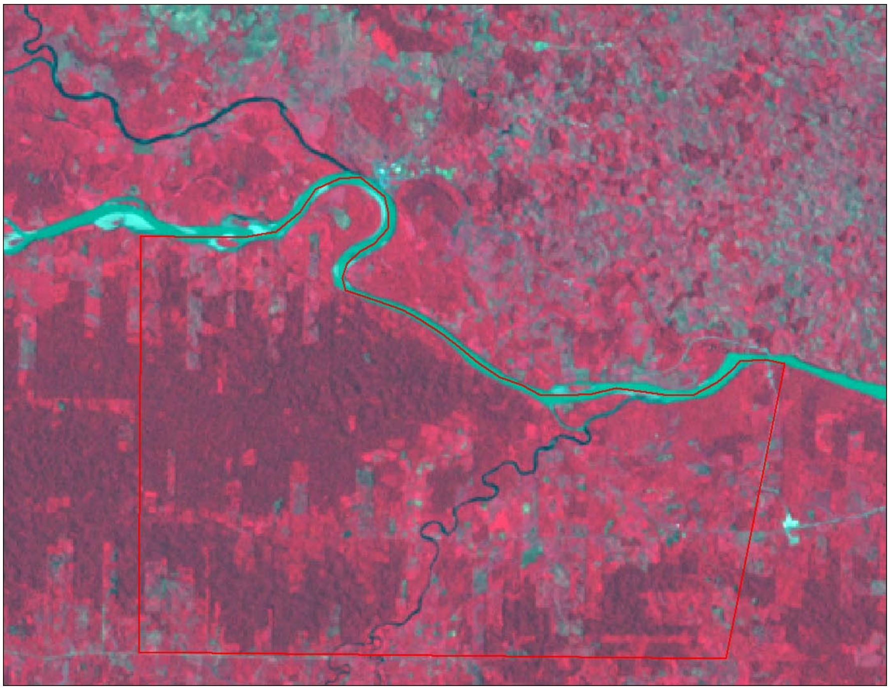


Figure 44. September 12, 2002 image of San Francisco I and II area.

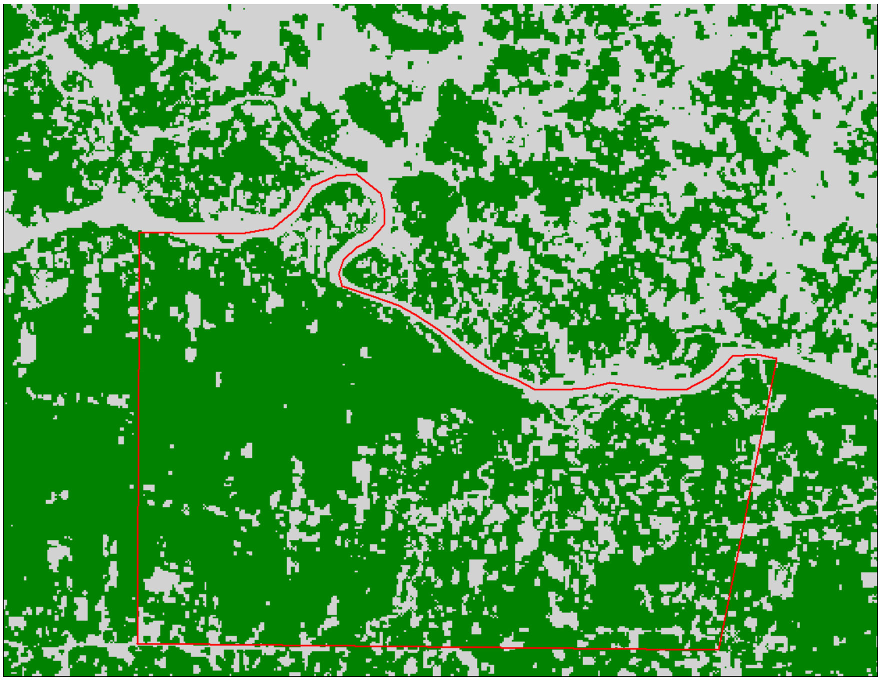


Figure 45. Map of “taller” vegetation for same area as Figure 44.

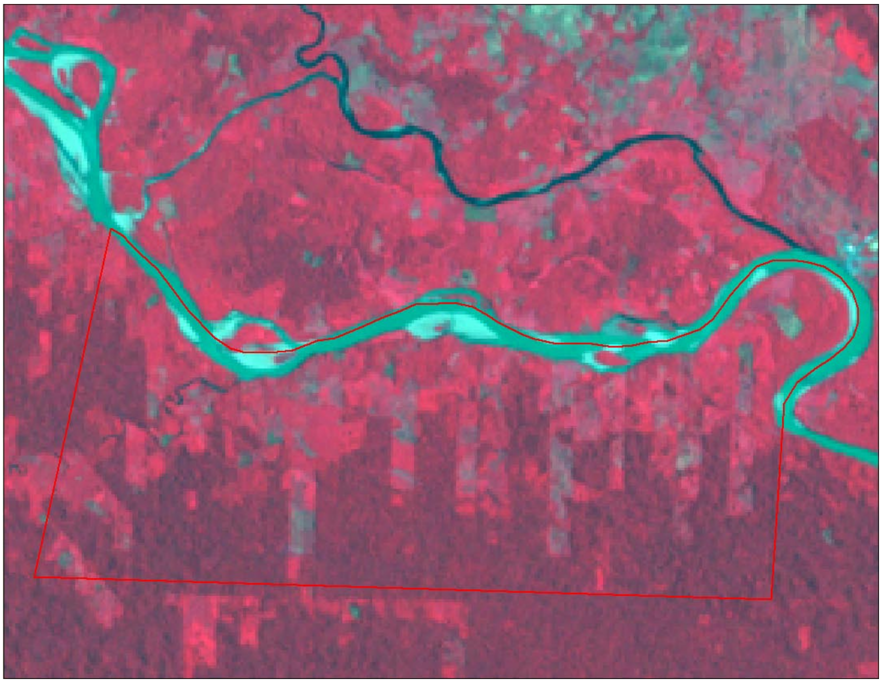


Figure 46. September 12, 2002 image of Salinas I and II area.

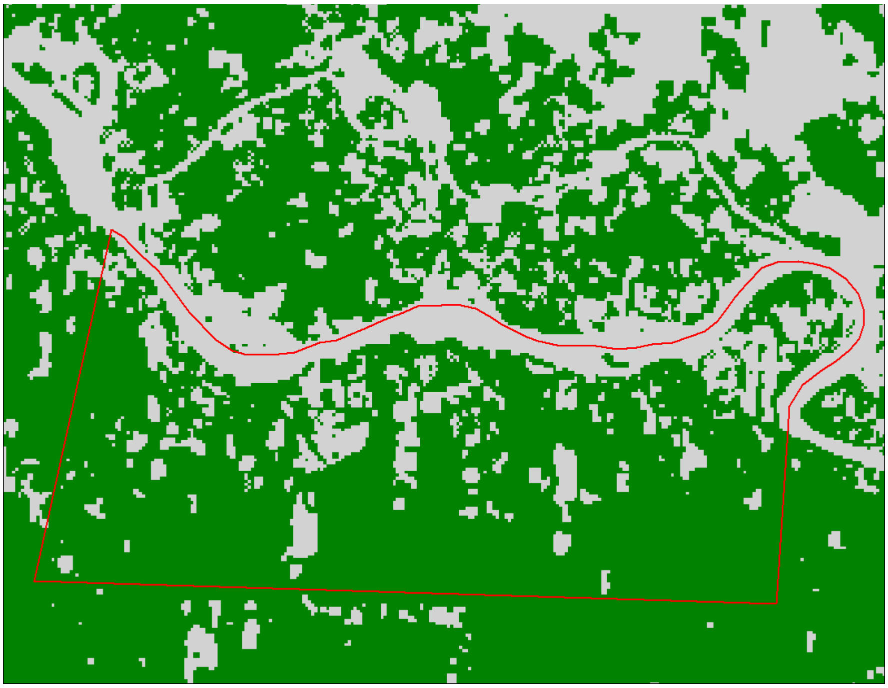


Figure 47. Map of "taller" vegetation for same area as Figure 46.

4.9 As is evident from the maps shown in Figures 43 through 47, a considerable amount of vegetation of significant height exists between spray sites in Colombia to the north and the San Francisco and Salinas study areas to the south. As described by Hewitt ("Response to Report "Spray Drift Modeling of Conditions of Application for Coca Crops in Colombia" by D.K. Giles"), because such vegetation can function as an effective filter of herbicide droplets that might drift from aerial spray sites, the intervening vegetation in such areas must be considered in any simulation modeling of aerial spray effects. However, as also described by Hewitt ("Aerial Spray Drift Modeling of Plan Colombia Applications"), the drifting of herbicide spray particles was considered to be negligible based on his analysis that extremely low concentrations of 2.71 g/ha and less were reached within meters of spray lines. Consequently, the effects of vegetation filtration near such spray lines was probably a moot point since the movement of drifting herbicides beyond intended target sites in Colombia was likely very insignificant in terms of both mass and concentration.

This concludes my report.

Dated: December 7, 2011

Barry M. Evans

Dr. Barry M. Evans

ADDENDUM

Background and Relevant Experience

My name is Dr. Barry M. Evans. I currently have a faculty research appointment at the Penn State Institutes of Energy and the Environment at the Pennsylvania State University in University Park, PA. During most of my career of over 30 years, I have managed and worked directly on GIS (geographic information systems) and environmental projects for both government and private parties. These projects have included a variety of environmental assessments that were conducted using GIS and remote-sensing technology, usually in the form of aerial photographic and/or satellite images. I have also performed environmental mapping, geomorphology and landscape analysis, as well as engineering sanitary surveys and environmental resource inventories, some of these for the U.S. Environmental Protection Agency and others for state government agencies and private businesses.

During the first 10 years of my career, my work activities revolved exclusively around the analysis of aerial photography and satellite images, and, at one point, I had a security clearance for analyzing data acquired from military satellites. Although more recently my professional focus has been more on the use/application of GIS software and digital map data, many of the my more recent projects have required the analysis of aerial photography and/or satellite images for analyzing landscape conditions. I have also prepared and taught short courses on image interpretation, and have prepared several image interpretation manuals funded by federal agencies for supporting such activities as surface mine reclamation and wetlands mapping/analysis. Most recently in 2010, I was a principal investigator in a project completed for the Pennsylvania Geological Survey in which high-altitude aircraft images were used to identify and map "fracture traces" within several areas around Pennsylvania.

From the mid-1990s to the early 2000's, I also worked as a consultant to the Amazon Center for Environmental Education and Research. This work involved the completion of a mapping project using GIS and satellite data for identifying the location of medicinal plants in the region around Iquitos, Peru, as well as the development and presentation of several short courses on the use of satellite and GIS data for vegetation mapping and ecological analysis. In the mid 2000's, I also made several trips to Ecuador as a consultant to World Water Watch to discuss GIS-based techniques for vegetation mapping and ecological analysis with various environmental non-profit groups. As a result of my travels to the Amazon region of Peru and Ecuador, I have become familiar with the geography, culture, and plant life in that region.

I received a Bachelor of Science degree in Natural Resources from Ohio State University in 1975. I received a Masters degree in Environmental Pollution Control from Penn State University in 1978, and a Ph.D. in Soil Science from Penn State in 2002.

A copy of my resume follows, which includes a list of all of my publications going back to 1979.

BARRY M. EVANS

EDUCATION

Pre-Engineering. Vincennes University, 1970-71.
B.S., Natural Resources. The Ohio State University, 1975.
M.E.P.C., Environmental Pollution Control. The Pennsylvania State University, 1978.
Ph.D., Soil Science. The Pennsylvania State University, 2002.

CAREER SUMMARY

2002-Present Senior Researcher, Penn State Institutes of Energy and the Environment

Dr. Evans is a senior research faculty member affiliated with the Penn State Institutes of Energy and the Environment (PSIEE). At PSIEE, he is primarily responsible for obtaining and managing applied research projects funded by a variety of governmental and institutional sponsors. In this role, he has managed a multi-year, multi-million dollar open-end contract to provide environmental /GIS support services to the Pennsylvania Department of Environmental Protection (PaDEP), as well as other state agencies. Of late, he has been primarily involved in developing specialized software applications to support water resource/water quality assessment needs. To date, Dr. Evans' group has developed numerous software applications (e.g., AVGWLF, MapShed, AVStreams, PRedICT, AVNPSTool and SWAP-GIS) to support ongoing activities in the areas of watershed modeling, TMDL assessment, source water protection, and evaluation of pollution mitigation strategies at the watershed level. Dr. Evans has also completed a number of water quality assessment projects for the PaDEP, National Park Service, and USEPA that have involved BMP evaluation, nutrient trading, water quality data analyses and water quality modeling. In addition to his state and national work, he has also provided technical expertise to various international groups such as the Joint Research Commission of the European Union; Mexican Institute of Water Technology; the Scottish Environmental Protection Agency; the Swedish Meteorological and Hydrological Institute; the Environment Agency (of England and Wales), the National Water Commission of Israel; the Argentine Institute of Oceanography; and to local and provincial groups in Ontario, Canada.

1995-2002 Senior Research Assistant, Environmental Resources Research Institute, Penn State University

Primarily responsible for obtaining and managing GIS projects funded by a variety of governmental and institutional sponsors. Managed a multi-year, multi-million dollar contract to provide GIS services to the Pennsylvania DEP and other state agencies.

1988-1995 President, Geo Decisions, Inc., State College, PA

Responsible for corporate management as well as obtaining and managing GIS and environmental projects undertaken by GDI, a large, nationally-recognized firm specializing in geo-spatial technologies.

1984-1988 Research Assistant, Environmental Resources Research Institute, Penn State University

Managed and conducted a variety of environmental assessment and mapping projects conducted using GIS and remote sensing technology.

1981-1984 Manager of Environmental Mapping Section, Resource Technology Corporation, State College, PA

Managed and supervised contracted work related to environmental mapping, geomorphology, and landscape analysis.

1980-1981 Owner/Manager, Remote Sensing Consultants, State College, PA

Obtained and managed contracted work such as septic system surveys, development of a wetlands analysis manual, and various non-point pollution source inventories.

1978-1980 Consultant, Development Sciences, Inc., Sagamore, MA

Worked on engineering sanitary surveys, various EPA-sponsored projects, and environmental resource inventories.

1976-1978 Project Manager, Trident Engineering, Warrenton, VA

Worked as an on-site contractor at the U.S. EPA's Environmental Photographic Interpretation Center. Projects completed involved use of aerial photography for various environmental analyses and mapping activities such as hazardous waste inventories, septic system analyses, oil spill emergencies, and land use/cover mapping.

5. PROFESSIONAL MEMBERSHIPS

Soil and Water Conservation Society
American Water Resources Association
International Water Association

RECENT CONSULTANCIES

Institute for the Application of Geospatial Technology
Greenland International Consulting, Inc.
Skelly & Loy, Inc.
Louis Berger International, Inc.
CH2M-Hill, Inc.
Amazon Center for Environmental Education and Research
Swedish Meteorological and Hydrological Institute
Mexican Institute of Water Technology
National Water Commission, State of Israel
Argentine Institute of Oceanography
The Cadmus Group, Inc.
Environment Agency of England and Wales
Joint Research Commission, European Union
BION Environmental Technologies, Inc.
Zedx, Inc.

OTHER

Management Committee of the Diffuse Pollution Sub-Group of the International Water Assoc.
Board of Directors, Institute of the Application of Geospatial Technology, Auburn, NY

SELECTED PUBLICATIONS AND REPORTS

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Annex 7

COLOMBIAN EXPERT ON ENVIRONMENTAL LAW, MR JOSÉ VICENTE ZAPATA, *CRITIQUE OF THE REPORT PREPARED BY MS CLAUDIA ROJAS QUIÑONEZ DATED JANUARY 2011 ON "THE AERIAL SPRAY PROGRAM AND VIOLATIONS OF COLOMBIA'S DOMESTIC LAWS REGARDING THE ENVIRONMENT AND THE RIGHTS OF INDIGENOUS PEOPLES"*, NOVEMBER 2011

SUÁREZ ZAPATA PARTNERS
ABOGADOS

Critique of the Report Prepared by Ms. Claudia Rojas Quiñonez, dated January 2011 on "The Aerial Spraying Program and Violations of Colombia´s Domestic Laws Regarding the Environment and The Rights of Indigenous Peoples"

Report Prepared by
José V. Zapata L.
November 22, 2011

PBX (571) 743 1005, Fax Ext. 104
Calle 87 No. 10 – 93, Of. 302 Bogotá D. C.

SUÁREZ ZAPATA PARTNERS
ABOGADOS

Introduction

Fundamentals

1. The present report refers to and analyzes Annex 8 to Ecuador's Reply of 29 March 2010 in the I.C.J. *Case Concerning Aerial Herbicide Spraying (Ecuador v. Colombia)* entitled *"The Aerial Spray Program and Violations of Colombia's Domestic Laws Regarding the Environment and Rights of Indigenous Peoples"* (the "Rojas Report") prepared by Mrs. Claudia Rojas Quiñonez, Esq. dated as of January 2011. This report examines the Rojas Report with a view to determining whether or not it conforms to the Colombian legal regime and the extent to which it in fact reflects the manner in which environmental regulations and laws pertaining to prior public consultation are in effect applied. This report further considers such public documentation obtained during the course of legal review, in order to ascertain the basis for the position presented by "Ecuador" and provides elements clearly evidencing that the position expressed in the Rojas Report does not reflect the existing legal regime.

2. As detailed throughout this report, the Rojas Report interprets the legal regime in a manner that favors Ecuador's position and does not correspond to Colombia's governing laws. Throughout the conduct of the aerial spraying program, Colombia has complied with and respected the applicable laws and regulations pertaining to the application of glyphosate. Colombia has also complied with any evolving legal requirements relating to the need of prior consultation with indigenous. Moreover, Colombian courts have consistently upheld the actions and undertakings of the Government of Colombia with regard to the aerial spraying of illicit crops.

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3. A detailed review of documents and regulations has been made to ensure that this report adopts an objective approach as to the actual requirements under Colombian law..

General Considerations

4. Overall, the Rojas Report appears to reflect the authors intentions as to what could be or should be the rule of law, but fails to clearly emphasize that in fact regulations have been appropriately complied with as they stand. From a strictly legal perspective and particularly as pertains to issues of environmental licensing, the Rojas Report assumes a subjective point of view, as will be further outlined in this report, and fails to correctly address various matters of substantive law. The Rojas Report provides its own interpretation of the regulations in force, rather than an objective analysis, and does not consider the implementation of certain provisions.

5. Environmental licensing is a strictly regulated matter under Colombian law and therefore offers little or no room for interpretation. Environmental licenses, are required only for activities, works or undertakings specifically listed in the law. An appreciation of whether any activities are correctly included in the lists falls outside the scope of current legislation on environmental licenses. The Rojas Report confuses activities that should or may warrant an environmental license, with the activities that require such a license under the current legal regime.

6. An environmental license is an environmental control and management instrument which at present[1] is defined as *"the authorization that is granted by the competent environmental authority for the execution of a project, undertaking or activity that, in accordance with the law and regulations, may cause serious*

[1] Currently both Law 99 of 1993 and Decree 2820 of 2010 regulate which activities, works and undertakings require an environmental license.

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deterioration to renewable natural resources or the environment or introduce considerable or notorious modifications to the landscape, which subjects its beneficiary to compliance with the requirements, terms, conditions and obligations that the license itself sets forth for the prevention, mitigation, correction, compensation and management of the environmental effects of the project, undertaking or activity which has been authorized."[2]

7. The Rojas Report contains extensive reference to rules and regulations that bear no particular relation to the case at hand. While the Rojas Report states that there must be a careful review of the legislation applicable within each specific period of time for a given activity, work or undertaking that was carried out, it fails to undertake an objective overview of the facts in the light of the relevant regulations in each specific timeframe. Transition of legislation in this matter is of particular importance. Facts take place at different moments and legislation has progressively evolved.

8. While certain statements contained in the Rojas Report appear to conform to applicable regulations, the theoretical background provided omits specific *praxis*. The fact that an "environmental license" might have been a requirement in the early 1970s, does not mean that an "environmental license" is required at present. The environmental license as a legal instrument is clearly different from one timeframe to another. A specific review of licensed activities in the 1970s vis-à-vis licenses granted at present reveals that the two notions represented different procedures and contents. It is simplistic to attempt to apply current licensing standards to pre-current regulation licenses.

9. Furthermore, the Rojas Report makes no reference to the most important precedent in its subject-matter in Colombia, that is, the ruling in the core subject-

[2] Article 3 of Decree 2820 of 2010.

matter made by the *Consejo de Estado* (State Council) in the class action filed by Claudia Sampedro Torres and others against the Ministry of Environment as a result of illicit coca crop fumigations as is further explained below. The claimants argued that the fumigations violated the right to a healthy environment and the duty of the State to guarantee ecological protection.[3] Key amongst the issues ruled upon are the following:

9.1 The position expressed by the Ministry of Environment, Housing and Territorial Development's (the "MAVDT" - currently Ministry of Environment and Sustainable Development) that all environmental legislation and requirements under Colombian were complied with.

9.2 The Court's analysis of numerous technical studies which concluded that only low impacts might ensue as a result of the aerial sprayings of illicit coca crops.

9.3 The Court's findings with respect to the need of prior consultations with the indigenous communities. Historically, and as will be further explained below, until 2003 the requirement of prior consultations was associated with the use of natural resources and their exploitation in indigenous territories and not applicable to cases such as the one at hand where the State had a duty to enforce the law against illicit activities. In other words, before 2003, there was no duty to undertake prior consultations with these communities in events where the State was exercising its powers to control unlawful activities on its territory. Only after that year did a court ruling require such consultations, within a specific scope, and the Government of Colombia complied with such requirement as of that time. More generally, prior public

[3] Docket 25000-23-25-000-2001-0022-02(AP)IJ, Consejo de Estado – Sala Plena de lo Contencioso Administrativo,

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consultation has also evolved through three fundamental approaches which triggered such a requirement: (i) originally, only if the exploitation of natural resources in territories of ethnic communities was liable to cause impacts was there a need to undertake prior public consultation; (ii) more recently, courts indicated that prior public consultation was a requirement if and when there were direct or indirect impacts on such communities within the area of direct influence of a given project or activity; and (iii) a final and current position indicates that it falls on the communities themselves to determine whether a project or activity generates impacts which require prior public consultation to be undertaken.

About the Author

10. José Vicente Zapata Lugo, is recognized as a leading environmental law practitioner in Colombia. Mr. Zapata is founding Partner at Suárez Zapata Partners Abogados S.A.S., one of the most reputed law firms in Colombia in addressing issues of natural resources. He has been recognized as one of the lawyers with the highest level of expertise in matters related to natural resources in Colombia. The leading lawyer in Colombia in environmental cases for oil and gas and mining ventures, he is also one of the most recognized lawyers in projects and negotiations pertaining to environmental matters in the mining and oil and gas sectors, both "upstream" and "downstream". With over 20 years experience in natural resources, he has been officer and legal representative of various oil and gas and mining corporations, as well as serving as president of one of the leading companies in Colombia, Columbus Energy Sucursal Colombia, a venture company successfully set-up in Colombia with 11 blocks in the Llanos and Putumayo basins in Colombia covering nearly 1 million acres of gross acreage(1), which during 2008 drilled 11 wells resulting in a 91% success rate and the addition of over 2,800 Bbl/d of net

production. Columbus Energy was incorporated as a subsidiary of Remora, one of the largest private equity backed E&P companies in the world with $1Bn of committed capital. With a strong background also in corporate and commercial law matters Mr. Zapata is recognized for providing environmental legal services in these areas to associations, the Government and companies from the electric, oil and gas, mining, agrochemical and industrial sectors. Similarly, Mr. Zapata has been legal counsel in the structuring of foreign investment transactions, mergers and acquisitions, as well as reorganization of corporations in Colombia. Mr. Zapata has been member of various Boards of Directors of multinational corporations in the automotive, energy, telecommunications, industrial and food sectors. He has also acted as of-counsel to various Ministries in Colombia. He is member of the American Society of International Law, the Institute for Energy Law (of the Center for American and International Law), Founder and General Secretary of the "Instituto Colombiano de Derecho Ambiental" (Colombian Institute of Environmental Law) and member of the "Colegio de Abogados de Minas y Petróleos" (Mines and Oil Lawyers Association), member of the International Bar Association, of the Association of International Petroleum Negotiators (AIPN), the Rocky Mountain Mineral Law Foundation, the European Society of International Law, and member and counsellor with the Gerson Lehrman Group. Author of "Desarrollo Sostenible: Marco para la Ley Internacional Sobre el Medio Ambiente" (Sustainable Development: Framework for International Law on the Environment) he has also authored various articles and publications relative to mining, oil and gas, as well as being the annual contributor to the Yearbook of International Environmental Law "The Year in Review - Colombia" published by Cambridge University Press. Mr. Zapata has worked extensively in matters of environmental liability, not only academically but also in judicial proceedings, particularly class actions and group actions. Mr. Zapata is an active member of the "*Good Practices* *and Portfolio Learning in GEF Transboundary Freshwater and Marine Legal and Institutional Frameworks*" project. He is adjunct Professor of the Javeriana, Andes, Rosario and Externado de Colombia Universities for corporate responsibility, environmental liability, sustainable development, oil and gas and mining. Mr. Zapata graduated from Universidad Javeriana, holds an LL.M. from McGill University. As head of the Natural Resources Practice (oil and gas, mining and environment) at his firm, Mr. Zapata has gained recognition as leading the most important legal team in this field in Colombia, and has recently been awarded the Joint Environmental Law Firm of the Year award granted by ACQ Law Awards. In addition, Mr. Zapata has been recognized as Latin American BTI Client Service All-Star for delivering superior client service, as part of a select group of 176 worldwide attorneys —The BTI Client Service All-Star Team— delivering the absolute best client service to Fortune 1000 clients. He is lead auditor in ISO 14001, and has undertaken management studies at the Yale School of Management. Mr. Zapata speaks Spanish, English and French.

Nota Bene

11. The following sections, as applicable, analyze the Rojas Report. For purposes of clarity, the headings of the sections below repeat the headings of the Rojas Report and comments are made with reference to the corresponding numbered paragraphs in that Report. The present report also includes specific considerations as to the status of the Colombian legal regime both in reference to the matter of environmental licensing, as well as to the issue of prior consultation with ethnic communities in the case of aerial spraying of illicit coca crops. Furthermore, while this document disagrees with many of the conclusions reached in the Rojas Report, in order to avoid unnecessary repetition only certain specific paragraphs of the latter Report have been specifically cited and critiqued below.

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Section I – As to the Matter of Environmental Protection in the Colombian Legal System

A. Constitutional Law and Basic Regulation

12. The historic account of the environmental regulatory background in Colombia provided in the Rojas Report is particularly useful in contextualizing the fact that Colombia has always been concerned with sustainable development. However, certain statements contained in the Rojas Report are subjective in nature and do not reflect the legal regime but rather are the author's own appreciations.

13. For instance, paragraph 2 of the Rojas Report states:

> *"As explained in the Conclusion, the aerial spraying program has been carried out in violation of Colombia's relevant domestic laws. These laws were established to protect the country's natural resources, human health, and the rights of indigenous peoples. The Colombian Government's violation of these laws has thus led to serious risks and harms to the things that these laws were designed to protect."*

14. There is, however, no evidence that Colombia's aerial spraying program has been carried out in violation of Colombia's relevant domestic laws. As will be explained below, the interpretation of the legal regime made in the Rojas Report, leads to the wrong conclusion, particularly in the matter of the requirement of environmental licenses. Contrary to what is asserted by Ms Rojas, the Colombian Government has complied in full with the legal requirements under Colombian law.

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15. Paragraphs 4 through 17 of the Rojas Report refer to the evolution of environmental laws in Colombia. It is true that Colombia has been a leader in defining environmental laws and regulations and in their effective implementation. However, it should be noted that the Rojas Report cites sections of the law that have been abrogated. For instance, paragraph 17 of the Rojas Report refers to article 85 of Law 99 of 1993 which was abrogated and replaced by Law 1333 of 2009, which created a new administrative environmental liability regime. This also indicates the clear nature of environmental duties and the efforts that Colombia makes on a continuous and regular basis to ensure legal compliance and effective implementation of its environmental laws. The protection of the environment is not a matter, which is taken lightly by the Government of Colombia.

B. Incorporation of International Environmental Law in Domestic/Municipal Colombian Law

16. Paragraphs 18 and 19 of the Rojas Report highlight the fact that Colombia has entered into various international environmental treaties and arrangements, whether of hard law or soft law. This goes to show that Colombia's interest in ensuring environmental protection and the respect for ethnic communities has been manifested also in international fora. Moreover, all environmental treaties to which Colombia is a party have been effectively developed and further regulated at the local level.

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Section II – Environmental Licensing and Environmental Impact Assessment in Colombia: Law and Practice

A. The Environmental License before Law 99 of 1993

17. Paragraph 21 of the Rojas Report states:

> *"The Environmental License does not simply represent a requirement to verify a series of data, but it is a process through which the relevant environmental authority decides on the viability of executing a project or carrying out a particular activity, by determining the maximum limit of damage to the environment, and the obligations required to achieve the desired objective."*

It is not true that the environmental license determines the *"maximum limit of damage to the environment"*. A clear distinction must be made between damage and impact. The requirement of an environmental license is one among various environmental instruments for the management of impacts. The license defines how such impacts are to be addressed. Note must be made that an environmental management plan is typically an integral part of the environmental licensing process, but can also be an independent instrument for environmental oversight. In fact, an environmental license typically includes terms of reference for the environmental impact assessment, the environmental impact assessment or environmental impact study, the environmental management plan and the environmental contingency plan. This set of documents conform what will ultimately be the environmental license.

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Clearly, if no environmental license or environmental management plan is required, no environmental impact assessment will be required either under law.

18. Paragraph 25 of Rojas Report states:

> *"In effect, beginning in 1974 and based on the CNRNR, two environmental management and oversight instruments were established: The Declaration of Environmental Effect (DEE) and the Ecological and Environmental Study (EES), which are considered to be the precursors of the Environmental License and the Environmental Impact Assessment. In particular, the EES, according to article 28 of the CNRNR, was required prior to obtaining the License and consisted of a study that had to be carried out before the execution of works, the establishment of an industry or the performance of activities that could produce serious environmental deterioration. This Study had to contain information about the social and economic environment of the project and its influence on the respective region."*

It is not possible to assume – as Ms Rojas appears to be doing in her Report - that the environmental license stipulated under Natural Non-Renewable Resources Code of 1974 (or "CNRNR") is the same instrument regulated by Law 99 of 1993. First of all, the CNRNR did not define a specific procedure for obtaining such license and furthermore, it did not set out the requirements to file for and obtain it. The Declaration of Environmental Effect originally only consisted in a unilateral declaration of presumptive consequences that the project or activity might entail. The environmental impact study foreseen in 1974 was not the same as that regulated at present and the only provisions to be taken into account were general physical, economic and social components. Currently, this differs significantly as presently a

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license would require much further review associated with the terms of reference adopted by the Ministry of the Environment for these purposes.

19. Additionally article 28 of CNRNR stated that an environmental license was **only required** when the project or the activity could produce serious deterioration to natural renewal resources. It is therefore very important to stress that pursuant to this law the aerial spraying program was not considered to be an activity , generating serious deterioration. As will be seen below, as of 1993, the regime of environmental licenses changed.

B. The Environmental License after Law 99 of 1993

20. The environmental license as a legal instrument after 1993 has been based on an exclusive list system. Only the listed activities require an environmental license pursuant to regulations which further develop Law 99 of 1993. If a specific activity is not listed therein, no environmental license is legally required.

C. Differences between an Environmental License, an Environmental Impact Assessment, and an Environmental Management Plan

21. In the post-1993 environmental licensing system, the environmental impact assessment and the environmental management plan are the fundamental basis of the environmental license. However, it is incorrect to state that an environmental management plan does not require an environmental impact assessment or that its importance is inferior to that of a license. An environmental impact assessment is concomitant to the establishment of an environmental management plan or an environmental license. Current regulations grant the same relevance to an

environmental management plan and an environmental license as will be explained in detailed in later sections of this report.

D. Regulations regarding Law 99 of 1993 in the area of Environmental Licensing

22. Paragraph 44 of Rojas Report states:

"Article 7 of the Decree defined those projects that were exclusively the domain of the Ministry of the Environment, including 'the production and importation of pesticides and those substances, materials or products subject to controls by virtue of international treaties, agreements and protocols

ratified for Colombia and currently in force' [...] (Art. 7, paragraph 8)".

The Rojas Report refers here to Decree 1753 of 1994 which developed the legal requirement of environmental licenses. It is clear from the terms of Article 7 of this Decree cited by Ms Rojas that no environmental license was required under the Decree for the use and application of pesticides.

23. Paragraph 47 of the Rojas Report states:

"Finally, the obligation to request an Environmental License and with it to submit Environmental Impact Assessments before initiating construction works, projects, or activities that are susceptible to producing environmental deterioration has existed without interruption since 1974. This obligation is

reinforced with the commitment that Colombia made to ratify the Convention on Biological Diversity of 1992 (...).”

As noted above, it is incorrect to state that there was an obligation since 1974 to request an environmental license and an Environmental Impact Assessment before initiating activities that are susceptible to producing environmental deterioration. One must not confuse these requirements as they currently stand with prior regulations which were much less precise. The Rojas Report itself differentiates the evolution of regulations in this respect. This, furthermore, has nothing to do with the Biodiversity Convention.

Section III. Colombian practice concerning Environmental Impact Assessments in relation to the eradication of illegal crops by aerial spraying

A. Colombian legislation and regulations on the eradication of illicit crops

24. Paragraph 54 of the Rojas Report states:

“Resolution 001 of 1994 was modified by the CNE in Resolution 005 of 2000, which recognized the need to assess environmental impacts, but relegated them to the phases of oversight, follow-up and monitoring of the illicit crop eradication program and not to the phase prior to the implementation of the project. The issuance of this Resolution and its emphasis on environmental protection, demonstrate that the authorities in the area of narcotics were aware that the implementation of the new spraying program, under the laws in place at that time, required Environmental Licensing. In this way the

modification of Resolution 001 of 1994 can be seen as an attempt to correct the lack of attention to environmental regulations."

This paragraph is based on an incorrect assumption and misinterprets the relevant regulations. According to article 49 of Law 99 of 1993, the only projects, works or activities that at present require environmental licenses are those specifically listed due to their potential to "*produce serious damage to renewable natural resources"*. This means that the environmental authority is not entitled to decide in which case the environmental license is required. The environmental license is a requirement only for those projects strictly defined by law or regulations. Accordingly, it is important to recall that article 52 of Law 99 of 1993 does not require an environmental license for application of pesticides. This is also confirmed by the subsequent regulatory decrees of Law 99 of 1993 (Decree 1753 of 1994, Decree 1728 of 2002, Decree 1180 of 2003, Decree 1220 of 2005, Decree 500 of 2006 and Decree 2820 of 2010). **<u>To this day, there is no regulation requiring an environmental license for the use and application of pesticides</u>**. This means that any activities related to pesticides, and notably spraying, are exempted from the requirement of an environmental license. In this regard, it is not legally correct to assert that for the years 1994 to 2000 the spraying of glyphosate in Colombia required environmental licenses . Indeed, this activity continues to the present to be exempted from the requirement to obtain an environmental license.

25. Paragraph 58 of the Rojas Report states:

"Finally, Resolution No. 0026 issued by the National Council of Narcotics in October 2007, authorized 'the eradication of illicit crops in areas of indigenous reservations where processes of consultation have taken place in

advance,' consolidating the legal framework for a situation that had already been taking place in practice in an unlawful manner. For many years, the government carried out spraying in indigenous reservations, openly violating laws on the protection of indigenous rights, particularly Law 21 of 1990 which approved ILO Convention 169 of 1989 and which requires holding a consultation with indigenous populations prior to the exploitation of natural resources or to affecting indigenous territories. This has been confirmed by the jurisprudence of the Constitutional Court and in the pronouncements of the Ombudsman's Office, as will be examined later in this study."

It is important to note that prior consultation with indigenous peoples is not only required in relation to projects, works or activities subject to environmental licensing requirements. Case studies, as explained below, clearly highlight that until 2003 such requirement was applicable in cases where there was to be use or exploitation of natural resources in territories of the indigenous communities. It is further clear that only after court rulings and interpretation of the legal regime, was it possible to determine the scope and content of the legal duty, and that the Government of Colombia has complied with the requirement as specified. On the other hand, it would be noted that the so called Ombudsman's Office ("Defensoría del Pueblo") does not have the authority to declare the existence or not of a legal requirement concerning prior consultation as its powers are limited in that respect under the responsible authorities pursuant to the Constitution of Colombia. In no manner whatsoever was the Government of Colombia in breach of any duty and on the contrary what the Government did was in compliance with the law. When requirements to consultation even where the use of natural resources was not at stake were set in place, the Government of Colombia complied with such new interpretation of the requirement.

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B. Aerial spraying operations in the context of Environmental Licensing regulations

26. Paragraph 61 of the Rojas Report states:

> *"The Colombian government has premised the legality of its aerial spraying operations on the environmental requirements established under Law 99 of 1993. According to article 49 of Law 99, as analyzed previously, any project that could cause serious damage to the environment must have an environmental license granted by the corresponding environmental authority. The use of pesticides – chemical herbicides – in aerial spraying operations, requires having an Environmental License, given that they are, in essence and by virtue of Law 9 of 1979 and its Regulatory Decree 1843 of 1991, substances that have the potential to cause serious changes to the environment and to natural resources. Yet, the Colombian Government has circumvented this requirement by conflating the different aerial spraying operations authorized over three decades into one single event and ignoring the significant distinctions between the various spraying programs over the years."*

The statement above is nothing other than Ms Rojas' own interpretation of Law 9 of 1979 and Decree 1843 of 1991 and does not reflect what these legal instruments actually do provide. Neither the Law nor the Decree regulated the need for an environmental license. Additionally, it should be recalled that since the early 1990s the aerial spraying program had already been implemented in full compliance

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with Law 30 of 1986 and, by the time Resolution 001 of February 1, 1994 was issued, Law No. 99 of 1993 was already in force. Accordingly, it is false to state that the "use" of pesticides in aerial spraying operations requires having an environmental license.

27. Paragraph 63 of the Rojas Report states:

> *"The first sprayings were carried out on an 'experimental' basis with the herbicide Paraquat in 1978 on marihuana crops in the Sierra Nevada de Santa Marta. At this time, the Decree Law 2811 of 1974 or the National Code of Renewable Natural Resources and Environmental Protection (CNRNR) was in effect. As a result, the spraying undoubtedly required what was then called the Ecological and Environmental Study (EES) and an Environmental License, according to article 28 of said Law. In light of the fact that these requirements were not met, the Colombian State was in violation of its environmental law in effect at the time when these experimental sprayings were carried out in the Sierra Nevada Santa Marta beginning in 1978. In effect, on the occasion of these sprayings, INDERENA (the Colombian environmental authority which predated the creation of the Ministry of the Environment in 1993) pointed out this fact, and advised the CNE that according to the CNRNR it was necessary to perform an EES. This demand was not met."*

It should be noted that all the applicable legal requirements were complied with by Colombia throughout the aerial spraying program. The Law 9 of 1979 had already adopted the measures required in the case of pesticides. Similarly, all requirements under Law 30 of 1986 were met. As noted above, at that time only the

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importation, manufacture or trade in pesticides required registration under Colombian law. In relation to the application of such products, Law 9 of 1979 in its article 142 provided that: *"In the application of pesticides, the interested party must have adopted all appropriate measures to avoid risks to the health of persons employed in that activity and the occupants of the areas or areas treated as well as the contamination of products for human consumption or the environment in general, according to the regulations issued by the Ministry of Health."* At the time, the Ministry of Health was the entity in charge of the study of the implications of the use of pesticides (within the framework of article 92(g) of Law 30 of 1986). As already recalled, according to the regulations of this Ministry, the environmental license was not a requirement for the use of pesticides. Once again, the Rojas Report assumes that arguable negative effects and impacts should have triggered an Ecological and Environmental Study and an Environmental License, even though these were not required under the law. Furthermore, clear differentiation should have been made in the Rojas Report between aerial spraying in National Parks and aerial spraying in general. The Rojas Report tries to make a case for applying restrictions in National Parks in a general manner.

28. Paragraph 69 of the Rojas Report states:

> *"The aerial spraying operations of 1994 were authorized through CNE Resolution 001 of February 1994. These were the first spray operations authorized under an official Government resolution. This spray program was intended to eliminate poppy, coca and marihuana crops. Despite the fact that the resolution mentions the communications sent in April 1993 by the General Manager of INDERENA and by the Minister of Health at the time, who gave their support for the aerial spraying operations over poppy fields,*

according to Law 30 of 1986 or the National Narcotics Statute, article 91(g), the authorization to spray given by the CNE did not comply with the legal-environmental requirements in effect in 1994 for two fundamental reasons […]"

As indicated before, according to article 52 of Law 99 of 1993 an environmental license is required only for specifically listed projects, activities and undertakings as of December 1993, which did not include aerial spraying of pesticides. Accordingly, the Rojas Report is incorrect when it states that Colombian legislation imposes the obligation to obtain an environmental license for the use and spraying of pesticides. Moreover, the Rojas Report provides its own interpretation of the scope of the requirement under Law 30 of 1986 and indifferently uses the notions of environmental license and environmental impact assessment in an attempt to make a case for the alleged omission of the environmental impact assessment supporting data, which is not the case.

29. Paragraph 70 of the Rojas Report states:

"In addition, while paragraph 7 of Resolution 001 of 1994 calls for the hiring of an environmental auditor to 'control and supervise the technical and proper execution of the eradication strategy,' this does not compensate for the failure to obtain the Environmental License and ignores the prevention principle which is enshrined not only in the law but in the Constitution, to the extent that the sprayings were carried out without any prior Environmental Impact Assessments which are part of the process of obtaining the license as put forth in article 57 of Law 99. It is worth noting that the environmental

audit, while still recommended for the purposes of environmental protection, is to be done after the corresponding project or activity has begun."

It should be noted that the environmental audit provided for in Resolution 001 of 1994 was not intended to replace the obligation to obtain the environmental license, since no such obligation existed according to the legislation in force at the time. The fact that an audit was provided for, however, even in the absence of a legal requirement to obtain an environmental license, attests to the diligence that the Government of Colombia exercised when undertaking the aerial spraying activities, which it in fact undertook in full compliance with the legal regime applicable at all relevant times.

30. Paragraph 72 of the Rojas Report states:

"Nevertheless, a strict legal analysis of the laws and regulations in force at that time, can only lead to the conclusion that the spraying operations of 1994 and subsequent programs, due to their particularities and their scope, would have had to be distinguished from those previously authorized, and therefore would have had to submit to the regulatory regime of the Environmental License contained in Law 99 of 1993."

The Rojas Report acknowledges that, for activities carried out after the year 1994, the regulatory regime of the environmental licenses of Law 99 of 1993 applies. This means that no environmental license was required. Furthermore, the Rojas Report itself recognizes that the Colombian Council of State (the highest administrative Court in Colombia) had ruled that an environmental license was not a requirement. One must therefore conclude that – since the aerial spraying program was a continuous and ongoing activity prior to the entry into force of Law 99 of 1993 – it clearly did not require an environmental license. Decree 1753 of 1994, which regulated Law 99 of 1993, specifically set forth that ongoing activities did not require an environmental license and could continue on the basis of any prior authorizations that allowed for such activities to be undertaken. This is of particular importance to the extent that it evidences various fundamental matters under the rule of law. On the one hand, it confirms that the aerial spraying program was in fact fully compliant with the laws in force in Colombia prior to 1994 and as such fell within the purview of the transitional environmental regime, which excluded the need for an environmental license. On the other hand, it confirms that because it was a lawful program, in compliance with Law 30 of 1986, it could continue to be undertaken without any limitation other than the establishment of an environmental management plan if the environmental agency in charge, the Ministry, so considered. Accordingly, on this specific point one must fully reject the position expressed in the Rojas Report as it is contrary to what the law itself indicated for projects or activities that fell within the purview of the environmental transitional regime. The regime clearly excludes the environmental license because of the fact that the activity had precisely already been authorized and the legislation was not meant to create a "new" obligation, the environmental license, for activities that had never required such an instrument.

31. Paragraph 75 of the Rojas Report states:

> *"Ultimately, the aerial sprayings of illicit crops carried out in 2000 under Resolution 005 of August 2000, constituted a significantly different activity from those programs designed and executed in the earlier years referred to*

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above. Resolution 005 of August 2000 announced a spraying program, to accompany the implementation of the recently implemented 'Plan Colombia'. This resolution marked the end of the 'experimental' nature of the former spraying program […]".

Resolution 001 of 1994 reiterated what had already been authorized by the Consejo Nacional de Estupefacientes since the early 1990s in compliance with Law 30 of 1986 authorizing fully the aerial spraying program. Resolution 5 of 2000, in turn, simply modified what was already authorized under Law 30 of 1986 to expand its content. In both instances, these activities were under the umbrella of Law 99 of 1993 and the transitional regime which resulted in the establishment of an environmental management plan. Environmental legislation does not restrict this activity in any manner in border areas. Moreover, neither Resolution 001 of 1994 nor Resolution 5 of 2000 implied a new program. In fact, the latter modified Resolution 001 of 1994, which clearly sets forth that it is the same program authorized by the Consejo Nacional de Estupefacientes in January 1992, which had all permits required under Law 30 of 1986, in particular from the Ministry of Health and the INDERENA. There is no doubt whatsoever that precisely because this was always an ongoing program; it fell within the transitional environmental regime. Only ongoing programs and activities fell under this regime.

The program is dynamic in nature and as time passes it evolves to adjust to changed circumstances, if any. The on-going, permanent and continuous nature of the aerial spraying program was recognized when its environmental management plan was requested as part of the additional requirements, which the Government of Colombia met.

32. Paragraph 76 of the Rojas Report states:

"The changes described above resulted in new risks that did not exist before, particularly the risk of cross-border environmental impacts."

This statement is based on an unsubstantiated assumption made by Ms Rojas. There are no objective grounds to state that the changes brought to the aerial spraying program in 2000 resulted in new risks, and *a fortiori* that they resulted in the risk of "cross-border environmental impacts". Moreover, the Rojas Report, instead of considering objectively the legal regime and the applicable laws and regulations, attributes to these alleged effects which clearly do not derive from the regulation or are contemplated in such laws.

33. Paragraph 77 of the Rojas Report states:

"Evidently, the aerial spraying program, carried out in the context of the Plan Colombia and strongly focused on the southern part of the country, was not part of the operations to which the transitional regime described in article 38 of the Regulatory Decree of Law 99 of 1993 applied, but rather they were operations which were to take place under the regular Environmental Licensing regime contained in that Law (Title VIII). In this respect, the 2000 spraying program required an Environmental License that should have been processed before the Ministry of the Environment, and for which an EIA would have had to be done, as required by article 57 of the Law. None of the above was done, and therefore Colombia failed to comply with its own internal environmental legislation."

At the time the aerial spraying program began in 2000, Decree 1753 of 1994 was in force. As stated above, this Decree did not require an environmental license for the use of pesticides. Indeed, there has never been a requirement for environmental licensing in Colombia in the terms indicated in the Rojas Report. The aerial spraying program had been conducted since 1993 in compliance with the requirements set out in Law 30 of 1986. Therefore, what ultimately occurred was that the program continued within the transitional regime developed as a consequence of Law 99 of 1993 and further to Decree 1753 of 1994. Evidence of this is particularly clear when reviewing the response provided by the then Minister of Environment, Mr. Juan Mayr Maldonado to the Secretary General of the Colombian Senate, dated 10 August 2001, where the Minister confirms that "*the aerial aspersion with glyphosate had the favourable opinion of the environmental authorities of the time and was in accordance with environmental regulations, duly supported in technical studies provided by the DNE and as well as those requested by the INDERENA*" (prior environmental authority to the Ministry of Environment). Furthermore, Minister Mayr in a response to the Office to the Ombudsman (Defensor del Pueblo) in a Public Hearing held on 24 August 2001, states that the Ministry confirmed that "*given that the procedure was authorized prior to the creation of the Ministry of Environment, the environmental measures were covered by the transitional regime established by Article 38 of Decree 1753/1994, which establishes that projects, works or activities which, in accordance with laws in force prior to the issue of this decree, had obtained permits, concessions, licenses or authorizations of an environmental nature, as then required, might continue, but the competent environmental authority might require them, through motivated order, to present environmental management, recovery and restoration plans*". There is, accordingly, absolutely no doubt whatsoever of the continuity and legality of the programme.

34. Paragraph 78 of the Rojas Report states:

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"In any event, even if one accepts that the transitional regime described in the Regulatory Decree of Law 99 of 1993 should apply to the spraying operations the Colombian government nonetheless still would have breached its environmental obligations, since, given the lack of an Environmental License, the Ministry of the Environment in Order 588A of August 13, 1996 had established Terms of Reference (TOR) for the EMP for the aerial spray program. Consequently, based on those TOR the CNE was required to design an EMP, which had to be submitted for approval by the Ministry of the Environment. […]."

The reference by the then Ministry of Environment to the fact that aerial spraying was under the transitional regime may not be deemed to imply that aerial spraying could not continue until an environmental management plan (or EMP) was approved. The fact that the approval process of the EMP took some years, until 2001, is not in any manner a breach of law. On the contrary, the clear and continued review by the Ministry during the EMP approval process, which is described by Ms Rojas as evidencing disagreement between the DNE and the Ministry of the Environment, is in reality indicative of the fact that the Colombian Government was seeking to ensure full knowledge of impacts and permanent oversight. Moreover, it is important to note that the DNE had the right to disagree with the recommendations made by the Ministry of Environment and the fact that it exercised such right cannot be interpreted as a breach of environmental obligations under Colombian law. This conclusion finds support in the 2004 judgment by the highest administrative Court of Colombia, the Council of State, which will be discussed in detail below.[2]

35. Paragraph 80 of the Rojas Report states:

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"With respect to the buffer zones, through Resolution 0013 of 2003, the CNE unilaterally and without due authority, reduced their dimensions, thus modifying the terms established by the Ministry of Environment for the EMP […]".

There is no reason to believe that buffer zones had been unilaterally reduced by the CNE. Should that have been the case, the then Ministry of Environment would have initiated investigation and sanction proceedings. This has not been the case and this allegation has no factual basis and is incorrect. In fact, the National Narcotics Directorate (DNE) appealed MAVDT Resolution 1065 of 2001, since the safety strips (buffer zones) of 1600 and 2000 metres established by the Ministry, were way above that of 100 metres set out in Decree 1843 of 1991 for the application of pesticides by air, and the Decree was a higher norm that could not be abrogated by a ministerial resolution (due to the fact that it is a lower hierarchy). Thus, since the Decree continued to be in force, Decree 1843 of 1991 continued to govern the matter. Additionally, DNE argued that setting 2000-metre buffer zones around natural parks, would encourage illicit growers to plant large extensions of illicit crops in those areas. Following Technical Opinion 1059 of 24 September 2003 which clearly sets out the Ministry's considerations for approving the 100-metre buffer zone, the EMP contained in Resolution 1054 of 2003, in its reasoning section quotes article 87 of Decree 1843 of 1991, refers to the aforesaid Technical Opinion, and orders that all applicable norms of Decree 1843 of 1991 must also be observed.

36. Paragraph 84 of the Rojas Report states:

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"The Ministry of Environment, in Resolution 1054 of November 2003, approved the DNE's request to modify the aerial program's Environmental Management Plan based on the transitional regime of article 28 (paragraph 3) of the new Decree 1180 of 2003, which regulates Law 99 of 1993 in the area of Environmental Licensing. Article 28 establishes that 'The projects, works or activities that before the issuance of this decree initiated all of the steps necessary to obtain the corresponding environmental license or to establish the environmental management plan, required by the laws in effect at that time, will continue their processes in accordance with those laws and should they obtain the license and/or management plan, may move ahead and/or continue the project, work or activity.' Thus, the Ministry of Environment approved the Environmental Management Plan proposed by the DNE with the respective proposed changes."

The Rojas Report, cites the regulation out of the context in which it was drafted and further attempts to impose a legal requirement which did not apply to the aerial spraying program by quoting selectively only article 28 of Decree 1180 of 2003 and ignoring altogether Decree 1753 of 1994. It is incorrect to assert that the Ministry of Environment by means of Resolution 1054 of 2003 stated that the aerial spraying program falls under the transitional regime provided for by Decree 1180 of 2003, which governs licensing procedure under provisions of Law 99 of 1993. The transitional regime originated under Decree 1753 of 1994 and. did not require or trigger the need for an environmental license for the aerial spraying of illicit crops. On the contrary, what the transnational regime recognized was that existing programs and activities continued to be valid and no further permits and authorizations needed to be undertaken. In other words, the only manner in which one would access the regime was if one was in compliance with applicable

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regulations prior to Decree 1753 of 1994 and Law 99 of 1993. The intent was to allow for a transitional period for activities that were duly complying with the law as was the case of the aerial spraying program under article 91, section g of Law 30 de 1986 (including therefore favorable opinions from the Ministry of Health and already mentioned INDERENA).

37. Paragraph 85 of the Rojas Report, states:

> *"In addition to what has been discussed already about the DNE regarding Resolution 0013 of 2003 -- in which it disregarded the EMP guidelines imposed on it by the Ministry of Environment in Resolution 1065 of 2001 -- the Ministry of Environment's approval of the EMP included in Resolution 0013 of 2003 also constitutes an open disregard of Colombian environmental law for the following reasons*
>
> *The spraying operations begun in 2003, authorized by CNE Resolution 0013, constitute a completely different program than those carried out previously, as its very title demonstrates: "By which Resolutions numbered 0001 of 11 February 1994 and 0005 of 11 August 2000 are repealed and a new procedure is adopted for the Illicit Crop Eradication Program".*
>
> *These operations, in terms of their scope, refer to all illicit crops in the national territory, whether industrial or small and independent crops and regardless of where they are found, that is, even in National Parks which are especially protected by Colombian environmental legislation.[…]."*

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It is not true that Resolution 0013 disregards Resolution 1065 of 2001 further to which the then Ministry of Environment imposed an environmental management plan was established. Resolution 0013 of 2003, as was the case of Resolutions 0001 of 1994 and 0005 of 2000, solely sought to "strengthen the fight against drug traffic and such actions for the control of illicit crops through the forced eradication, via aerial spraying with glyphosate" and never created a new program. Moreover, Resolution 0013 in its considerations (section 11) clearly reiterates that it is the same program which was "requested and obtained as set forth in article 91 section g) of Law 30 of 1986, such authorizations on this subject matter from the Ministry of Health and INDERENA."

In addition, it should be noted that in accordance with environmental regulations, Colombian environmental authorities may request amendment of the adopted environmental management instrument (EMP or license) for a project, without being required to apply for a new permit or license. As recalled above, there was a normal process for the EMP during which the DNE had the right to contest aspects it did not agree with. This does not constitute a breach of law nor does it amount to a disregard of applicable requirements. Resolution 1504 of 2003 confirms this when it states that the "environmental management plan is a dynamic instrument that may be adjusted in accordance with the characteristics of the activity and the environmental conditions where it is executed". Furthermore, with respect to projects affecting National Parks, the only manner in which these could have triggered any environmental license would have been if there was evidence of negative environmental effects on the parks. However, that was never the case. Moreover, any law providing for environmental permits for activities affecting national parks, is solely for the Government of Colombia to define, even in the early 1990s, since national parks are within its exclusive territorial jurisdiction.

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38. Paragraph 96 of the Rojas Report states:

"Based on the analysis presented in this Section, it can be concluded that Colombia did not have the Environmental License required for performing aerial spraying activities. Therefore, Colombia was not in compliance with its own legal obligations. It is worth repeating that the presentation of an EMP in 2003 did not satisfy the Colombian legal requirements for Environmental License, and specifically did not comply with the fundamental principle of prevention in environmental matters[...] ."

There is no single regulation in Colombia, and the Rojas Report does not cite one that supports its arguments, which triggers the need for an environmental license for the aerial spraying of illicit crops. Environmental licenses in Colombia are strictly regulated and there is no room whatsoever for interpretation in this respect. While it is true that an environmental management plan is an essential component of environmental license, for projects which fell under the transitional regime, i.e. those which began before Law 99 of 1993 and continued thereafter, the law itself equated environmental management plans with environmental licenses and has since then considered that both are clear environmental management instruments which provide sufficient grounds for appropriate oversight, control and follow-up activities. For projects such as the case at hand, the Rojas Report is incorrect in assuming that a subjective consideration of potential impacts can trigger an environmental license. This is not the case under the legal regime in Colombia. Furthermore, it is important to note that none of the judicial decisions rendered in relation to aerial spraying of pesticides to control illicit crops have indicated that environmental licenses are required, to the extent that the law has never required such an instrument and has considered that an environmental management plan suffices as it too presupposes an environmental impact assessment.

Section IV. Colombian practices regarding pesticides in relation to eradication of illicit crops by aerial spraying

39. Paragraph 113 of the Rojas Report states:

> *"In addition, Decree 1843 regulates in detail the various activities related to use and handling of pesticides, and requires licenses or special permits for such activity […]." "*

Contrary to what is stated in the initial part of this paragraph, as provided in Decree 1843 of 1991, a toxicological opinion for the use of a pesticide is a matter different from an environmental license requirement. Decree 1843, as indicated by the Rojas Report refers to experimentation, production, processing, formulation, storage, distribution, supply and transport of pesticides and not to their application which is what is ultimately being debated. The application, in turn, was undertaken in full compliance with Law 30 of 1986. What the Rojas Report incorrectly asserts, i.e. that every individual handling a product which falls under the category of pesticides must obtain an individual environmental license, is absurd. This is not what is provided in the regulations and furthermore does not conform to comparative laws on the same subject matter.

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40. Paragraph 114 of the Rojas Report states:

"It should be clarified that Andean Decision 436 of 1998, which became effective in 2002, regulates the harmonized requirements and procedures for the registration and control of chemical pesticides intended for agricultural use, orienting their correct use and handling toward preventing or minimizing damage to health and the environment in the conditions authorized, and facilitating their commercialization in the region Therefore, with respect to those activities, the national internal regulations remain in effect. In other words, Decree 1843 of 1991 and the other special regulations govern this specific subject area[…]."

The Government of Colombia has not failed to comply with Decree 1843 of 1991, and there is no evidence in that respect. On the other hand, it is interesting to observe that little attention is placed in the Rojas Report to Andean Decision 436 of 1998. This decision sets a common process for registration of pesticides in the Andean Community. This is of particular importance to the extent that the same analysis made for importation, production and use of pesticides in Colombia would apply to Ecuador as per the decision. This is likely purposely omitted. However, one should observe that the purpose that the Andean Nations had when issuing this regulation was precisely to harmonizing their views to the effect that product importation and production was the key aspect to be addressed when referring to environmental potential impacts. Thus, the same principles that govern environmental laws in Colombia are the ones that have been supra-nationally applied and are therefore compulsory to member countries. To assert that a matter which has been regulated supra-nationally in detail can be diverted from at the national level would entail a breach of regional regulations. In this respect, Colombian Courts have also had much to say.

What has been stated allows for the conclusion that there are in fact clear parameters and methodologies determined by the Andean Nations which, on the basis of international criteria such as that of the US EPA or the European Union, seek to define the orientations that local governments must follow on the subject matter of agrochemical pesticides. Various rulings including C-137 of 1996 and C- 231 of 1997 of the Constitutional Court, attest to the primacy and preferential and privileged applicability of supra-national regulations, as do Supreme Court Ruling dated February 27 de 1973 and Council of State Ruling dated April 28, 2011 Sala de lo Contencioso Administrativo – Sección Primera (Chamber for Contentious Administrative Affairs – First Section).

41. Paragraph 115 of the Rojas Report states:

> *"From the time the above-mentioned Andean Ruling became effective in Colombia, certain regulations were issued, such as Decree 502 of 2003 by the Ministry of Agriculture 'which regulates Andean Ruling 436 of 1998 for registration and control of chemical pesticides for agricultural use,' Resolution 0662 of 2003 of the Ministry of the Environment which regulates issuance of the Technical Environmental Rulings, and Resolution 770 of 2003, overturned by Resolution 3759 of 2003 of the ICA, which is currently in effect for the registration and control of pesticides. This last regulation, in its Article 2, establishes that 'obtaining the national registration is a requirement for the use of agricultural chemical pesticides in Colombia, in accordance with the stipulations of this resolution.'"*

Once again, as explained above, there is no legal duty to obtain an environmental license for the use of pesticides. These products typically carry their respective analyses and authorizations in order to be used in Colombia. There is no other duty with respect to environmental licensing and the Rojas Report does not cite a single law and/or regulation that can attest otherwise. When a pesticide is purchased for use by any individual in Colombia, it undergoes the appropriate screening processes and authorizations. In addition, and as an additional element beyond what is typical in the use and application of pesticides, the Government of Colombia in connection with the aerial spraying program requested and obtained an environmental management plan which further controls and ensures appropriate application. In other words, there is a two-tier control mechanism when it comes to the aerial spraying program. Not only do the pesticides used have to have an environmental license as required by the producer or the importer, but also when application is made the Government of Colombia strictly follows the environmental management plan approved by the then MAVDT.

Section V. Colombian practices regarding indigenous rights in relation to the eradication of illicit crops by aerial spraying

42. Paragraph 140 of the Rojas Report states :

> *"Therefore, Law 21 of 1991, under Article 6, establishes the obligation to apply the procedure of prior consultation with indigenous communities in any case involving activities related to the exploitation of natural resources or that affect their territory. That mandate specifically states that the Government must [...]."*

Much debate has been given to the extent of prior consultation with indigenous communities when aerial spraying is involved. As explained further below in this document, the view prevailing initially was that any such consultation was to be undertaken only when exploitation of natural resources or effects on indigenous territories were at stake. The State had the right to act upon an activity – such as the cultivation of illicit coca crops - which was in fact generating serious environmental impacts in addition to being illicit. When the courts defined the nature and extent of the duty of prior consultation vis-à-vis aerial spraying, the Government of Colombia proceeded to adapt its understanding to such rulings. There was no attempt to disregard the regulations and no evidence of unlawful conduct by the Government has been provided. On the contrary, there are minutes of extensive consultations undertaken and MAVDT writs which clearly evidence that the Government of Colombia complied not only with the applicable laws, but when court rulings required additional actions, these were effectively implemented.

43. Paragraph 141 of the Rojas Report states:

> *"In this regard, Article 76 of Law 99 of 1993 stipulates that 'The exploitation of natural resources must be done without negatively affecting the cultural, social, or economic integrity of the indigenous or traditional black communities, in accordance with Law 70 of 1993 and Article 330 of the National Constitution, and the decisions regarding the matter must be made only after consulting the representatives of those communities.'"*

All regulations cited throughout the Rojas Report point to the fact that the restrictions to access to indigenous territories were limited to the exploitation of natural resources. No single regulations provided for cases were illicit activities were being undertaken in such territories. This was only clarified through applicable case law at a later stage. Accordingly, no breach in that respect may be attributed to the Colombian Government. In fact, as will be shown below, a number of court rulings considered that aerial sprayings targeting illicit crops were outside of the purview of prior consultation.

44. Paragraph 147 of the Rojas Report states:

> *"In that regard Article 40 of the Constitution has been ignored. That article makes reference to the participation of citizens in the decisions of the State, as expressly indicated by the Constitutional Court […]".*

It is incorrect to state that article 40 of the Colombian Constitution has been ignored. The Government of Colombia, as has been evidenced in the decisions reached by Colombian Courts and administrative tribunals, has complied with and consistently respected the right of prior public consultation. In fact, the Constitutional Court's ruling of 1997, referred to at para. 147 of the Rojas Report, ordered consultation as of that moment in time and in no manner referred to any previous breach of that duty by the Government of Colombia. Again, rulings prior to those that led to prior consultation for aerial spraying, clearly referred to the "exploitation of natural resources in indigenous territories," but not to illicit activities undertaken in these.

Conclusions (as defined in the Rojas Report)

45. Paragraph 163 through 168 of the Rojas Report alleges that there have been various and separate aerial spraying program. This has never been the case. The program was never fundamentally changed and has never been interrupted or ceased. Contrary to what is argued, the program has evolved progressively, complying in each phase with regulations in force at the time when the relevant

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activities were undertaken. Throughout this period of time, the governing laws were Law 30 of 1986 and currently Law 99 of 1993 and Decree 2820 of 2010, and the Government of Colombia has respected the legal regime. In addition, as of the moment in time when the Constitutional Courts' interpretation as to prior public consultation with ethnic communities referred to aerial spraying of illicit crops, these were undertaken as requested. The premise of the Rojas Report, i.e. that since 1978 the Government of Colombia failed to meet the corresponding environmental requirements, is devoid of any factual evidence. It is unfortunate that the Rojas Report chooses to provide its own interpretation of the legislation rather than show what that legislation actually provides. An objective review of the relevant laws – applied to the conduct of the Colombian Government –shows that there has always been legal compliance by the Government of Colombia.

46. There exist no Colombian laws or regulations that can be used as basis for the assertion made in the Rojas Report that an environmental license (and an environmental impact assessment as part of such a licensing process, which forms part of the procedure necessary to obtain that license) was required for the aerial spraying of illicit crops to be undertaken. Indeed, Ms Rojas herself is unable to specify what regulations serve as basis for her claim to that effect. .

47. Furthermore, the allegation that the purported relevance of environmental impacts – besides the fact that the Rojas Report does not document any – would have triggered an environmental license is an incorrect legal statement from the perspective of Colombian law.

48. As to prior public consultation with indigenous communities, of particular relevance are the rulings in cases before the 15th Civil Court of Bogotá, the Superior Tribunal of Bogota and the Constitutional Court as to the need, or not, of prior consultation in the case of aerial spraying of illicit crops. These cases evidence the

evolution, which the matter of aerial spraying of illicit crops has had vis-à-vis-ethnic communities, and the fact the Government of Colombia never failed to comply with its legal duties as to prior public consultation. In analyzing this subject matter of relevance are the following annotations:

48.1 15th Civil Bogotá Circuit Judge, Ruling of August 3, 2001, resulted from an Action for the protection of constitutional rights *(Acción de tutela)* rights brought against the Republic of Colombia, as represented by the President of the Republic and the National Narcotics Council, the Ministry of Interior, the National Narcotics Directorate and the Director of the Police. The Claimant, the Organización de Pueblos Indígenas de la Amazonía Colombiana (OPIAC) – or the Indigenous Organization, indicated that rights to a health environment, to life and to their cultural identity were being violated as a result of aerial spraying in the Provinces of Putumayo, Guanía, Amazonas, Vaupés, Caquetá and Guaviare.

48.2 As a result thereof, claimants requested injunctive relief through the suspension of activities and an order for due process via public prior consultation. Particular mention was made by these communities of the traditional use of coca. In the view of the Indigenous Organization, ILO Convention No. 169 was not being complied with. Respondents argued that (i) glyphosate has been classified as of low toxicity, (ii) Law 30 of 1986 had been complied with and (iii) no such prior consultation was required in the case at hand as there was no exploitation of natural resources but a program against illicit activities that generated serious damage.

48.3 However, the Court disagreed with the claimants and held as follows: *"one must not set aside the fact that the reports filed by the respondents, attached to their responses to the action leads one to conclude that the main environmental, socioeconomic and cultural impact, which in fact is irreversible, is the procedures by which the land is prepared and illicit crops cultivated and illicit products* *processed" […] "In conclusion, it is not the fumigation of illicit crops what is destroying and/or contaminating in different aspects and in an eminent and irreversible manner the environment of the cultivated regions, but it is the procedure used to prepare, cultivate and obtain the illicit product, that is really the cause of serious alterations of our ecosystem, generating environmental, socioeconomic and cultural impacts"* (page 26).

48.4 The Court distinguished, the cases where prior public consultation is in fact required from those where there is a request to use natural resources lawfully. Prior public consultation was not considered to be a requirement for intervention when illicit activities were being undertaken, as this would defeat the purpose of law enforcement against an illicit activity. Accordingly, *"the Government of Colombia may not be subject to authorization of indigenous communities to apply an execute regulations pertaining to illicit crops; if this were the case, one would be legitimizing an activity that in its different phases of preparation, elaboration and consumption is being more lethal than the process of fumigation itself that has the eradication as its objective*."

48.5 The ruling accordingly denied the claims of applicant.

49. In a subsequent decision, the Superior Bogotá District Tribunal, Civil Chamber, ruling of September 12, 2001, rejected an appeal against the Ruling of August 3, 2001, deciding on an Action for the protection of constitutional rights *(Acción de tutela)*–National Narcotics Directorate–The Claimant, the Organización de Pueblos Indígenas de la Amazonía Colombiana (OPIAC) – or the Indigenous Organization. After citing extensive judicial precedents with respect to the nature of the claims brought against the Government of Colombia, the Tribunal indicated that *"in no manner whatsoever has there been indication, on an individual, specific and*

concrete basis, of the threat to or breach of the fundamental constitutional rights in relation to specific individuals."

50. The Tribunal further clarified what on a prior occasion the Colombian Constitutional Court had already ruled (Case T-067 of 1993), i.e. that there was no breach of fundamental constitutional rights as a result of aerial spraying with glyphosate.

51 In its ruling, the Tribunal held that there was no violation of the fundamental right to prior public consultation.

52. The Rojas Report fails to develop upon the extent to which Colombian court precedents evidence an evolution in the interpretation of laws and regulations on the matter of prior public consultation with ethnic communities. Moreover, it fails to explain that Courts have progressively increased the scope of such consultation, which originally was very much limited to cases involving the use of natural resources.

Section VII. Case Law on Prior Public Consultation

53. Furthermore, note must also be made of the evolution of the issue of prior public consultation throughout the last decades. As has been emphasized, historically no prior consultation was considered necessary for cases other than those where the use of natural resources for lawful activities was in fact to be undertaken.

54. The following aspects and principles originally upheld by the Constitutional Court in connection with prior consultation can be highlighted (Case T-067 of 1993 of the Colombian Constitutional Court being of particular relevance to this respect). The Courts expressly recognized prior consultation as mandatory only if the assumptions set forth in paragraph of Article 330 of the Political Constitution of Colombia were satisfied, that is, in the case of exploitation of natural resources within indigenous peoples' territories. The foregoing implied that prior consultation would only take place when the following conditions were met:

a) The projects at issue involved the exploitation of natural resources; and

b) Said exploitation was to take place within indigenous peoples' territories.

The exceptional limitation to the right of consultation rests on the following assumptions: (i) That the measure taken constitutes a necessary measure to safeguard an interest of superior nature; and (ii) That it is the least harmful measure to the self-determination granted to ethnic communities.

Section VIII. Prior Consultation Supporting Analysis in the Case of Aerial Spraying of illicit Crops

55. Supporting data from the DNE indicates that as at July 2011, 21 prior consultation processes have been undertaken with 716 indigenous communities[4]. This included in particular communities in the Putumayo and Nariño provinces. As a result of ruling SU-383 of 2003, the "Regional Amazon Forum" ("Mesa Regional Amazónica" – November 14, 2003) was set up as a permanent forum for

[4] Refer to communication from DNE of July 12, 2011, Reference 40000-391-2011 / S-2011-41964.

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concertation with these indigenous peoples. Nevertheless, the Constitutional Court set limits to the prior consultation mechanism. The Court clearly stated that *"the right to prior consultation, provided for in Convention 169**, does not entail the right of indigenous and tribal peoples to veto the legislative and administrative measures that affect them**, but rather present an opportunity for the States Party to consider and assess the views on their decisions held by members and representatives of national ethnic minorities, undertaking to promote an approximation and, **if possible**, an agreement"* (p. 127, emphasis added). Consequently, although before implementing measures under the aerial spraying program prior consultations are to be conducted with the corresponding indigenous authorities of the territory where the illicit crops are to be eradicated, these authorities may not prevent the Colombian State to fulfil its sovereign duty to eradicate the illicit crops that are not indispensable to ensure consumption related to their ancestral use. As ILO has acknowledged, <u>Article 6 does not require consensus to be obtained in the process of prior consultation.</u> Therefore, the Court concluded that, *"[i]f having carried out consultations in good faith and in a manner appropriate to the circumstances, the consent of the consulted peoples is not achieved with regard to the proposed measures, the defendant agencies [in charge of the PECIG Program implementation] must assess, in what each of them is concerned with, the seriousness of the individual and collective harms caused by the measures, with the purpose of implementing any necessary corrective measures to the Program in order to safeguard the people, their property, institutions, culture and territory"* (p. 125).

In addition, numerous writs from the MAVDT clearly attest and evidence that the prior consultation process has always been complied with. MAVDT, in charge of overseeing the environmental management plan for application of glyphosate to illicit crops, has certified this compliance as part of Section 6 (Communication and

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Social Development Program) of the environmental management plan. There is extensive evidence on the record that MAVDT has further declared that the Office of the President of the Republic, through its Social Action Office, the Ministry of Interior and Justice, MAVDT, INS, ICA, DNE and DIRAN, undertook prior consultation with communities and in particular those which are of indigenous ethnicity. One can cite to this respect and of particular relevance in the case at hand, such consultations undertaken with the indigenous groups of Buenavista, La Italia, Pinuna Blanco, Santa Elena, Inga, Los Pastos, Moniya Amena and the Regional Indigenous – OZIP as weill as OCIMPA, located in Puerto Asís municipality in the Province of Putumayo (please refer to writs from MAVDT: (i) No. 0917 of April 13, 2007 ; (ii) No. 918 of April 13, 2007; (iii) No. 1607 of June 26, 2007; (iv) No. 2018 of July 31, 2007; (v) No. 2940 of October 30, 2007; (vi) No. 3237 of December 4, 2007; (vii) No. 170 of January 30, 2009; (viii) No. 171 of January 30, 2009). No less important are the minutes of prior consultation undertaken on November 14, 2003, after ruling SU 383 de 2003 and minutes Nos. 20 and 21 of December 2006, with regard to prior consultation with indigenous authorities of the Putumayo Province.

Section IX. The Judgment of the Colombian Council of State regarding theAerial Spraying Program

56. One of the issues of utmost importance which is not addressed in the Rojas Report, is the judgment of the Colombian Council of State Chamber of Administrative Contentious Affairs, Councilor Nicolás Pájaro Peñaranda presiding, October 19, 2004, Docket No. 25000-23-25-000-2001-0022-02(AP) IJ, in an action brought against the then Ministry of Environment, seeking a permanent injunction of the aerial spraying of illicit crops on the basis of the alleged transgression of environmental rights and duties. It is perhaps not surprising that this judgment is

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nowhere mentioned in the Rojas Report as it is directly contrary to any attempt to its assertions that Colombia violated the environmental laws in undertaking aerial spraying of illicit crops with glyphosate,

The lawsuit was filed with the purpose of obtaining protection of the collective rights to enjoy a healthy environment, guarantee, use and restore natural resources, animal and plant species and areas of particular environmental importance. The Claimant asked the Council of State to adopt measures to prevent the alleged deterioration that they claimed was being caused under the pretext of eradicating illicit crops. Claimants repeatedly insisted that the aerial spraying of paraquat and glyphosate, has led to disastrous results in Colombia and that the Ministry of Environment had not undertaken the required control and oversight for the protection of health and environment.

57. After a thorough analysis and evidentiary discovery, the Council of State concluded that grounds for the claim were not valid. In view of the high tribunal, there was no need to suspend or halt the aerial spraying of illicit crops with glyphosate. As the Council held:

- Evidence does not allow to infer with certainty that glyphosate used in the eradication of illicit crops produces irreversible damage to the environment. On the contrary, in view of the tribunal there are elements to conclude that regeneration of sprayed areas occurs within a short period of time and that, on the contrary, large extensions of forest are destroyed as a result of tree felling by the growers of illicit crops.

- The Council held that aerial spraying should be undertaken in conformity with guidelines provided by environmental authorities and with due controls.

Albeit, such conditions did not lead it to conclude that suspension of aerial spraying was necessary.

- There was absolutely no evidence in the file, of breach of the measures imposed by the Ministry of Environment under Order No. 341 of 2001.

Section X. Concluding Remarks

58. Colombian laws have not provided for the requirement for an environmental license as a condition concomitant to application of pesticides in Colombian territory in any manner whatsoever. As was the case after the enactment of Law 99 of 1993 and Decree 1753 of 1994, and is still the case under the current Decree 2820 of 2010 on environmental licensing, the application of pesticides does not require an environmental license as an activity considered to be subject to such licenses. As a consequence of regulations issued after Law 99 of 1993, only activities specifically listed as requiring an environmental license are those that require such an environmental management instrument. As currently defined under law, the environmental license is the authorization granted by the competent environmental authority for the execution of a project, work, or activity that, according to the law and regulations, might entail serious damages to natural renewable resources or to the environment, or bring about significant or noticeable changes to the landscape, requiring its beneficiary to comply with requirements, terms, conditions, and obligations contained in it with respect to the prevention, mitigation, correction, compensation, and handling of the environmental effects caused by the project, work, or activity. Furthermore, the environmental license includes all permits, authorizations, and/or concessions for the use of and/or effects caused to natural renewable resources, as required throughout the duration of the project, work, or

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activity. In addition, effectiveness, toxicological and environmental assessments have been carried out on such pesticide products in accordance with Andean Pact Decision 436 of 1998 on the Registration and Control of Chemical Pesticides for Agricultural Use. To the extent that Colombia applies such control at the source, environmental licenses are not required before any use or application of pesticides.

59. Since the outset of the program, aerial spraying activities undertaken by the Colombian Government have been monitored and supervised, by Colombian courts and by the Government itself. Initial aerial spraying activities were regulated by the health and environmental regulations in force since the early 1970s and the Government duly complied with such regulations. Environmental impact assessments have since then considered environmental impacts as changes to the biotic, abiotic and socioeconomic environmental system, whether adverse or beneficial, partly or wholly, and that can be attributed to the development of a project, work, or activity. Under the legal regime of Decree 2811 of 1974, there was no duty to obtain an environmental license to the extent evidence of serious impact or deterioration had not been established. Articles 27 and 28 of Decree 2811 of 1974 (later repealed by Law 99 of 1993) were clear in respectively providing that (i) any person or entity, public or private, that intends to undertake a work or activity susceptible of producing environmental deterioration, must declare the presumptive hazard/risk which can be a consequence of such work or activity and (ii) for the execution of works, the establishment of industries or the development of any other activity that, due to its characteristics, may cause serious deterioration to renewable natural resources or the environment or introduce considerable or notorious modifications to the landscape, a prior ecological and environmental review shall be undertaken and an environmental license obtained. Despite the fact that in the case at hand there was no prior evidence of serious impacts and, as documented, that is

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still the case, the corresponding environmental impact assessments were in fact undertaken in compliance with laws in force at the time including, in particular, both Law 9 of 1979 and Law 30 of 1986. Under article 137 of Law 9 of 1979 for the importation, production and commercialization of pesticides, the requirement was to have a registration in accordance with the law, registration that would "only be issued by the competent authority when in view of the Ministry of Health the pesticide in question does not represent a serious threat to human health or the environment and its substitution for less dangerous products is possible". Accordingly, it is clear that when a product was used with the registry it was precisely because it did not pose serious threat in accordance with law.

60. Much focus has been placed in the Rojas Report as to why an environmental license was not in fact obtained prior to the aerial spraying in the Republic of Colombia, and the reason has been clearly explained. There was before Law 99 of 1993 no legal requirement for this particular activity to have a license. Moreover, even after 1993, when stricter laws were in force, there continues to be no requirement to obtain an environmental license as a precondition for such aerial spraying to be undertaken, most likely due to the fact that further scientific knowledge pertaining to the aerial spraying of illicit crops does not warrant it. Regulations in force since 1993 have clearly reaffirmed that only the production and importation of pesticides require an environmental license. For purposes of clarity:

60.1 The first regulatory decree of Law 99 of 1993, Decree 1753 of 1994, again set forth that the authority responsible for environmental licensing was the then Ministry of Environment, but solely for the "production and importation of pesticides".

60.2 Each of the posterior regulations on environmental licensing, Decree 1728 of 2002, Decree 1180 of 2003, Decree 1220 of 2005 as amended by Decree 500 of 2006 and the current Decree 2820 of 2010, reinstated the original conditions. Colombian legislation has not required environmental licensing for the use or application of pesticides. The Rojas Report therefore misrepresents the legal framework and argues on the basis of alleged violations of environmental laws which have never taken place and could not have taken place under the legal regime that existed in the past and as it currently stands. At present, and for avoidance of doubt, the relevant regulation (Decree 2820 of 2010, article 8) still does not impose any requirement of an environmental license for the use of pesticides.

60.3 Moreover, the Government of Colombia also chose to issue an environmental management plan for the aerial spraying of illicit crops. Indeed, as recognized by Colombian courts, the adoption of an environmental management after the issuance of Decree 1753 of 1994 was a discretionary measure and represents the confirmation that before such date, there was no legal requirement to even have an environmental management plan, much less and environmental license. Article 38 of Decree 1753 of 1994, was adamant in clarifying that projects, works or undertakings that, in accordance with regulations in force prior to its issuance, had already obtained their permits, concessions, licenses or authorizations of environmental nature as required, could continue, but the environmental competent authority was enabled to request or require, in a reasoned decision, the submission of a plan for environmental management, recovery or restoration. There is thus absolutely no doubt that the fact that the then Ministry of Environment chose to require an environmental management plan, presupposed that aerial spraying of illicit crops until such date of the requirement was in fact complying with the legal regime as the activity been could not have been otherwise subjected to the requirement of an environmental management plan. Moreover, Decree 1753 of 1994 further stipulated that projects,

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works or activities that began their activities before Law 99 of 1993 would not require an environmental license. Accordingly, when the then Ministry of Environment proceeded to require an environmental management plan for an activity which had begun prior to 1994 and was therefore not subject to an environmental license, it did so beyond any standard duty of care taking into account that until that date, compliance had been met. It should be noted, similarly, that the aforementioned Decree 1753 of 1994 did not set a specific timeframe or limit for the establishment of an environmental management plan to the extent that it was discretionary on the part of the environmental authority and not a necessary requirement. The environmental management plan, once established, specifies the measures and activities that, as a result of an environmental assessment, focus on preventing, mitigating, correcting, or offsetting properly identified possible environmental effects and impacts caused by development of a project, work, or activity. Further it includes follow-up, monitoring, contingency, and abandonment plans depending on the nature of the project, work, or activity.

60.4 The issue of environmental licensing has been discussed on many occasions before Colombian courts. In none of the cases brought to trial at the highest level has there ever been any judicial finding that the Government breached an alleged requirement for environmental licensing due to the aerial spraying of illicit crops. On the contrary, Colombian courts have consistently accepted that the establishment of the environment management plans for the aerial spraying of illicit crops was undertaken in accordance with applicable regulations. Order 558A of August 13, 1996 as issued by the then Ministry of Environment not only imposed the requirement for an environmental management plan, but also defined the terms and conditions which the environmental impact assessment had to contain as an integral component of the environmental management plan ultimately approved. This in no manner implied, indicated or considered that before such time aerial spraying of illicit crops had not complied with the legal regime. On the contrary, there was never a single administrative environmental proceeding for breach of law in this respect. *Strictu sensu*, the environmental management plan resulted in even further controls, impact analyses and effective preventive and precautionary measures than those that were already in place, resulting in strengthened environmentally protective conditions for such applications. In fact, in a response provided by the then Minister of Environment, Mr. Juan Mayr Maldonado to the Secretary General of the Colombian Senate (dated the 10 August 2001 Rad. No. 3111-2-10640), the Ministry confirmed that "the aerial aspersion with glyphosate had the favorable opinion of the environmental authorities of the time and was in accordance with environmental regulations, duly supported by technical studies provided by the DNE as well as those requested by the INDERENA" (predecessor of the Ministry of Environment as national environmental authority).

60.5 Decision 436 of 1998 of the Andean Community is of particular importance when analyzing requirements and conditions for the use of pesticides in the Andean region, considering the fact that it is also applicable in Ecuador as a supranational regulation. The purpose of this regulation was the harmonization of regulations pertaining to the registration and control of chemical pesticides of agriculture use in the Andean Community, taking into account the health, agronomic, social, economic and environmental conditions of the member countries, in accordance with the FAO code of conduct for the use and distribution of pesticides. The regulation is again based on the registrations of the product and not on its application. Registration is compulsory solely for the manufacturer, formulator, importer, exporter, as well as for the packing and distribution of chemical pesticides of agricultural use. Evaluation of pesticides is therefore undertaken at the time of manufacture or prior to their commercialization to fully determine their effectiveness, toxicity and environmental impacts. Should a product be registered regionally, the product may be commercialized in all such Andean countries that have accepted its registration. The regulation imposes no further requirement for an environmental license for the application of such pesticides.

60.6 Prior to the Colombian Constitutional Court's Ruling of unification of jurisprudence of May 13 2003, SU-383 – Docket T-517.583, resulting from the Court's power to review decisions on actions for the protection of constitutional rights when and to the extent such review is deemed of constitutional importance, the courts' rulings on the issue of whether or not prior consultations were mandatory for aerial spraying of illicit crops were premised on the fact that such a requirement did not exist. The fundamental basis for this conclusion, as has been documented in the cases referred to above, was that the prior consultation with indigenous communities was required in cases where the lawful use of natural resources was to be undertaken in their territories. It was only with the Ruling of May 13 2003, of the Colombian Constitutional Court, that this position was clarified by the Constitutional Court when it held that prior consultation should be interpreted to be required even in the event of aerial spraying of illicit crops. Accordingly, following that decision, the aerial spraying of illicit crops has been undertaken only in compliance with the Constitutional Court's ruling. Thus, argumentative interpretations seeking to establish that aerial spraying of illicit crops have failed to comply with Colombian and international regulations associated with the right to consultation of indigenous peoples are inaccurate. The issue of prior consultation with indigenous peoples as it relates to the aerial spraying of illicit crops was only resolved after the Colombian Constitutional Court's ruling of 2003, and as of that time such requirement has been duly complied and met with.

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60.7 There is no doubt that throughout the years in which aerial spraying of illicit crops has been undertaken, the DNE has followed prior environmental impact analysis as a precondition for such aerial spraying.

61. In light of the above, this report concludes that there are no grounds for asserting that there was a breach of law due to an alleged failure to obtain an environmental license or violations of the duty of prior consultation with indigenous communities on the part of the Government of Colombia with respect to the aerial spraying of illicit crops.

JOSE V. ZAPATA L.

SUÁREZ ZAPATA PARTNERS

ABOGADOS

Curriculum Vitae

of

José Vicente Zapata Lugo.

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José Vicente Zapata Lugo (2011)

EDUCATION

E-Learning Basic Course International Environmental Law, UNITAR **2008**

Executive Management Program for Lawyers, Yale School of Management **2004**

Santiago, Chile

Bureau Veritas, Lead Auditor ISO 14001 **2003**

Bogotá, Colombia (Focus: International Law)

Doctoral Studies, McGill University **1994 - 1996**

Montreal, Canada (Focus: International Transactions)

Master in Comparative Law (Ll.M.), McGill University **Ended 1994**
Montreal, Canada (Focus: Sustainable Development & International Business Law)

- Thesis: Sustainable Development: A Role for International Environmental Law

Law Programme (Law Degree), Pontificia Universidad Javeriana **Ended 1990**

Bogotá, Colombia

- Thesis: Non-Voting Preferential Shares

ACADEMIC AWARDS

Principal's Dissertation Fellowship, McGill University **1994-1995**
Montreal, Canada

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Judge Greenshields Memorial Scholarship, McGill University **1994**

Montreal, Canada

Max Binz Major Fellowship, McGill University **1993**

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Judge Greenshields Memorial Scholarship, McGill University **1992**

Montreal, Canada

WORK EXPERIENCE

Partner, Suárez Zapata Partners Abogados **2010 -**

Bogotá D.C., Colombia

- Corporate Affairs - Mergers and Acquisition
- Oil, Gas & Mining – Environment Practice Director
- Coordinator Environmental Litigation Group

Partner, Holguin, Neira & Pombo Abogados **2000 - 2010**

Bogotá D.C., Colombia

- Corporate Affairs - Mergers and Acquisition
- Head Oil, Gas & Mining – Environment Practice

External General Legal Counsel, Colombian Ministry of Education **2000 -**

Bogotá D.C., Colombia

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Senior Associate, Brigard & Urrutia Abogados **1997- 2000**

Bogotá D.C., Colombia

- Head Environmental Law Division
- Mergers and Acquisitions
- Corporate Law
- Commercial Transactions
- Exchange Regulations – Foreign Investment

External Legal Counsel, Ministry of the Environment **1996**

Bogotá D.C., Colombia

- Terms of Reference Colombian Electric Sector

Senior Associate, Posse, Herrera & Ruiz **1996-1997**

Bogotá D.C., Colombia

- Head of Environmental Law Division
- Commercial - Corporate Law (Project Finance - Structuring)
- Foreign Investment
- Assistant Taxation

Research Assistant, McGill University Faculty of Law

Montreal, Canada

Dean Stephen J. Toope & Professor Jutta Brunnée **1994-1996**

- Project on Freshwater Resources & Environmental Security

Professor Jutta Brunnée **1993-1994**

- International Forest Resources Project
- European Union Environmental Law

SUÁREZ ZAPATA PARTNERS
A B O G A D O S

- ♦ International State Responsibility

Assistant - Legal Counsel, Dow Chemical Co. **1989-1992**
Bogotá D.C., Colombia

Dr. Oswaldo Parra

- ♦ Project Structuring – Financing
  - ♦ Corporate Law
  - ♦ Labor Law
- ♦ Foreign Investment
- ♦ Environmental Law

Head Monitor - Legal Clinic, Pontificia Universidad Javeriana **1989**

Bogotá D.C., Colombia

Legal Assistant, Esguerra, Gamba, Barrera, Arriaga & Associates **1988**

Bogotá D.C., Colombia

PROFESSIONAL AWARDS

Special Recognition Award, Dow Chemical Co. **1991**

Bogotá D.C., Colombia

- ♦ For the Obtention of Adequate Support to Credit Lines

PUBLICATIONS

Journals: "The Year in Review – Colombia Legislative Development" **2009**

Yearbook of International Environmental Law – Cambridge University Press

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Journals: "The Year in Review – Colombia Legislative Development" **2008**

Yearbook of International Environmental Law – Cambridge University Press

Journals: "The Year in Review – Colombia Legislative Development" **2007**

Yearbook of International Environmental Law – Cambridge University Press

Journals: "The Year in Review – Colombia Legislative Development" **2006**

Yearbook of International Environmental Law – Cambridge University Press

"Revista de Orientación Tributaria – Impuestos" (Bogotá D.C.: Legis 2006) **2006**

Proporcionalidad entre la Carga Ambiental y el Uso del Recurso

"Industria y Medio Ambiente. Responsabilidad por Pasivos Ambientales: consideraciones respecto de la problemática" en Perspectivas del Derecho Ambiental en Colombia (Universidad del Rosario, Bogotá). **2006**

"Viabilidad Jurídica del Desarrollo Sostenible: El Caso del Parágrafo del artículo 43 de la Ley 99 de 1993: La Inversión Forzosa del 1%" en 15 Años de la Constitución Ecológica de Colombia (Universidad Externado de Colombia, Bogotá). **2006**

Journals: "The Year in Review – Colombia Legislative Development" **2005**

Yearbook of International Environmental Law – Cambridge University Press

Journals: "The Year in Review – Colombia Legislative Development" **2004**

Yearbook of International Environmental Law – Cambridge University Press

Journals: "The Year in Review – Colombia Legislative Development" **2003**

Yearbook of International Environmental Law – Cambridge University Press

Journals: "The Year in Review – Colombia Legislative Development" **2002**

Yearbook of International Environmental Law – Cambridge University Press

Journals: "The Year in Review – Colombia Legislative Development" **2001**

Yearbook of International Environmental Law – Cambridge University Press

Journals: "The Year in Review – Colombia Legislative Development" **2000**

Yearbook of International Environmental Law – Cambridge University Press

Journals: "The Year in Review – Colombia Legislative Development" **1999**

Yearbook of International Environmental Law – Cambridge University Press

Book: "*Desarrollo Sostenible: Marco Para la Ley Internacional Sobre el Medio Ambiente*" Ediciones Librería del Profesional, Bogotá, Colombia **1997**

<u>ACADEMIC ACTIVITIES</u>

Professor, Oil and Gas, Mining and Environmental Responsibility **2009 -**

Bogotá D.C., Universidad Nuestra Señora del Rosario

Professor, Oil and Gas, Mining and Environmental Responsibility **2009 -**

Bogotá D.C., Universidad Externado de Colombia

Professor, Corporate Responsibility and Environmental Liability **2004 -**

Bogotá D.C., Universidad Nuestra Señora del Rosario

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Professor, ISO 14000 – Total Quality Management Systems **1997-**

Bogotá D.C., Universidad Externado de Colombia

Professor, International Commerce and Sustainable Development **1997-**

Bogotá D.C., Universidad Nuestra Señora del Rosario

<u>EXTRACURRICULAR ACTIVITIES - BOARDS</u>

Member IBA – Committee Section on Energy, Environment, Natural Resources and Infrastructure Law

(London, U.K.) **2006 -**

Member IEL of the Center for American and International Law **2006 –**

Houston, U.S.A.

Member Colegio de Abogados de Minas y Petróleos **2000 -**

Bogotá D.C., Colombia

Board or Directors Member, Rayovac Varta S.A. **2002 -**

Bogotá D.C., Colombia

Board of Directors Member, SOFASA S.A. **2000 –**

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SUÁREZ ZAPATA PARTNERS
ABOGADOS

General Secretary, Instituto Colombiano de Derecho Ambiental **1998 -**

Bogotá D.C., Colombia

Member, American Society of International Law (ASIL) **1994-**

Washington D.C., United States of America

Member, Canadian Council on International Law (CCIL) **1994-1997**

Ottawa, Canada

Representative, Colombian National Education and Learning Center (SENA) **1991-1992**

Bogotá D.C., Colombia

José Vicente Zapata Lugo

Lawyer, LL.M.

Annex 8

Expert Report of Dr G. Marcella, Ph.D. on behalf of the DynCorp Defendants in *Arias/Quinteros v. DynCorp* (D.D.C.), 17 January 2011

(United States District Court for the District of Columbia, Cases No. 1:01-cv01908 (RWR-DAR) and 1:07-cv01042 (RWR-DAR). Cases consolidated for Case Management and Discovery)

EXHIBIT 10

EXPERT REPORT BY DR. GABRIEL MARCELLA ON BEHALF OF THE DYNCORP DEFENDANTS IN *ARIAS/QUINTEROS v. DYNCORP* (D.D.C.)

I. Expert Credentials and Required Disclosures

A. General Professional Credentials.

My name is Dr. Gabriel Marcella. I teach the "Americas" course at the United States Army War College (USAWC), where I served from 1981 until 2008 as a professor of Third World Studies and the Director of the Americas Regional Studies in the Department of National Security and Strategy. I am a recognized authority on United States policy and strategy in Latin America and have been working in this field for over 45 years, dating back to my studies as a Fulbright Scholar in Quito, Ecuador in 1964-65. I have instructed military and civilian officers of the United States and foreign countries (including Colombia and Ecuador) on international security issues in Latin America, including the threats posed by narcoterrorism. I have also served as a consultant on these matters to the U.S. Department of Defense, United States Southern Command, U.S. Department of State, and National Defense University.

My publications include over 100 articles, book chapters, monographs, edited volumes and commentaries on Latin America and the United States' vital security interests in the region. I have written extensively about "Plan Colombia," the United States' security interests in Colombia, and the threats posed by the narcoterrorist organizations. My publications on these topics include: "Colombia's Three Wars: U.S. Strategy at the Crossroads," Carlisle, PA: Strategic Studies Institute (SSI), March 5, 1999; "Plan Colombia: The Strategic and Operational Imperatives," Carlisle, PA: SSI and North-South Center, April 2001; "Plan Colombia: Some Differing Perspectives," Carlisle, PA: SSI, June 2001; "The U.S. Engagement with Colombia: Legitimate State Authority and Human Rights," Miami: University of Miami, North-South

Center, March 2002; "The United States and Colombia: The Journey from Ambiguity to Strategic Clarity*,"* Carlisle, PA: SSI, May 2003; "American Grand Strategy for Latin America in the Age of Resentment," Carlisle, PA: SSI, September 2007; "War Without Borders: The Colombia-Ecuador Crisis of 2008," Carlisle, PA: SSI, December 2008; and "Democratic Governance and the Rule of Law: Lessons Learned From Colombia," Carlisle, PA: SSI, December 2009. With respect to Ecuador, I also have co-authored a book and authored a report for the Strategic Studies Institute about its war with Peru in the 1990s: *Security Cooperation in the Western Hemisphere: Resolving the Ecuador-Peru Conflict*, Miami: University of Miami, North-South Center Press, May 1999; "War and Peace in the Amazon: Strategic Implications for the United States and Latin America of the 1995 Ecuador-Peru War," Carlisle, PA: SSI, November 24, 1995.

Prior to joining the USAWC, I served from 1974 to 1981 as a Foreign Affairs Analyst at the Strategic Studies Institute of the USAWC. From 1987 to 1989, I took leave from USAWC to serve as the International Affairs Advisor to the Commander-in-Chief at the United States Southern Command in Panama. In 1997, I took a research sabbatical at the Bureau of Western Hemisphere Affairs of the U.S. Department of State. During my service in government I have consulted with officials responsible for formulating and implementing U.S. policy for Colombia.

I received a B.A. in Latin American Studies from St. Joseph's University in Philadelphia in 1964. I received an M.A. in History from Syracuse University in 1967, a Ph.D. in Latin American History from the University of Notre Dame in 1971, and a diploma from the Inter-American Defense College in Washington, D.C. in 1981. I was a member of the Bipartisan Commission on Central America, the Atlantic Council Study Group on Central America and the

Caribbean, the Atlantic Council Study Group on International Terrorism, and the Inter-American Dialogue. I have also lectured extensively in the United States, Canada, and Latin America.

A copy of my current CV and list of publications is attached hereto as Exhibit A.

B. Compensation and Prior Expert Witness Experience

I am being compensated at a rate of $250 per hour for my work in this matter. I have not previously served as a testifying expert in other litigation.

C. Materials Considered

I have cited in this report a number of the authorities that I have considered in forming the opinions set forth. A full list of the sources is attached as Exhibit B.

II. Summary of Opinions

International terrorism poses one of the greatest threats to the security of the United States and the international community. The ability of international terrorist organizations to threaten U.S. and international interests is heavily dependent upon those terrorist organizations' securing the necessary financial resources to fund operations. Accordingly, the United States has a vital security interest in pursuing every available avenue to deprive foreign terrorist organizations of financing.

Narcotics trafficking[1] is a key source of financing for international terrorist organizations. The link between terrorism and narcotics trafficking is evident in many regions of the world, including Afghanistan, Africa, Asia, Europe, Mexico, Central and South America. The threat to U.S. security from narcotics funding of terrorist groups is very real. For example, the opium market in Afghanistan is a major source of funding for the Taliban and Al Qaeda. Moreover,

[1] For purposes of this report, "narcotics trafficking" refers to the entire chain in the supply of cocaine and heroin into end-user countries, from the growing of the illicit coca and poppy crops, to the processing of the narcotic drugs, and to the packaging and smuggling of those drugs into the United States and other countries.

other transnational criminal organizations funded by narcotics also pose threats to the United States. In 2009, Mexican drug cartels were present in at least 230 American cities, up from 50 cities in 2006.[2] The cross-cutting nature of the threat of narcotics and its linkage to terrorism and crime is underscored by numerous policy statements from both government and non-government organizations and academic writings.

In Colombia three foreign terrorist organizations, the Revolutionary Armed Forces of Colombia (FARC), the Army of National Liberation (ELN), and the United Self-Defense Forces of Colombia (AUC), have relied heavily on narcotics trafficking to finance violent terrorist attacks against the government, institutions, and people of Colombia, as well as against U.S. citizens and property located within that country. These terrorist groups also have fostered violence and corruption in South and Central America, Mexico, and the Caribbean. Since 2000, as the various components of *Plan Colombia* have taken hold and the revenues from drug trafficking have declined, the FARC and the ELN have been substantially weakened, and the AUC formally disbanded. While the FARC, the ELN, and remnants of the AUC continue to pose a significant security threat to the United States, their ability to conduct terrorist operations against Colombia and U.S. interests has been greatly diminished.

The aerial coca and poppy eradication operations of *Plan Colombia* have played an important role in weakening the three groups. According to the latest United Nations (UN) statistics: "Coca cultivation in Colombia decreased by 58% between 2000 and 2009, mainly due to large-scale eradication,"[3] and poppy cultivation was virtually eliminated between 2000 and

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[2] Lanny A. Breuer, Statement Before Subcommittee on Human Rights and the Law Committee on the Judiciary, U.S. Senate, "Drug Enforcement and the Rule of Law: Mexico and Colombia," May 18, 2010, p. 4.

[3] United Nations Office on Drugs and Crime (UNODC), *World Drug Report 2010*, New York, NY: United Nations, 2010, p. 65.

2009.[4] This sharp reduction has led to a corresponding decline in revenues for the FARC and ELN. The Colombian government has estimated that FARC income from narcotics trafficking fell by greater than 30% during the period 2003-2007 (or by about $200 million),[5] and the continued decline in coca cultivation between 2007 and 2009 suggests that FARC revenues from narco-trafficking has continued to drop.[6] Moreover, the coca growers' responses to aerial eradication (e.g., relocating, planting smaller plots, earlier harvesting of low yield coca) have increased the costs to the FARC and weakened its hold on the populations in coca growing areas. *Plan Colombia*'s aerial eradication operations have accordingly played a key role in the battle against international terrorism and are vital to U.S. national security interests.

III. The Link Between Narcotics Trafficking and Terrorism Poses a Grave Threat to United States' Security Interests and the Security Interests of the Broader International Community.

As former Attorney General John Ashcroft explained in the months following the September 11 attacks: "Terrorism and drugs go together like rats and the bubonic plague – they thrive in the same conditions, support each other, and feed off of each other."[7] Terrorist groups engage in drug trafficking not only as a major source of funding but also as a weapon in their

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[4] Ibid., Table 14, p. 138.

[5] See Juan Manuel Santos, República de Colombia, Ministerio de Defensa Nacional, *Tendencias y resultados 2007*, January 24, 2008, p. 12 (http://colombiaemb.org/docs/Plan%20Colombia%20Documents/Main%20Results/Tendencias_y_Resultados_2007_SP.pdf). See also: International Crisis Group (ICG), "Colombia: Making Military Progress Pay Off," Bogotá/Brussels, April 28, 2008, p. 8, n. 65; Peter De Shazo, Johanna Mendelson Forman, Phillip McLean, "Countering Threats to Security and Stability in a Failing State: Lessons from Colombia," Washington, DC: Center for Strategic & International Studies, September 2009, p. 56, which cites ICG, "Ending Colombia's FARC Conflict: Dealing the Right Cards," March 26, 2009, p. 12.

[6] Of course, these reductions in narcotics production also serve a vital U.S. interest in reducing the flow of illegal narcotics into this country. It is my understanding that the importance of the aerial eradication operations to counter-narcotics efforts within the Colombia is being addressed by another expert, and I do not address this issue in my report.

[7] Attorney General John Ashcroft, "Prepared Remarks of Attorney General John Ashcroft: DEA/Drug Enforcement Rollout," March 19, 2002 (http://www.justice.gov/archive/ag/speeches/2002/031902newsconferencedeaenforcementrollout.htm).

war against the United States. Thus, for example, the Hezbollah issued a *fatwa* (an Islamic legal pronouncement) on the distribution of drugs in the mid-1980s that proclaimed: "We are making these drugs for Satan – America and the Jews. If we cannot kill them with guns, so we will kill them with drugs."[8]

The close link between narcotics and the financing of terrorism is well established by the international community, and is frequently addressed in academic research, the work of think tanks, and government statements and publications.[9] According to the United Nations Office on Drugs and Crime (UNODC), drug trafficking is a global enterprise that generates approximately $394 billion per year, providing a revenue stream for terrorists and other international criminal organizations that dwarfs the proceeds of any other form of organized criminal activity.[10] Eighteen of the 44 organizations designated by the United States as Foreign Terrorist Organizations have been linked to the international drug trade, including the FARC, the ELN, and the AUC.[11] Likewise, 24 of the 55 organizations on the United States Attorney General's FY 2009 Consolidated Priority Organization Target list – a unified list of the most significant

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[8] Rex A. Hudson, *et al.*, "A Global Overview of Narcotics Funded Terrorist and Other Extremist Groups," Library of Congress: Federal Research Division, May 2002, p. 10.

[9] Anthony P. Placido, Assistant Administrator for Intelligence, U.S. DEA, Statement Before the Subcommittee on National Security and Foreign Affairs Committee on Oversight and Government Reform, U.S. House of Representatives, "Transnational Drug Enterprises (Part II): Threats to Global Stability and U.S. Policy Responses," March 3, 2010; Joint Report of the U.S. Senate Committee on the Judiciary Subcommittee on Terrorism, Technology, and Homeland Security, "Three Years After September 11: Keeping America Safe," March 2005, pp. 60-63; Rex A. Hudson, *et al.*, "A Global Overview of Narcotics-Funded Terrorist and Other Extremist Groups," May 2002; Rand Beers and Francis Taylor, Joint Testimony Before the U.S. Senate Committee on the Judiciary Subcommittee on Technology, Terrorism and Government Information, "Narco-Terror: The Worldwide Connection Between Drugs and Terror," March 13, 2002. See also: Paul Rexton Kan, *Drugs and Contemporary Warfare*, Washington, DC: Potomac Books, 2009; Vanda Felbab-Brown, *Shooting Up: Counterinsurgency and the War on Drugs*, Washington, DC: Brookings, 2009; Juan Carlos Garzón, *Mafia & Co.: The Criminal Networks in Mexico, Brazil, and Colombia,* Washington, DC: Woodrow Wilson Center for International Scholars, 2010. An excellent study of the sociological and psychological dimensions of the problem is Francisco Thoumi, *Illegal Drugs, Economy, and Society in the Andes*, Washington, DC: Woodrow Wilson Press, 2004. Sayaka Fukumi painstakingly analyzes the policy dimensions in *Cocaine Trafficking in Latin America: EU and US Policy Responses*, Burlington, Vermont: Ashgate, 2008.

[10] Placido, "Transnational Drug Enterprises (Part II)," p. 1.

[11] Ibid., p. 3.

international drug and money laundering targets around the world that affect the supply of illegal drugs in the United States – have been linked to terrorist organizations.[12] As reported in a March 2005 Report of the Subcommittee on Terrorism, Technology, and Homeland Security of the Senate Judiciary Committee:

> Narcoterrorism is a world-wide problem. In South America, the State Department has officially designated the National Liberation Army (ELN), the Revolutionary Armed Forces of Colombia (FARC), and the United Self-Defense Groups of Colombia (AUC) as terrorist organizations. Hezbollah and the Islamic Resistance Movement (known as Hamas) operate in the tri-border area of Paraguay, Argentina, and Brazil. The Kurdish Workers Party (PKK) operates among violent separatist Kurds in Turkey. The United Wa State Army is the largest heroin- and methamphetamine-producing organization in Southeast Asia. The Abu Sayyaf Group engages in kidnapping, drug-smuggling, extortion, and other profitable criminal activity in support of its goal of establishing a separate Islamic state in the Philippines.[13]

This same report noted that "Osama bin Laden and his organization finance many of their terrorist activities through the drug trade."[14]

More recently, the U.S. Department of State, in its *2010 International Narcotics Strategy Report*, stated:

> The United States and many other countries are particularly concerned by evidence of links between international terrorist groups and the drug trade. Some of these linkages – such as the longstanding ties between drug trafficking, terrorist and insurgent groups in Colombia and Afghanistan – are well documented and directly endanger the stability of these governments and, in the case of Afghanistan, the lives of U.S. service members. … More globally, there is evidence that individuals belonging to or

[12] Ibid., p. 4.

[13] Joint Report of the U.S. Senate Committee on the Judiciary Subcommittee on Terrorism, Technology, and Homeland Security, "Three Years After September 11: Keeping America Safe," March 2005, p. 63.

[14] Ibid., p. 61.

> sympathetic to international terrorist groups have turned to the drug trade as a revenue source.[15]

In July 2010, General Douglas Fraser, of the United States Southern Command, explained:

> Illicit trafficking feeds an income stream to drug cartels and subversive movements. The revenues in the hands of criminals and narco-terrorists have weakened state structures throughout the region, subverted the rule of law and ripped apart the fabric of social order. To address this challenge, U.S. Northern Command… and USSOUTHCOM, in support of other interagency partners, are collaborating in countering illicit trafficking…[16]

The United States is not alone in recognizing the grave security risks posed by the link between drug trafficking and international terrorism. There has long been a broad consensus that narcoterrorism poses a major threat to the international community and that it requires a coordinated, international response. The UN, for example, has repeatedly warned about this threat over the past dozen years:

- In 1998, the UN General Assembly Special Session on drugs expressed "deep concern about links between illicit drug production, trafficking and involvement of terrorist groups, criminals and transnational organized crime."[17]

- Shortly following the September 11 attacks, the UN Security Council passed Resolution 1373 which, in part, "*notes* with concern the close connection between international terrorism and transnational organized crime [and] illicit drugs …" and "… *emphasizes* the need to enhance coordination of efforts on national, subregional, regional, and international levels in order to strengthen a global response to this serious challenge and threat to international security."[18]

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[15] U.S. Department of State, Bureau for International Narcotics and Law Enforcement Affairs, *2010 International Narcotics Control Strategy Report*, *Volume I: Drug and Chemical Control*, Policy and Program Developments, Washington, DC, March 2010, p. 17.

[16] Douglas Fraser, Commander-in-Chief, "The United States Southern Command Strategy for 2010," Miami: United States Southern Command, July 2010, p. 6. USSOUTHCOM has the responsibility to provide military support to Colombia's counternarcotics effort.

[17] UNODC, *World Drug Report 2010*, p. 37 (quoting the United Nations General Assembly Special Session on the World Drug Problem, New York, NY, June 8-10, 1998).

[18] UN Security Council Resolution 1373, September 28, 2001.

- In October 2004, Antonio Maria Costa, Executive Director of UNODC issued the following warning on the nexus between drugs, crime and terrorism: "Drug trafficking has always meant untold suffering and death for addicts. Today, drug trafficking is also the source of a different and very urgent problem: the financing of terrorism. The revenue generated by organized crime offers terrorist groups a steady flow of funding, making the effort to eliminate drug trafficking and to reduce drug abuse critical strategies in the global fight against terrorism."[19]

- In December 2009, UN Secretary General Ban Ki Moon proclaimed: "…drug trafficking has emerged as a leading threat to international peace and security" and "is evolving into an ever graver threat that is affecting all regions of the world" and "I call on Member States to work with each other and to support the UN in this crucially important endeavor."[20]

- In February 2010, the President of the UN Security Council issued a statement on behalf of the Council, noting "…with concern the increasing link, in some cases, between drug trafficking and the financing of terrorism, including through the use of proceeds derived from illicit cultivation, production of and trafficking in narcotic drugs…" and "…encourages States to strengthen international, regional and sub-regional cooperation to counter drug trafficking, transnational organized crime, terrorism and corruption…."[21]

The major regional international organizations likewise have expressed their concern over the narcoterrorism threat. The Organization of American States (OAS), in its Declaration of Montevideo in January 2004, affirmed that "the threat of terrorism is exacerbated by the connections between terrorism and illicit drug trafficking."[22] The European Union (EU) warns that: "Drug trafficking networks have many links, especially with terrorist networks, making it

[19] UN Press Release, "UN Warns About Nexus Between Drugs, Crime and Terrorism," SOC/CP/311, October 1, 2004 (http://www.un.org/News/Press/docs/2004/soccp311.doc.htm).

[20] UN Secretary General, "Remarks to Security Council Meeting on Drug Trafficking as a Threat to International Peace and Security," New York, NY, December 8, 2009, pp. 1-3 (http://www.idpc.net/sites/default/files/alerts/SG_SC_Drug_Trafficking.pdf).

[21] UN Security Council, "Statement by the President of the Security Council," S/PRST/2010/4, February 24, 2010, pp. 1-2.

[22] OAS, Inter-American Committee Against Terrorism, "Declaration of Montevideo," OEA/Ser.L/X.2.4, CICTE/DEC. 1/04 rev.3, February 4, 2004, p. 2.

ever more important for us to stop drugs being brought into Europe,"[23] and the EU issued a joint declaration with the Association of South East Asian Nations (ASEAN), acknowledging "that terrorism, including its links with trans-national organized crime, such as money laundering, arms-trafficking and the production of and trafficking in illicit drugs … forms part of a complex set of new security challenges, which have to be addressed urgently in all aspects and in all fora, including the ASEAN Regional Forum."[24] And a recent African Union report stated: "Drugs have political, social and economic impacts on Member States and are linked to money laundering, organized crime and terrorism; a coordinated multifaceted response is required."[25]

IV. Colombia: Epicenter of the International Narcoterrorism Threat.

Along with Afghanistan, Colombia has been at the epicenter of the connection between drug trafficking and terrorism. In September 2002, President George W. Bush stated:

> In Colombia, we recognize the link between terrorist and extremist groups that challenge the security of the state and drug trafficking activities that help finance the operations of such groups. We are working to help Colombia defend its democratic institutions and defeat illegal armed groups of both the left and right by extending effective sovereignty over the entire national territory and provide basic security to the Colombian people.[26]

In 2004, Sandro Calvani of the UNODC, explained: "The two major determinants of the poor human security situation in Colombia are the production and trafficking of illicit drugs and the

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[23] Council of the European Union, Political and Security Committee, "Statement on strengthening international security," 16751/2/08 REV 2 (en), Brussels, December 8, 2008, p. 5 (http://www.eu2008.fr/webdav/site/PFUE/shared/import/1211_Conseil_europeen/Statement%20on%20strengthening%20international%20security_EN.pdf).

[24] Association of South East Asian Nations and European Union, "Joint Declaration on Cooperation to Combat Terrorism," 14th ASEAN-EU Ministerial Meeting, January 27-28, 2003, paragraph 4 (http://archive.asean.org/14030.htm; last visited November 30, 2010).

[25] African Union, 4th Session of the African Union Conference of Ministers for Drug Control and Crime Prevention, Report of Experts' Meeting, "Turning the Tide of Drugs and Crime in Africa – From Policy to Action," CAMDCCP/EXP/Report (IV), Addis Ababa, September 28-October 2 2010, p. 7 (http://www.uneca.org/coda/Documents/AU_Drugs_Crime_Experts%20Report_October2010_%20English.pdf).

[26] George W. Bush, *The National Security Strategy of the United States of America*, September 20, 2002, pp. 9-10.

internal conflict sustained by the Colombian 'outlaw' armed groups. Both scenarios are intimately linked to the global threats caused by narcotrafficking and terrorism."[27] As Juan J. Quintana, Counselor for the Colombian Embassy, explained in testimony to the United States Congress, "the European governments have consistently expressed support for the Colombian state in its fight against terrorism and drugs trafficking, and on several occasions they have underlined the need for the international community to contribute to Colombian efforts aimed at defeating those who are waging a war against our democratic institutions."[28]

As noted above, the U.S. Department of State has designated three groups in Colombia as Foreign Terrorist Organizations, *i.e.*, as terrorist organizations that threaten the security of U.S. nationals or the national security of the United States: (1) the FARC; (2) the ELN; and (3) the AUC. Each depended in a major way upon narcotics trafficking to finance operations. Although *Plan Colombia* has significantly weakened the FARC and the ELN and led to the official disbanding of the AUC (in 2006), the FARC, the ELN, and remnants of the AUC continue to pose a significant threat to Colombia, the United States, and the international community.

A. History of Narco-Terrorism in Colombia Leading Up to *Plan Colombia*

The FARC and the ELN originate from *La Violencia,* a combination of partisan conflict and rural banditry that occurred from 1948 to 1964 and cost some 200,000 lives. The FARC and the ELN shared the goal of establishing a communist state. The Colombian military had seriously weakened the FARC and the ELN by the 1980s. However, the eruption of the cocaine economy in that decade resuscitated them. As the ELN and the FARC parlayed drug money into

[27] Sandro Calvani, UNODC Representative in Colombia, "Summary Statement: UNODC Briefing on Foreign Aid to Colombia and the European Role in the Fight Against Narco-terrorism," Committee on International Relations, U.S. House of Representatives, October 14, 2004, p. 1.

[28] Juan J. Quintana, Counselor, Embassy of Colombia, Prepared Statement before the Committee on International Relations, U.S. House of Representatives, Hearing on Aid to Colombia: The European Role in the Fight Against Narco-terrorism, "European Assistance to Colombia," November 18, 2004, p. 1.

greater control over large regions of the country, the growing insecurity gave rise to the paramilitary AUC, which brutally competed for territory, population control, and the illegal drug economy.

Narcotrafficking totally transformed Colombia. State and society came under assault. Narcotraffickers assassinated Justice Minister Rodrigo Lara Bonilla in April 1984, triggering the resignation of some 100 judges. The attack on the Palace of Justice on November 6, 1985 by the small M-19 guerrilla group, with the financial aid of narco-trafficker Pablo Escobar, is akin to the United States' September 11, 2001.[29] Eleven Supreme Court justices were killed. Later, the assassination of three presidential candidates and of Judge Miryam Rocío Veléz in 1992 showed that the narco-traffickers had become a mortal threat to the institutions of government.[30]

By the early 1990s, four groups were making war against the state, each other and the Colombian people. These were: (1) internationally organized drug trafficking groups (estimated to number 162 drug cartels within Colombia); (2) the FARC, with 17,000 to 20,000 members; (3) the ELN, with perhaps 5000 members; and (4) the AUC, which would reach over 30,000 members.

With the assistance of the United States, the Colombian government in the 1990s defeated the leadership of the largest drug cartels, particularly the Medellín and Cali cartels. Nonetheless, the FARC, the ELN, and the AUC seized even greater control over drug trafficking

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[29] Ana Carrigan, *The Palace of Justice: A Colombian Tragedy,* New York, NY: Four Walls Eight Windows, 1993; Rex A. Hudson, "Colombia's Palace of Justice Tragedy Revisited: A Critique of the Conspiracy Theory," *Terrorism and Violence*, Vol. 7, No. 2, Summer 1995, pp. 93-142. The narco-traffickers intended to have the legal records about their illicit activities destroyed in the attack. Much like the 9/11 attack, Colombians are considering erecting a monument to memorialize the tragedy. See "Preliminary Report of the Commission of Truth for the Holocaust in the Palace of Justice of Bogotá of November 6 and 7, 1985," November 15, 2006 (http://www.verdadpalacio.org.co/Assets/DOCs/informe_prelimiar.pdf).

[30] For an analysis of the impact of violence on state institutions and the search for a solution, see Rafael Pardo Rueda, *De Primera Mano, Colombia 1986-1994: Entre Conflictos y Esperanzas*, Bogotá: Norma, 1996. For the thesis of war against society, see Daniel Pécaut, *Guerra Contra La Sociedad,* Bogotá: Planeta, 2001. See also

and a larger share of the financial proceeds. The narcoterrorist activities of the FARC, ELN, and AUC were facilitated by Colombia's difficult geography of mountains and jungle regions. Moreover, the state infrastructure of judicial system, public security, schools, markets, roads, and communications was nearly absent in major portions of the national territory. Indeed, the state has not exercised control over an estimated 40 percent of the national territory, precisely the areas where illegal drugs are cultivated and where the FARC, ELN, and the AUC have been active, filling the void with *de facto* and brutal administrative systems.[31]

By 1997, the FARC was defeating the Colombian Army in battalion-sized battles. This was the first time that a modern Latin American army was beaten by irregular formations. In Washington, D.C., there were ominous warnings about the entry of the FARC into Bogotá and the possibility of a narco-state emerging. The threat posed by drug-financed Colombian foreign terrorist organizations to U.S. and international security shortly after *Plan Colombia* was instituted was clearly stated by then-DEA Administrator Asa Hutchison in testimony before the U.S. Senate Caucus on International Narcotics Control on September 17, 2002:

> The DEA continues to develop overwhelming evidence about the connection between the Revolutionary Armed Forces of Colombia (FARC), other terrorist groups in the Andean region, and the drug trade. . . . The FARC and ELN have routinely kidnapped U.S. citizens and attacked U.S. economic interests in Colombia. According to the 2001 U.S. State Department Annual Report on Global Patterns of Terrorism, 55 percent of all the terrorist acts in the world reportedly were committed in Colombia by the FARC or

Rafael Pardo Rueda, *La Historia de las Guerras*, Bogotá: Vergara, 2004, especially pp. 390-652. In addition, see Eduardo Pizarro Leóngomez, *Una Democracia Asediada,* Bogotá: Norma, 2004.

[31] This was especially true of the northwestern areas of Urabá and Chocó as well as those of eastern and southeastern Colombia, including the lightly populated departments of Arauca, Guaviare, Meta, Guainía, Caquetá, Vaupés, Vichada, and Putumayo, parts of which are in the Amazon Basin, where permanent habitation is difficult and the state is only minimally present. See Gabriel Marcella, "The United States and Colombia: The Journey From Ambiguity to Strategic Clarity," Carlisle, PA: SSI, May 2003, p. 17 (http://www.strategicstudiesinstitute.army.mil/pdffiles/PUB10.pdf).

> ELN. The report also claims that almost 85 percent of the terrorist attacks (219 attacks) against U.S. interests occurred in Colombia.[32]

B. The Revolutionary Armed Forces of Colombia

The FARC is the oldest, largest, and most capable insurgency in Latin America. Tactics run the gamut: terrorism, extortion, intimidation, bribery, kidnapping, use of anti-personnel mines, explosive gas cylinders, assassination, and exploiting narcotics. The FARC's traditional power base has been in southern Colombia, including areas in Putumayo and Nariño (the two Colombian departments that share a border with Ecuador), as well as in northwestern Colombia. The FARC has also had a significant presence in northern Ecuador for rest, recreation, procuring weapons, processing drugs, laundering money, and obtaining precursor chemicals.[33] In some parts of Ecuador's northern border, the FARC exercises significant control over the local population.[34] In 2002 FARC had roughly 17,000 fighters under its command.[35]

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[32] Asa Hutchinson, Administrator, U.S. DEA, Statement Before the U.S. Senate Caucus on International Narcotics Control, September 17, 2002, p. 2. (http://www.justice.gov/dea/pubs/cngrtest/ct091702.html).

[33] See Douglas Farah and Glenn Simpson, "Ecuador at Risk: Drugs, Thugs, Guerrillas and the Citizens Revolution," International Assessment and Strategy Center, January 24, 2010. Unfortunately, these problems in northern Ecuador persist to the present time. See Philip Alston, "Statement by Professor Philip Alston, UN Special Rapporteur on extrajudicial executions, Mission to Ecuador: 5-15 July 2010," Quito, July 15, 2010, p. 2. Alston states: "Illegal armed groups enter Ecuador to obtain food, goods and health services; to traffic drugs and weapons; to conduct combat training; and to escape the conflict in Colombia."

[34] On March 1, 2008 Colombian forces killed FARC commander Raúl Reyes inside Ecuador at Angostura. In response, the Ecuadorian government established the Comisión de Transparencia y Verdad Angostura, a bi-partisan commission of prominent citizens to prepare a report. The report confirmed the extensive presence of the FARC in Ecuador. The report states: "There is a situation on the border where Ecuadorean peasants and Indians have been 'displaced' by the Farc (*sic*) to facilitate narco-trafficking and operations by irregular groups. Marcial Campaña is a Colombian who used violence to expel [Ecuadorian] peasants near the San Miguel River. There he built a house to lodge more than 60 persons. This place was turned into storage of precursors, drugs, and weapons. As well as a meeting place for Farc members and traffickers from various nationalities….near the junction of the Putumayo and San Miguel rivers were laboratories for processing drugs, fixed and mobile camps, arms caches and fuel. Along the border there were 42 illegal entry points. The [Ecuadorian] province of Sucumbíos is utilized as a center of operations by the 48th and 32nd front of the Farc. In Carchi and Esmeraldas, the 29th front exercises influence." "Informe Comisión de Transparencia y Verdad Angostura," Quito, December 10, 2009, Section 3.2 (http://www.ecuadorenvivo.com/images/pdf/INFORME-ANGOSTURA.pdf). For additional detail about the attack at Angostura, see Gabriel Marcella, "War Without Borders: The Colombia-Ecuador Crisis of 2008," Carlisle, PA: SSI, December 2008 (http://www.strategicstudiesinstitute.army.mil/pdffiles/PUB891.pdf).

[35] Admiral James Stavridis, "U.S. Southern Command Posture Statement," Miami, FL: United States Southern Command, 2008, p. 15.

The FARC has established links with terrorist groups throughout Latin America under the umbrella of the Bolivarian Continental Coordinator (CCB), which was founded by the FARC in 2003.[36] The FARC has also worked with individuals associated with the Irish Republican Army[37] and the Basque Terrorist Group Euskadi ta Askatasuna (ETA).[38]

The FARC is responsible for numerous terrorist attacks on U.S. citizens. In January 1994, the FARC kidnapped two American missionaries, Stephen Everett Welsh and Timothy Van Dick. Their bodies were found a year and a half later. In March 1999, the FARC executed three U.S. Indian rights activists on Venezuelan territory after kidnapping them in Colombia. According to journalist Ana Arana: "The three Americans were abducted on February 25 as they left the reservation of the indigenous U'wa tribe in northeast Colombia, where they had attended a religious ceremony."[39] In May 2003, the Colombian government extradited to the United

[36] The CCB was founded by the FARC to reverse its international isolation. The group held its second congress in Quito, Ecuador, on February 24-27, 2008 to "confront the imperialist aggression against our peoples…and to demand the immediate departure of foreign military bases from our territories…." The allusion to foreign military bases meant the U.S. Forward Operating Location at Manta Air Base, which, under a 10 year agreement with Ecuador, supported by U.S. counter-narcotics reconnaissance flights targeting the cocaine traffic. Through mid-2009, the reconnaissance helped in the seizure of 1,700 metric tons of cocaine, with an estimated street value of 35.1 billion dollars. Nine foreign delegations attended the Quito conclave, including terrorists from Spain and Peru. For details, see: Comisión de Transparencia y Verdad Angostura, "Informe Comisión de Transparencia y Verdad Angostura," Quito, December 10, 2009, pp. 31-40 (http://www.ecuadorenvivo.com/images/pdf/INFORME-ANGOSTURA.pdf). With respect to the FARC in Ecuador, see also pages 31-32 below.

[37] As reported following a U.S. congressional investigation: "The IRA has had well-established links with the FARC narco-terrorists in Colombia since at least 1998…. It appears they have been training in the FARC safe haven in explosives management, including mortar and possibly car-bomb urban terrorist techniques, and possibly using the rural jungles of the safe haven as a location to test and improve the IRA's own terrorist weapons and techniques." Committee on International Relations, U.S. House of Representatives, "Summary of Investigation of IRA Links to FARC Narco-Terrorists in Colombia," April 24, 2002, p. 1. Gerry Adams, the Sinn Fein leader in Ireland, denied that these individuals represented the IRA.

[38] In November 2009, Spanish prosecutor Vicente González stated in his investigation about links between the FARC and the ETA: "From the investigation procedures it has been revealed that the collaboration between both organizations, which was suspected for several years, has been proven by demonstrating contacts and collaboration. That collaboration is centered both in terms of contacts among heads of both organizations and as much as in the providing of short courses on the use of explosives." "The FARC-ETA Connection," *Semana*, February 16, 2009 (http://www.semana.com/noticias-print-edition/the-farceta-connection/120812.aspx). *Semana* states that collaboration started in 1993.

[39] The workers were Ingrid Washinowatok, Lahe'na'e Gay, and Terence Freitas. Washinowatok headed the Rockefeller funded American Indian philanthropic group Fund for Four Directions. See: Ana Arana, "Murder in Colombia," *Salon.com*, December 14, 1999 (http://www.salon.com/news/feature/1999/12/14/colombia). Colombian

States Nelson Vargas Rueda, one of the six FARC members suspected of committing the murders.[40] On February 13, 2003 the FARC captured three American citizens and a fourth was executed by the FARC after their plane crashed. The three spent nearly 5 ½ years in captivity before being rescued, along with former Colombian presidential candidate Ingrid Betancourt and others, by the Colombian army on July 2, 2008.[41] According to a Congressional Research Service (CRS) report, by February 2004 the FARC and the ELN had kidnapped more than 100 Americans, 13 of whom had been killed.[42]

Perhaps the most brutal example of FARC terrorism occurred in the town of Bojayá on May 2, 2002, where innocent civilians had taken refuge in a Catholic church. The FARC, in violation of international norms barring military operations near places of worship, launched a bomb containing 40 pounds of dynamite. The bomb struck the church, killing 119 (including 40 children) and injuring 98.[43] The UN condemned the attack as a violation of international law.

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authorities charged FARC commander Germán Suárez Briceño, brother of FARC military commander Jorge Suárez Briceño (AKA Mono Jojoy), who was killed in September 2010 by Colombian troops for the murder. Both were wanted by American authorities for drug trafficking and murder. The FARC outraged world opinion by refusing to turn over the killers to authorities. U.S. Department of State, Office of the Coordinator for Counterterrorism, *Patterns of Global Terrorism: 1999, Latin America Overview*, April 2000 (http://www.state.gov/www/global/terrorism/1999report/1999index.html). The FARC also killed Awa Indians, located in the Nariño department, near the Ecuadorian border. See Rick Kearns, "FARC Massacre of indigenous in Columbia (sic), more deaths and displacement," *Indian Country Today*, March 13, 2009 (http://www.indiancountrytoday.com/global/latin/41204617.html?corder=reverse). Kearns reports: "In the first week of February… FARC rebels massacred up to 27 Awa people in the southern Nariño province, including women and young children (from ages 3 to 6), bringing the total number of murdered Native people to 50 since the national march in the fall."

[40] Audrey Kurth Cronin, Huda Aden, Adam Frost, and Benjamin Jones, "Foreign Terrorist Organizations," Washington, DC: Congressional Research Service (CRS), February 6, 2004, p. 91.

[41] Their ordeal is described in Marc Gonsalves, Tom Howes, Keith Stansell, *Out of Captivity: Surviving 1,967 Days in the Colombian Jungle*, New York, NY: Harper Collins, 2009.

[42] Cronin, *et al.*, "Foreign Terrorist Organizations," p. 90.

[43] For more information, see: Colombian Office of the UN High Commissioner for Human Rights, *Informe de la Oficina del Alto Comisionado de las Naciones Unidas para los Derechos Humanos Sobre la Misión de Observación en el Medio Atrato*, Bogotá, May 20, 2002. See also: Scott Wilson, "No Sanctuary from War," *Washington Post*, May 8, 2002 (http://www.globalexchange.org/countries/americas/colombia/26.html.pf). For the lasting psychological effects among the people of Bojayá, see "Una cicatriz en lo profundo del Atrato," *Semana*, September 18, 2010 (http://www.semana.com/noticias-nacion/cicatriz-profundo-del-atrato/144758.aspx). With respect to the massacres of Awa Indians in the Nariño department, see also: Pilar Lozano, "Matanza de 27 indígenas en el sur de

On February 7, 2003, the FARC attacked the Club El Nogal in Bogotá using a car bomb of 200 kilograms of explosives, killing 32 persons and wounding 160. A FARC e-mail recently revealed by President Juan Manuel Santos on October 16, 2010, details the FARC's planning of the El Nogal bombing: "…lately the possibility has emerged to explode it in the presence of 150 industrialists and diplomats who meet there weekly."[44] The UN Security Council approved Resolution 1465, which called the attack an "act of terrorism" that threatened "peace and security."[45] The Permanent Council of the OAS affirmed in Resolution 837: "… its profound repudiation of the despicable terrorist attack carried out by the FARC on February 7, 2003, in Bogotá and to pledge its cooperation in pursuing, capturing, prosecuting, punishing, and, when appropriate, expediting the extradition of the perpetrators, organizers, and sponsors of this act…."[46]

The FARC began financing its terrorist operations with drug money in the 1980s.[47] The FARC's role in narcotics trafficking began with "revolutionary" taxes on farmers who were growing coca and "protection" fees imposed on drug traffickers for the security of their landing strips, crops, and processing facilities.[48] Revenues from these operations accelerated dramatically in the 1980s and the heroin boom of the early 1990s. In 1998 the FARC's narcotics

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Colombia," *El País* (Madrid), February 14, 2009 (http://www.elpais.com/articulo/internacional/Matanza/27/indigenas/sur/Colombia/elpepuint/20090214elpepiint_5/Tes).

[44] "Correos del 'Mono Jojoy' revelan cómo se planearon atentados contra El Nogal y la Universidad Militar," October 16, 2010 (http://wsp.presidencia.gov.co/prensa/2010/octubre/paginas/20101016_02.aspx).

[45] UN Security Council Resolution 1465 (2003), February 13, 2003, p. 1 (http://daccess-dds-ny.un.org/doc/UNDOC/GEN/N03/247/96/PDF/N0324796.pdf?OpenElement).

[46] OAS Permanent Council Resolution 837 (1354/03), *Condemnation of Terrorist Acts in Colombia*, February 12, 2003 (http://www.oas.org/consejo/resolutions/res837.asp).

[47] Alejandro Reyes, "Compra de tierras por narcotraficantes," in Francisco Thoumi, *et. al.*, *Drogas ilícitas en Colombia*, Ministerio de Justicia, Dirección Nacional de Estupefacientes, Bogotá: Ariel Naciones Unidas-PNUD 1997, pp. 270-346.

[48] John Rollins, Liana Sun Wyler, and Seth Rosen, "International Terrorism and Transnational Crime: Security Threats, U.S. Policy, and Considerations for Congress," Washington, DC: CRS, March 18, 2010, p. 17.

revenues received yet another boost when the government ceded FARC operational control over 42,000 square kilometers in the Caquetá region as a basis for peace negotiations. The FARC quickly turned this territory into a drug depot and a safe haven for its narcotics trafficking activities.[49] Moreover, as the Medellín and Cali cartels ceased to be the main trafficking organizations in the 1990s, the FARC expanded its drug trafficking activities.[50] By 2005, 65 of the 110 FARC fronts were reported to be involved in the cultivation of coca and marketing of cocaine.[51] The CRS reported that 60% of the FARC's revenue came from the drug economy.[52] A CRS report of February 2004 stated that the FARC might very well be "one of the richest, if not *the* richest, insurgent group in the world."[53] The FARC's link to the cocaine market, and the tremendous amount of money derived therefrom, is illustrated by the account of captured Brazilian trafficker Luis Fernando da Costa:

> The FARC are the richest and strongest guerrillas in the world. Their leaders live like millionaire capitalists: beautiful women, good food and liquor. . . In Colombia not a kilo of cocaine moves without the permission of the FARC . . . For each kilo I sent they paid me $3,000. . . . The drug business is pretty good for the FARC; for each kilo that is ready to be shipped they charge $500, for each flight . . . $15,000. . . . I paid the FARC $10 to $12 million a month. Each flight carried between 700 kilos and a ton of coca . . . Each pilot was paid $25,000 and the co-pilot $5,000 . . . and a little bit was paid to the air controllers so that they would not cause problems with the flights. . . . Part of the payment for the coca was

[49] Rollins and Wyler, "International Terrorism and Transnational Crime: Security Threats, U.S. Policy, and Considerations for Congress," pp. 17-18.

[50] Ibid., p. 18.

[51] Ibid.

[52] Ibid.; Cronin, *et al.*, "Foreign Terrorist Organizations," p. 92. See also: Gabriel Marcella, "Plan Colombia: The Strategic and Operational Imperatives," Carlisle, PA: SSI and North-South Center, April 2001, p. 4 (http://www.strategicstudiesinstitute.army.mil/pdffiles/PUB29.pdf).

[53] Cronin, *et al.*, "Foreign Terrorist Organizations," p. 92.

> made to the FARC in 3,000 guns and three and a half million rounds of ammunition, which came from Paraguay.[54]

Further proof is an e-mail from FARC leader Edgar Tovar to Raúl Reyes, dated July 13, 2007, which states: "Comrade, this coming Tuesday I have to deliver 700 kilos of crystal (refined cocaine), but Saturday or Sunday I have to collect the money in Quito (Ecuador). It is $1.5 million."[55]

The U.S. government has aggressively pursued the FARC for its role in narcotics trafficking. On March 18, 2002, Attorney General John Ashcroft and DEA Administrator Asa Hutchinson announced the indictment of three members of the FARC's 16th front for drug trafficking.[56] On February 19, 2004, several leading members of the FARC and AUC were designated by the Treasury Department as Significant Foreign Narcotics Traffickers pursuant to the Kingpin Act.[57] By January 2009, the Department of the Treasury's Office of Foreign Assets Control had designated 77 FARC members or associates as narcotics traffickers.[58] A number of them have been extradited to the United States and are currently incarcerated on drug charges.

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[54] "La confesión de Fernandinho," *Semana*, April 30, 2001 (http://www.semana.com/wf_imprimirarticulo.aspx?IdArt=17243). For more details: Marcella, "The United States and Colombia: The Journey from Ambiguity to Strategic Clarity," pp. 12, 16, 19-21, 27, 37; Marcella, "Plan Colombia: The Strategic and Operational Imperatives," pp. 3-4.

[55] Douglas Farah, "What the FARC Papers Show Us about Latin American Terrorism," Washington, DC: NEFA Foundation, April 1, 2008, p. 13 (http://www.nefafoundation.org/miscellaneous/FeaturedDocs/nefafarc0408.pdf).

[56] U.S. DEA Press Release, "Department of Justice Hands Down Indictments Against FARC Terrorists," March 18, 2002 (http://www.justice.gov/dea/pubs/pressrel/pr031802.html).

[57] U.S. Department of the Treasury Press Release, "Treasury Takes Action Against FARC/AUC Narco-Terrorist Leaders in Continued Effort to Halt Narcotics Trafficking," February 19, 2004 (https://ustreas.gov/press/releases/js1181.htm). Marín was AKA Manuel Marulanda and Tirofijo. Briceño Suárez, AKA Mono Jojoy, was the military leader of the FARC killed by Colombian troops in September 2010.

[58] U.S. Department of the Treasury Press Release, "Treasury Designates Additional FARC International Commission Members," January 14, 2009 (https://ustreas.gov/press/releases/hp1353.htm). From December 1997 to the end of November 2010, over 1,100 Colombians had been extradited, most for drug trafficking, and a good number being FARC members.

C. The Army of National Liberation

The ELN, which in the 1990s fielded perhaps 5,000 fighters, is a junior partner to the FARC in operational capability. Born also in the 1960s, the ELN's political goals are similar to those of the FARC: to establish a Marxist state. While they sometimes coordinate their activities, they also clash at times over territory and influence.

Like the FARC, the ELN has directly attacked Colombian and U.S. interests in Colombia. The ELN has extorted money from energy companies and blown up the Coveñas-Limón pipeline, which brings petroleum to the Caribbean coast for export.[59] Local offices and franchises for U.S. companies, such as Drummond, Coca-Cola, Nestle, Halliburton and 3M are reported to have received threatening letters.[60] In 1998, ELN activists bombed and ransacked a Dole-owned subsidiary and attacked the Ocensa pipeline, which is jointly owned by a consortium of American, British, French, Canadian, and Colombian companies.[61] On March 5, 2003, a car bomb exploded in a shopping center in Cucutá, a northeastern Colombian city. The bomb, attributed to the ELN by military and police sources, killed seven people and injured more than 50.[62] As stated previously, between 1980 and February 2004, the FARC and ELN together had kidnapped more than 100 Americans, 13 of whom had been killed.[63]

While the ELN has publicly expressed disdain for illegal drugs and denied involvement in the drug business, it is well-established that the ELN funds much of its operations through

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[59] The FARC also attacks oil pipelines. For example, see: Thomson Financial, "Colombia's main oil pipeline closed after guerrilla attack," *Thomson Financial News*, June 23, 2008 (http://www.forbes.com/feeds/afx/2008/06/23/afx5143758.html).

[60] John Otis, "Colombians Forced to pay rebels / Fighting extortion may come at deadly price for opponents," *Houston Chronicle*, October 28, 2001 (http://www.chron.com/CDA/archives/archive.mpl?id=2001_3344360).

[61] Cronin, *et al.*, "Foreign Terrorist Organizations," p. 69.

[62] Steven W. Casteel, Assistant Administrator for Intelligence, Statement Before the U.S. Senate Committee on the Judiciary, "Narco-Terrorism: International Drug Trafficking and Terrorism- a Dangerous Mix," May 20, 2003.

[63] Cronin, *et al.*, "Foreign Terrorist Organizations," p. 90.

narcotics trafficking.[64] The ELN supplements its income derived from narcotics trafficking with income derived from kidnapping and extortion.[65]

D. The Colombian Self Defense Forces

Founded in 1997, the AUC was an umbrella organization of paramilitary groups. Prior to demobilization, the AUC fought the FARC and ELN. The paramilitaries competed with the FARC for territory and the narcotics market in various parts, including in the south, east, and northwest.[66] The AUC groups became notorious for their brutality and penetration of local and regional politics. Their involvement in moving cocaine to the United States made them a major threat. The Colombian National Police reported that during the first 10 months of 2000, the AUC conducted 804 assassinations, 203 kidnappings, and 75 massacres with 507 victims.[67]

In 2000, AUC leader Carlos Castaño claimed that 70 percent of the AUC's operational funding came from drug-related earnings.[68] On February 19, 2004, 18 AUC members and three front companies affiliated with the AUC, along with members of the FARC, were designated by the Treasury Department as Significant Foreign Narcotics Traffickers pursuant to the Kingpin

[64] U.S. Department of State, *2009 Country Reports on Terrorism—Colombia*, August 5, 2010; Rand Beers and Francis Taylor, Joint Testimony Before the U.S. Senate Committee on the Judiciary Subcommittee on Technology, Terrorism and Government Information, "Narco-Terror: The Worldwide Connection Between Drugs and Terror," March 13, 2002.

[65] U.S. Department of State, *2009 Country Reports on Terrorism—Colombia*; Stephanie Hanson, "FARC, ELN: Colombia's Left-Wing Guerrillas," Council on Foreign Relations, August 19, 2009 (http://www.cfr.org/publication/9272/farc_eln.html).

[66] U.S. Department of State, Office of the Coordinator for Counterterrorism, *Patterns of Global Terrorism: 2000*, Appendix B: Background Information on Terrorist Groups, April 2001 (http://www.state.gov/s/ct/rls/crt/2000/2450.htm). For more information on the paramilitaries, see Mauricio Romero, *Paramilitares y autodefensas, 1982-2003,* Bogotá: Instituto de Estudios Políticos y Relaciones Internacionales and Editorial Planeta, 2003.

[67] U.S. Department of State, Office of the Coordinator for Counterterrorism, *Patterns of Global Terrorism: 2000*, Appendix B: Background Information on Terrorist Groups.

[68] Ibid.; see also: Rand Beers and Francis Taylor, "Narco-Terror: The Worldwide Connection Between Drugs and Terror."

Act.[69] In 2006, following peace talks with the Colombian government, the AUC formally disbanded, and eventually, 31,671 paramilitaries demobilized and surrendered 18,051 weapons.[70]

V. *Plan Colombia* and the Aerial Eradication Operations

By the mid 1990s, the magnitude of the Colombian crisis, the noxious effects of cocaine (and heroin) on a growing number of people, and the stakes for security in the Andean region, the Caribbean, and Central America, convinced officials in Colombia and the United States that an ambitious and comprehensive plan was needed to sustain an effort by the Colombian government to regain control over its country.[71] Thus was born *Plan Colombia*, an initiative conceived by the administration of President Andrés Pastrana in Colombia (1998-2002), in close collaboration with the United States. The U.S. Congress first approved support for *Plan Colombia* on July 13, 2000 and has continued to do so as *Plan Colombia* has evolved.

The strategic theory of *Plan Colombia* linked economic development and security to peace. The central premise was that drug money feeds the coffers of the FARC and ELN, whose criminal activity gives rise to the AUC paramilitaries. If the money was taken away, the narco-terrorists could not mount attacks, they would become less threatening, and the paramilitaries would have less reason for being. *Plan Colombia* endeavored to strengthen the state, reenergize

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[69] U.S. Department of the Treasury Press Release, "Treasury Takes Action Against FARC/AUC Narco-Terrorist Leaders in Continued Effort to Halt Narcotics Trafficking," February 19, 2004 (https://ustreas.gov/press/releases/js1181.htm).

[70] Colleen W. Cook and Clare Ribando Seelke, "Colombia: Issues for Congress," Washington, DC: CRS, September 12, 2008, p. 3; Colombian Embassy, Washington, DC, "Peace & Justice Law" (http://colombiaemb.org/index.php?option=com_content&task=view&id=45&Itemid=74; last visited December 10, 2010). See also: Juan Forero, "New Colombia Law Grants Concessions to Paramilitaries," *The New York Times*, June 23, 2005 (http://www.nytimes.com/2005/06/23/international/americas/23colombia.html?_r=1).

[71] Thomas R. Pickering, "Anatomy of Plan Colombia," *The American Interest Online*, November-December 2009 (http://www.the-american-interest.com/article.cfm?piece=703).

the economy, generate the conditions for peace, reduce the expansion of drug trafficking, and strengthen civil society.[72]

Within the framework of *Plan Colombia*, American military and other support to Colombia was initially limited to counternarcotics operations, force protection, and to provide humanitarian assistance when necessary. However, the September 11 attacks radically changed the threat assessment for terrorism and gave new urgency to American support to Colombia.[73] In the fall of 2002, President George W. Bush signed Presidential Decision Directive 18, a new Colombia policy that went beyond counter-narcotics support and focused more particularly on counter-terrorism, in addition to economic assistance.[74] These policy changes were codified into law in 2003, when Congress granted expanded authority for counter-terrorism missions in Colombia "because it concluded that there is no useful distinction between a narco-trafficker and his terrorist activity -- hence, the term 'narco-terrorist.'"[75] A State Department report to Congress added: "The expanded authority, as envisioned by the Congress and implemented by the Department of State, has provided useful operational flexibility when the distinctions between counternarcotics and counterterrorism may not be clear cut, and recognizes and

[72] For more analysis of Plan Colombia, see Marcella, "Plan Colombia: The Strategic and Operational Imperatives;" Marcella, "Democratic Governance and the Rule of Law: Lessons Learned from Colombia," Carlisle, PA: SSI, December 2009, p. 11 (http://www.strategicstudiesinstitute.army.mil/pubs/display.cfm?PubID=955); Marcella, "The U.S. Engagement with Colombia: Legitimate State Authority and Human Rights," Miami: University of Miami, North-South Center, March 2002. There were 10 elements to the plan: economic strategy, fiscal and financial steps, peace, national defense, judicial and human rights, counternarcotics strategy, alternative development, social participation, human development, and international strategy.

[73] These developments are explored in Marcella, "The United States and Colombia: The Journey From Ambiguity to Strategic Clarity," pp. 35-39 and 50-58; Marcella, "Plan Colombia: The Strategic and Operational Imperatives," pp. 5-6.

[74] See Secretary of State, "A Report to Congress on United States Policy Towards Colombia and Other Related Issues," Washington, DC: Department of State, February 3, 2003, p. 6 (http://www.state.gov/p/wha/rls/rpt/17140.htm).

[75] "U.S. General Outlines Existing and Emerging Hemispheric Threats," *America.gov*, March 25, 2004 (http://www.america.gov/st/washfile-english/2004/March/20040325145251ASrelliM0.9962274.html).

reaffirms the practicality of providing assistance to address both scourges simultaneously, since, as occurs more often than not, they are essentially one and the same."[76]

The scope of *Plan Colombia* also expanded in 2002, with the election of President Alvaro Uribe. The prior administration of Andrés Pastrana had pursued peace talks with the FARC. For this purpose, between 1999 and 2002 the government ceded the FARC a demilitarized area. The talks went nowhere, but they allowed the FARC to buy time, kidnap and assassinate local populations, re-equip, and expand their narcotics operations.[77] President Alvaro Uribe abandoned peace negotiations with the FARC, re-asserted government control over the ceded territory, and pursued an aggressive strategy against the terrorists and traffickers. Via the implementation of *Plan Colombia* and its sequel, the *Democratic Security and Defense Policy,* the Colombian government undertook a dramatic expansion of its capabilities to consolidate control over national territory in order to deny sanctuary to the terrorists, protect the population, and to destroy the illegal drug trade. The military and police were expanded in size and operational capabilities, and ministries were given more resources to provide the benefits of governance. The results have been impressive: greater security, a much weakened FARC, demobilization of over 30,000 paramilitaries, reduction in coca and heroin cultivation, confidence in the government, reduced unemployment, and a dynamic economy.[78]

One key component of *Plan Colombia* has been the aerial eradication campaign against illicit coca and poppy. The aerial eradication campaign has had two key objectives. First, the

[76] U.S. Department of State, "Use of United States Assets in Colombia," Report to Congress, 2004, p. 2. The report added: "The managers [in Congress] are supportive of the Colombian government in its attempts to provide security for the Colombian people and has provided the expansion of authorities in recognition that the narcotics industry is linked to the terrorist groups, including the paramilitary organizations, in Colombia."

[77] See, e.g., Ashley Turton 43.

[78] The impact of Uribe and the synchronization of US policy are explored in Marcella, "The United States and Colombia: The Journey from Ambiguity to Strategic Clarity," pp. 50-64.

campaign directly attacks the supply of coca and poppy, thereby decreasing the available supply of cocaine and heroin coming out of Colombia (and into the United States and other countries) while concurrently decreasing the revenues to narcoterrorists. Second, as the aerial eradication operations weakened the economic and security links between the farmers and the terrorists, the government has regained control over large areas of the country that had been *de facto* ceded to the terrorists.

The reaction of the FARC itself to these *Plan Colombia* initiatives is described in a press release from the U.S. Department of Justice when a notorious FARC leader was extradited to the United States for prosecution:

> [R]ecognizing that the FARC could not survive without its cocaine revenue, the indicted [FARC leaders] directed . . . members to attack and disrupt coca eradication fumigation efforts, including shooting down fumigation aircraft; [and] forcing local farmers to participate in rallies against fumigation . . . . Recognizing that the United States has contributed significantly to Colombian fumigation efforts, the FARC leaders [late in 2001 and early 2002] also ordered FARC members to kidnap and murder U.S. citizens in order to dissuade the United States from its continued efforts to fumigate . . . .[79]

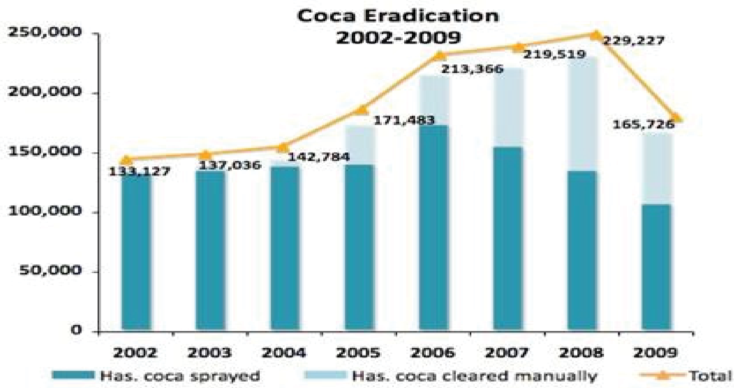
The graphic below illustrates the evolution and success of the coca eradication program from 2002 to 2009.[80] Throughout this period, the Colombian government, with U.S. assistance, eradicated large areas of coca cultivation, in excess of 130,000 hectares a year, reaching a peak of over 200,000 hectares a year in 2006, 2007, and 2008. During the early part of this period, the eradication operations were almost exclusively conducted by aerial spraying because the FARC

[79] Erin Mulvey, U.S. DEA Press Release, "Leader of Colombian Narco-Terrorist Group Extradited to the United States on Cocaine Importation Charges," July 17, 2009 (http://www.justice.gov/dea/pubs/states/newsrel/2009/nyc071709.html).

[80] The graph comes from the Colombian Embassy, Washington, DC, "Plan Colombia: Institution Building & the Fight Against Drug Trafficking" (http://colombiaemb.org/index.php?option=com_content&task=view&id=989&Itemid=237; last visited December 10, 2010).

and other narco-trafficking organizations still controlled most of the territories in which coca was cultivated, making manual eradication too dangerous. Over time, as the effects of *Plan Colombia* took hold, the government regained control over significant portions of the country and manual eradication operations became a viable option in those areas. By the end of the decade, manual eradication operations represented a substantial percentage of the total volume of eradicated coca crops.

Source: Ministry of Defense



The eradication of illicit drug crops has helped open the door for a comprehensive strategy that includes security and more effective and permanent governance in areas formerly influenced or controlled by the FARC. Governance includes the permanent presence of the police and military, improved access to justice, the construction of infrastructure, schools, and medical facilities, the availability of markets and credit, and the development of alternative crops for legitimate farmers. By September 2009, alternative development programs had benefited more than 439,276 families in 18 (out of 32) departments in Colombia, including in Putumayo and Nariño. Approximately 1,290 social and productive infrastructure projects were completed in the last seven years with communities that remain free of illicit crops.[81] The expansion of the capability of the public security forces (military and police) also has allowed the state to better govern its citizens. Among the accomplishments is the impressive reform in the administration of justice, whereby the judicial system, with the support of the Department of Justice and the Agency for International Development, has been converted from the inquisitorial to the accusatorial system. The results are remarkable in expediting cases and building confidence in the judicial system.[82] With security and the development of more effective and legitimate institutions, the territorial space for terrorists has been reduced, their revenue flow has been decreased, and their ability to attack institutions and officials has been diminished.

VI. *Plan Colombia* Has Successfully Weakened Foreign Terrorist Organizations in Colombia and Improved United States National Security.

The aerial eradication operations of *Plan Colombia* have played a critical role in weakening the FARC, ELN, and AUC. According to the latest UN statistics, "coca cultivation in Colombia decreased by 58% between 2000 and 2009, mainly due to large-scale eradication"[83] and poppy cultivation in Colombia between 2000 and 2009 had been virtually eliminated. The U.S. Department of State reported in 2010 that because of "…sustained aerial eradication and increased manual eradication operations in 2008," there was a "decline in pure cocaine production potential of 39 percent from 485 metric tons in 2007 to 295 metric tons in 2008. The UN reported an 18 percent drop in cultivation in 2008, down to 81,000 hectares, and a 28 percent

[81] U.S. Department of State, *2010 International Narcotics Control Strategy Report, Volume I: Drug and Chemical Control,* Colombia section.

[82] The impact of the changes is discussed in more detail in Marcella, "Democratic Governance and the Rule of Law: Lessons from Colombia," pp. 28-33.

[83] UNODC, *World Drug Report 2010*, New York, NY: United Nations, 2010, p. 65.

fall in cocaine production potential to 430 metric tons."[84] As President Obama explained in his *2010 National Drug Control Strategy*, one of the "lessons learned" from *Plan Colombia* is that "[e]radication can be an effective deterrent to illicit cultivation."[85] This sharp reduction in narcotics crop cultivation has led to a correspondingly sharp decline in revenues for the FARC and ELN.[86] The Colombian government has estimated that FARC income from narcotics fell by greater than 30% between 2003 and 2007, or by about $200 million,[87] and the continued decline in coca cultivation between 2007 and 2009 suggests that FARC revenues from narco-trafficking continued to decline. Moreover, the coca growers' responses to eradication (relocating, dispersal, camouflage, smaller plots, pruning, and earlier harvesting) increased the costs to the FARC and weakened the FARC's hold on the populations. These responses also have depressed the yield of coca plants. Between January 2007 and September 2009 the price per pure gram of cocaine in the United States increased 75.4 percent, while the purity decreased 31.5 percent, according to the DEA.[88]

In its 2010 report, *The Globalization of Crime: A Transnational Organized Crime Threat Assessment*, the UNODC strongly proclaimed the success of *Plan Colombia* in confronting the threat of narcoterrorism, identifying Colombia as "the country which has made most progress

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[84] U.S. Department of State, *2010 International Narcotics Control Strategy Report, Volume I: Drug and Chemical Control*, Colombia section.

[85] White House Office of National Drug Control Policy, *National Drug Control Strategy*, 2010, p. 84. Of course, these reductions in narcotics production in Colombia also serve a vital U.S. interest in reducing the flow of illegal narcotics from Colombia into this country. More than 31,000 Americans die each year from drug abuse, and an estimated seven million people are addicted to controlled substances. See Placido, "Transnational Drug Enterprises (Part II)," p. 1.

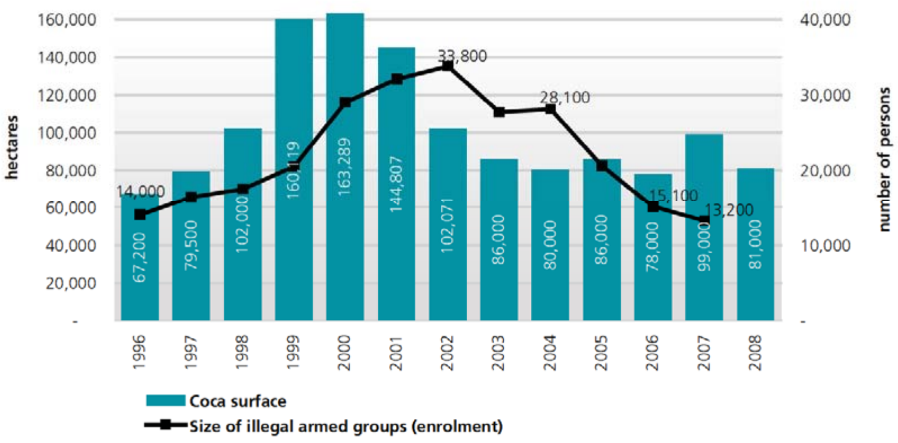
[86] ICG, "Colombia: Making Military Progress Pay Off," Bogotá/Brussels, April 28, 2008, p. 8; De Shazo, *et al.,* "Countering Threats to Security and Stability in Failing State: Lessons from Colombia," p. 56; ICG, "Ending Colombia's FARC Conflict: Dealing the Right Cards," p. 12.

[87] See footnote 5.

[88] Colombian Embassy, Washington, DC, "Plan Colombia: Institution Building & the Fight Against Drug Trafficking" (http://colombiaemb.org/index.php?option=com_content&task=view&id=989&Itemid=237; last visited December 10, 2010).

over the last few years in curbing the threats to national and international security emerging from drug production and trafficking" and announcing that "[t]he progress made in Colombia over the last few years in reducing the threats emerging from the narco-business has been impressive."[89] The UNODC gave much of the credit for these improvements to the sharp drop in coca cultivation, which the UNODC explained was "mainly due to eradication."[90] The UNODC included in its report the following chart, which demonstrates a clear temporal relationship between the reduction of coca cultivation in Colombia and the size of the FARC and ELN:

FIG. 175: COCA CULTIVATION AND SIZE OF ILLEGAL ARMED GROUPS (FARC AND ELN)



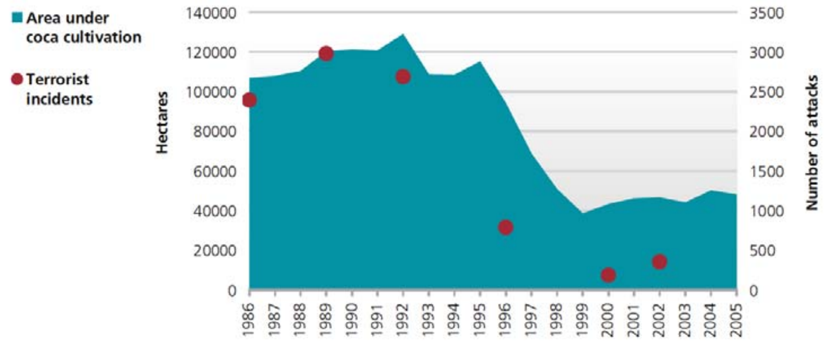
Sources: UNODC, Colombia: Coca Cultivation Survey, June 2009 and previous years

In addition, UNODC found that this same temporal relationship between reducing illicit coca cultivation and a reduction in terrorism had also occurred in Peru:

[89] UNODC, *The Globalization of Crime: A Transnational Organized Crime Threat Assessment*, Vienna: UNODC, 2010, pp. 228-29.

[90] Ibid., p. 228.

FIG. 176: AREA UNDER COCA CULTIVATION AND TERRORIST INCIDENTS IN PERU, 1986-2005



Source: DEVIDA, Cocaine production Monitoring in the Andean region, Lima, July 2004; UNODC cultivation data

The US Government likewise has declared *Plan Colombia* a "dramatic success" as clearly stated by President Barack Obama in his *2010 National Drug Strategy Report* to Congress.[91] And, in a recent appearance before Congress, David T. Johnson, Assistant Secretary of State for the Bureau of International Narcotics and Law Enforcement Affairs, testified that "as a result of progress under *Plan Colombia* and its follow-on programs, more than 50,000 paramilitary members and guerilla combatants have demobilized, coca cultivation and cocaine production potential have been significantly reduced … [and] public security has improved enormously."[92] Appearing before the same hearing, R. Gil Kerlikowske, the current United States "Drug Czar," testified that "the Revolutionary Armed Forces of Colombia (FARC) has been significantly weakened through aerial and manual eradication, causing serious damage to

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[91] White House Office of National Drug Control Policy, *National Drug Control Strategy*, 2010. p. 84.

[92] David T. Johnson, Assistant Secretary of State, Bureau of International Narcotics and Law Enforcement Affairs, Prepared Testimony Before the House Oversight and Government Reform Subcommittee on Domestic Policy, "International Counternarcotics Policies: Do They Reduce Domestic Consumption or Advance Other Foreign Policy Goals," July 21, 2010, p. 2 (http://www.state.gov/p/inl/rls/rm/144982.htm).

its financial viability, which had benefited from profits generated by its increased involvement in narcotics trafficking."[93]

The success of the aerial eradication operations in depriving the narco-terrorists of funding has been confirmed by the FARC itself. Among the computer files seized during the Colombian military raid of the camp of FARC commander Raúl Reyes on March 1, 2008, was an email in which Reyes bemoaned the impact of the spraying: "In the area of finances, we have been unable to do a big deal, we have only done some small things, and the situation is difficult because of the eradication and fumigation."[94] Other captured records reflect the FARC's efforts to stop the spraying operations by raising concerns about alleged environmental effects. In one document, Raúl Reyes discussed a message from Ecuadorian Minister of National Security, Gustavo Larrea, in which the Ecuadorian minister was believed to be seeking to foster relations with the FARC in part by agreeing that Ecuador "will sue the state and government of Colombia before the International Court for the damages the aerial spraying has caused."[95] In another document, a top FARC commander notes that: "The Bi-national Commission is being strengthened, made up of members of the PCCC [Clandestine Communist Party of Colombia, the civilian wing of the FARC] and Ecuadoran friends, so we can denounce the violations of Ecuadoran sovereignty by [Colombian President] Uribe's troops, and show the damaging effects

[93] R. Gil Kerlikowske, Director of National Drug Policy, Prepared Testimony Before the House Committee on Oversight and Government Reform Subcommittee on Domestic Policy, "International Counternarcotics Policies: Do They Reduce Domestic Consumption or Advance Other Foreign Policy Goals," July 21, 2010, p. 4 (http://www.whitehousedrugpolicy.gov/news/testimony10/07212010.pdf).

[94] Letter from Edgar Tovar to Raúl Reyes, document obtained from FARC hard drive, March 1, 2008, Farah, "What the FARC Papers Show Us about Latin American Terrorism," p. 13.

[95] Farah and Simpson, "Ecuador at Risk: Drugs, Thugs, Guerrillas and the Citizens Revolution," p. 19.

of fumigation."[96] The FARC have also reportedly organized peasant demonstrations against the spraying.[97]

The loss of narcotics revenues has deeply affected the FARC's military capability. According to Colombian sources cited by the International Crisis Group (ICG), in 2002, the FARC was present in 514 of 1,098 municipalities, while in 2009, "insurgent military actions were registered in only 206 municipalities."[98] Decreased revenues, battlefield losses and desertions have forced the FARC to devote personnel and resources to defend senior officers, to defend strategic corridors for the movement of cocaine, to hold valuable hostages, and to secure geographic space in Cauca, Nariño, Chocó, Meta, Huila, Tolima and Guaviare that is critical for their finances. Moreover, the loss of equipment and ammunition has diminished the FARC's arsenal. The military has also penetrated the FARC's communications, making coordination between fronts difficult, dangerous, and time-consuming.[99]

A number of senior and mid-level terrorist commanders have died or been killed (some at the hands of subordinates) and thousands of terrorist "soldiers" have deserted (reportedly 6,091 between 2008 and mid 2010).[100] Because of the desertions, the average age of new recruits was 11.8 years in 2009, down from 12.9 years in 2008, according to the UN High Commissioner for Human Rights.[101] The FARC's offensive capability has been reduced by 70% in the same period.[102] The Colombian Ministry of Defense lists the FARC's critical losses: command and

[96] Ibid., pp. 17-18.

[97] ICG, "Ending Colombia's FARC Conflict: Dealing the Right Card," p. 4.

[98] ICG, "Improving Security Policy in Colombia," Latin American Briefing, Number 23, June 29, 2010, p. 2.

[99] The factors in the decline of the FARC, ELN, and AUC are explored in Fundación Seguridad y Democracia, "El debilitamiento de los Grupos Irregulares en Colombia-2002-2208," Bogotá, March 2, 2009.

[100] ICG, "Improving Security Policy in Colombia," p. 3.

[101] Ibid., p. 5, footnote 35.

[102] Fundación Seguridad y Democracia, "El debilitamiento de los Grupos Irregulares en Colombia-2002-2208," p. 5.

control, ability to communicate and coordinate among fronts, income and liquidity from the loss of coca zones, logistical capabilities, combat capacity, morale, and manpower.[103] In addition, the FARC's international support has eroded even more because of the atrocities they committed and revelations of their involvement in narcotics trafficking.

The sharp setbacks for the FARC are mirrored by the declines of the two other narcoterrorist organizations in Colombia. It is estimated that the ELN has been reduced to 2,000 members and is much less of a military threat. Analysts predict that because of its weakness the group may eventually agree to put down its arms, like the AUC did with over 30,000 of the AUC members undergoing demobilization, demilitarization, and reintegration.

The bottom line is that Colombia is a dramatically safer place than it was when *Plan Colombia* began. From 2002 to 2009, kidnappings in Colombia were down by 83 percent, and terrorist attacks decreased by 76 percent, while the area of coca cultivation was down from 163,000 hectares in 2000 to 77,870 in 2006, and 68,000 in 2009.[104] The expansion of the public security forces has created safer conditions on the roads of the nation and greater citizen security. In addition, the state has consolidated control over areas where the FARC held sway. The government's increased control over the country has facilitated fundamental reforms of the judiciary and legal systems. Finally, the economy is dynamic, unemployment is reduced to nearly 10 percent, investment is high, the stock market is performing well, and the Colombian *peso* is rising impressively among international currencies.[105]

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[103] Ministry of National Defense, Republic of Colombia, "The FARC at Their Worst Moment in History," Bogotá, 2008, pp. 5-10 (http://web.presidencia.gov.co/english/publicaciones/farc_peor_momento.pdf).

[104] Marcella, "Democratic Governance and the Rule of Law: Lessons Learned from Colombia," p. 21; Marcella, "War Without Borders: The Colombia- Ecuador Crisis of 2008," p. 16.

[105]Various indicators of success, including eradication, are analyzed in De Shazo, *et al.*, "Countering Threats to Security and Stability in a Failing State: Lessons from Colombia."

VII. Conclusion/Summary of Opinions

The aerial eradication operations of *Plan Colombia* have played an integral role in what has unquestionably been a significant success story. In 2000, the FARC, the ELN and the AUC posed a grave threat to the very existence of Colombia and were increasingly threatening U.S. interests and international security. Today, the flow of drug money has been sharply curtailed, with the result that the terrorist groups have been significantly weakened. This success story and the need for continued vigilance is clearly set forth in the *2010 National Drug Control Strategy*:

> Perhaps no country has faced a greater burden from drug-trafficking organizations than Colombia. At one point, the very existence of the Colombian state was threatened by insurgent and drug-trafficking groups enriched with drug-trafficking proceeds… Colombia was able to slowly regain the upper hand against illegal armed groups through its sustained efforts and with a deep commitment from the United States. Today, although Colombia must continue to show progress and expand governance to long-ignored rural areas, the existence of the Colombian state is no longer in doubt. Colombia is a vibrant, democratic nation and is increasingly assisting the hemisphere by sharing the knowledge it has gained pushing back against drug trafficking for the past 20 years. Success in Colombia remains critical to the United States' efforts to combat increasingly corrosive drug-trafficking activity in Mexico, Central America, and the Caribbean.[106]

Dated: January 17, 2011

Gabriel Marcella

Gabriel Marcella

CR Note: Dr. Marcella's CV (Exhibit A), found in CD - Original Annexes

[106] White House Office of National Drug Control Policy, *National Drug Control Strategy*, 2010, p. 84.

EXHIBIT B

Exhibit B

Dr. Gabriel Marcella Materials Considered

Publications

1. African Union, 4th Session of the African Union Conference of Ministers for Drug Control and Crime Prevention, Report of Experts' Meeting, "Turning the Tide of Drugs and Crime in Africa – From Policy to Action," CAMDCCP/EXP/Report (IV), Addis Ababa, September 28-October 2 2010 (http://www.uneca.org/coda/Documents/AU_Drugs_Crime_Experts%20Report_October 2010_%20English.pdf).

2. Philip Alston, "Statement by Professor Philip Alston, United Nations (UN) Special Rapporteur on extrajudicial executions, Mission to Ecuador: 5-15 July 2010," Quito, July 15, 2010.

3. Ana Arana, "Murder in Colombia," *Salon.com*, December 14, 1999 (http://www.salon.com/news/feature/1999/12/14/colombia).

4. Gersón Ivan Arias, Natalia Herrera, and Carlos Andrés Prieto, "Mandos medios de las FARC y su proceso de desmovilización en el conflicto colombiano: ¿Una apuesta para la paz o para la guerra?" Bogotá: Fundación Ideas para la Paz, September 2010.

5. Attorney General John Ashcroft, "Prepared Remarks of Attorney General John Ashcroft: DEA/Drug Enforcement Rollout," March 19, 2002 (http://www.justice.gov/archive/ag/speeches/2002/031902newsconferencedeaenforcementrollout.htm).

6. Association of South East Asian Nations and European Union (ASEAN-EU), "Joint Declaration on Cooperation to Combat Terrorism," 14th ASEAN-EU Ministerial Meeting, January 27-28, 2003 (http://archive.asean.org/14030.htm; last visited November 30, 2010).

7. Rand Beers and Francis Taylor, Joint Testimony Before the U.S. Senate Committee on the Judiciary Subcommittee on Technology, Terrorism and Government Information, "Narco-Terror: The Worldwide Connection Between Drugs and Terror," March 13, 2002.

8. Sebastian Brett, "'You'll Learn Not To Cry:' Child Combatants in Colombia," New York, NY: Human Rights Watch, September 18, 2003 (http://www.hrw.org/reports/2003/colombia0903/).

9. Lanny A. Breuer, Statement Before Subcommittee on Human Rights and the Law Committee on the Judiciary, U.S. Senate, "Drug Enforcement and the Rule of Law: Mexico and Colombia," May 18, 2010.

10. George W. Bush, *The National Security Strategy of the United States of America*, September 20, 2002.

Exhibit B

11. Sandro Calvani, United Nations Office on Drugs and Crime (UNODC) Representative in Colombia, "Summary Statement: UNODC Briefing on Foreign Aid to Colombia and the European Role in the Fight Against Narco-terrorism," Committee on International Relations, U.S. House of Representatives, October 14, 2004.

12. Ana Carrigan, *The Palace of Justice: A Colombian Tragedy,* New York, NY: Four Walls Eight Windows, 1993.

13. Steven W. Casteel, Assistant Administrator for Intelligence, Statement Before the U.S. Senate Committee on the Judiciary, "Narco-Terrorism: International Drug Trafficking and Terrorism- a Dangerous Mix," May 20, 2003.

14. William J. Clinton, *A National Security Strategy for a Global Age*, White House: December 2000.

15. Colombian Embassy, Washington, DC, "Peace & Justice Law" (http://colombiaemb.org/index.php?option=com_content&task=view&id=45&Itemid=74; last visited December 10, 2010).

16. Colombian Embassy, Washington, DC, "Plan Colombia: Institution Building & the Fight Against Drug Trafficking" (http://colombiaemb.org/index.php?option=com_content&task=view&id=989&Itemid=237; last visited December 10, 2010).

17. Colombian Office of the UN High Commissioner for Human Rights, *Informe de la Oficina del Alto Comisionado de las Naciones Unidas para los Derechos Humanos Sobre la Misión de Observación en el Medio Atrato*, Bogotá, May 20, 2002.

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Annex 9

Expert Report of Dr J.M. DiTomaso, Ph.D. prepared for the Dyncorp Defendants in *Arias/Quinteros v. Dyncorp* (D.D.C.), 20 January 2011

(United States District Court for the District of Columbia,
Cases No. 1:01-cv01908 (RWR-DAR) and 1:07-cv01042 (RWR-DAR).
Cases consolidated for Case Management and Discovery)

EXHIBIT 3

EXPERT REPORT OF JOSEPH M. DITOMASO
Prepared for the DynCorp Defendants in
Arias/Quinteros v. DynCorp (D.D.C.)

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BACKGROUND & CREDENTIALS

My name is Joseph M. DiTomaso, and I submit this written report on behalf of the DynCorp defendants in the Arias/Quinteros v. DynCorp litigation. I am a weed scientist by training, and I am presently a Cooperative Extension Weed Specialist with the University of California, Davis (UC Davis). I received my BS degree in 1978 in Wildlife and Fisheries Biology from UC Davis. In 1981, I received an M.A. degree in Biological Sciences from Humboldt State University in Arcata, California. I received my Ph.D. in Botany/Weed Science from UC Davis in 1986.

Among some of my recent accomplishments, in 2008, I was appointed by the Secretary of the Interior of the United States to serve on the Invasive Species Advisory Committee, a committee which advises primarily the Secretaries of the Interior, Agriculture and Commerce (as well as all other cabinet committees) on issues related to invasive species. In 2009, I was appointed by the California Secretary of Agriculture to serve on the California Invasive Species Advisory Committee. I am President of the Western Society of Weed Science (elected in 2009), and I am the editor of the journal *Invasive Plant Science and Management* (appointed to this position by the Board of Directors of the Weed Science Society of America in 2007). In March 2011, I will be named a Fellow of the Weed Science Society of America. This is the highest award the society bestows on its membership and represents career accomplishments in the Weed Science discipline.

At UC Davis, I co-teach the introductory Weed Science course to undergraduates once a year. In this course, we discuss the biology and ecology of weeds, mode of action of herbicides, and different weed control options. Cooperative Extension Specialists such as myself also conduct applied research and are responsible for statewide leadership in extending information to clientele, end users, the general public, and other relevant groups throughout the state. In this role, my research extension program focuses on understanding the biology and ecology of invasive plants in non-crop areas, and we use information developed through this research to establish more effective, scientifically-based, and cost effect methods for the management of invasive plant species. I conduct studies using all forms of weed control, including herbicides, mechanical and cultural methods, as well as biological control agents. Whenever possible, my program uses an integrated approach to weed management that relies on understanding the biology of the target and non-target plants, as well as the ecology of the ecosystem, to develop environmentally safe, economical, and effective strategies for invasive plant management. My research, particularly that on susceptibility of invasive plant and non-target species, has been used by both the federal and California EPA to assist in making decisions on registration of new products, including where a compound will be registered for use (*e.g.*, rangelands, wildlands, right-of-ways, etc.) and how the product label will be written.

I have published 109 peer-reviewed papers and five books. In addition, I have published an additional 218 extension papers or articles. All these publications concern weeds or invasive plants, management strategies, or herbicide activity – including mode of action, mechanism of resistance, control, or selectivity issues related to herbicides. Since my appointment at UC Davis in 1995, I have given 772 extension talks and have also been an invited speaker at professional conferences on 74 occasions, including 13 as the keynote speaker. Among my keynote speaker invitations, I have been invited to international conferences in France, China and Australia.

I have routinely worked with glyphosate in all facets of my professional career. In my extension program, I am regularly requested to explain how herbicides – such as glyphosate – work in plants, describe the fate of herbicides in the environment, provide options for control of a variety of invasive plant species, and determine what herbicide may have caused a particular symptom in a variety of plant species. And, while my research efforts often include studies related to the biology, ecology and impact of invasive plants, most also focus on management options to deal with invasive plants, of which herbicides are a key component. As such, I have conducted trials and larger studies with many different compounds. My research with glyphosate has compared different formulations for most efficient control. In addition, we have conducted large studies or trials using glyphosate for the control of jubatagrass, yellow starthistle, perennial pepperweed, medusahead, cheatgrass, tree tobacco, Scotch broom, tree-of-heaven, yellow flag iris, running bamboo, switchgrass, miscanthus, hedgeparsley, houndstounge, wild blackberry, *Conyza* spp., periwinkle, many other rangeland weeds, and woody plants that interfere with forest replantation efforts, particularly oaks. I have published 30 peer-reviewed papers that either include glyphosate in the underlying research or discuss the effect, mode of action, or fate of glyphosate. I have published an additional 84 extension papers that report on the effects of glyphosate use or discuss some aspect of its phytotoxic effects.

A more thorough description of my background and qualifications is set out in my curriculum vitae, attached to this report as **Exhibit A**, which also includes a list of my publications.

STATEMENT OF COMPENSATION

I am being compensated at a rate of $300.00 per hour for my work in this matter, including deposition and trial testimony.

PRIOR TESTIMONY

Date	**Nature of Testimony**	**Case Information**
2006	Deposition	Shaw v. County of Santa Cruz, Case No. CV 141711 (Superior Court, Santa Cruz County, CA)
2007 – 2009	Deposition and Trial	Adams, et al. v. United States of America, et al., No. CIV 03-0049-E-BLW (D. Idaho)
2009 – 2010	Deposition and Trial	Christine Bettencourt et al. vs. Arroyo Seco Resort, et al., No. M74585 c/w M83877

SUMMARY OF EXPERT OPINIONS

I have been asked to evaluate the test plaintiffs' claim that the glyphosate-based herbicide used in Plan Colombia has damaged their crops, as evidenced by the photographs, videos, deposition testimony, and other descriptions provided by the test plaintiffs in this litigation. My opinions can be summarized as follows:

1. Glyphosate is a widely used and a widely studied chemical with known phytotoxic effects (toxic effects on plants).

2. The crop damages attributed by the test plaintiffs to the Plan Colombia spray mixture are incompatible with the known phytotoxic effects associated with exposure to glyphosate. Therefore, it is my opinion, to a reasonable degree of certainty, that the test plaintiffs' alleged crop damages were not caused by the Plan Colombia spray mixture.

3. The test plaintiffs' sole expert witness, Dr. Wolfson, is incorrect when he concludes that:

   (a) the labeling for the glyphosate formulation used in the Plan Colombia spray mixture categorically prohibits the use of an additional surfactant like Cosmo-Flux; and

   (b) the Plan Colombia spray mixture contains excessive amounts of the glyphosate formulation.

My opinions are based upon my training, background and experience in weed science. They are also based upon my review of numerous materials consulted throughout the course of my work on this matter, many of which are cited throughout this written report. A comprehensive list of materials considered in reaching my opinions is attached to this report as **Exhibit B**.

GLYPHOSATE IS WIDELY USED AND WIDELY STUDIED

Glyphosate is a widely used herbicide. Glyphosate was identified four decades ago in a Monsanto discovery program that initially produced the sugarcane ripener glyphosine. Both glyphosate and glyphosine were considered important to chemically ripen sugarcane under conditions that do not favor natural ripening (Dusky et al. 1986). The first herbicide utilizing glyphosate as an active ingredient was introduced in 1971. Today, glyphosate is the most widely used herbicide globally,[1] and its widespread use can be attributed to its very favorable toxicological / environmental profile combined with its effectiveness in controlling a wide spectrum of weeds (Nandula 2010; Duke and Powles 2008).

As testimony to its outstanding toxicological profile and low impact on urban, agricultural, and natural environments, many glyphosate formulations[2] are registered for use in the United States in numerous agricultural and non-agricultural areas, including rangelands, wildlands, natural areas, aquatic systems, schools, parks, recreational areas, and residential areas. It is also available to homeowners on a widescale basis.

While I will specifically address each of the individual test plaintiffs' allegations in the next section of this report, it is important to note at the outset that many of their allegations are plainly at odds with the real world experience with glyphosate, most notably glyphosate's major role in agricultural and environmental land management. For example, if glyphosate had any of the deleterious effects on soil fertility or future crop yield alleged by the test plaintiffs, those effects would have been readily apparent given the tremendous use of glyphosate directly on agricultural land with Roundup Ready crops and in agricultural/soil conservation systems, and the effects would have been devastating to this country's agricultural industry and that of many other countries around the world. Likewise, if glyphosate caused significant adverse impacts to the environment, it would not be used – as it is – in some of the most sensitive environments in the world. And, given the widespread use of formulated glyphosate both in agricultural, non-agricultural, and residential settings, if glyphosate could cause the types of adverse health effects claimed in this litigation, one would by now expect a large body of scientific literature evidencing those effects.

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[1] Although it is difficult to quantify the amount of each herbicide used in the entire United States, reported numbers for California alone show that 6.8 million lbs of glyphosate formulations were applied in 2008 (http://www.cdpr.ca.gov/). This is by far the leading herbicide used (with propanil (rice herbicide) second with 1.7 million lbs). In terms of total acreage treated in California, glyphosate formulations again led with 3.7 million acres treated in the state (followed by oxyfluorfen at 1.6 million acres). The use of glyphosate in California was throughout many crop areas (such as grapes, almonds, walnuts, prunes, corn for forage and human use, apples, cotton, barley, olives, garlic, lemons, oranges, alfalfa, avocados, and wild rice) and non-crop areas (such as landscape maintenance, rights-of-way, outdoor plants in containers, structural pest control, timberland forests, uncultivated non-agriculture sites, and pastureland).

[2] In practice, glyphosate is often mixed with certain additives (e.g., surfactants) which enhance the herbicide's activity. Therefore, glyphosate comes in many different formulations.

- **Use of glyphosate throughout modern agriculture.** Glyphosate is by far the leading herbicide used in the agricultural setting, which includes row crops, orchards, fallow lands, and pastures worldwide (Duke and Powles 2008). In numerous crop settings, glyphosate is often used in preparing tilled or no-tilled seedbeds for planting. Because glyphosate has no soil residual activity (discussed in more detail below), it can be applied to fields prior to planting to clear any undesirable crops or weeds; then, only days following this initial application of glyphosate, the intended crops can be planted without any ill effects.

  Glyphosate is also very commonly used in any number of agricultural settings to control weeds along field borders, fencelines, and the edge of ditchbanks. In orchards, for example, controlled applications of glyphosate are a common treatment to eradicate developing or established weeds in the tree rows or space between the rows.[3]

  In addition, glyphosate is increasingly used today for weed control in "Roundup Ready" crops. "Roundup Ready" crops are genetically modified to be resistant to glyphosate, thus allowing what is commonly called "over-the-top" or "broadcast" applications of glyphosate, where glyphosate is applied simultaneously and indiscriminately to both the crops and any undesirable weeds growing alongside them. These are often referred to as transgenic crops. Of all the transgenic crops grown in the world, 90% are glyphosate resistant, amounting to about 100 million hectares in 2006 (Duke and Powles 2008). This number is undoubtedly higher today. Roundup Ready crops account for approximately 90% of the soybeans grown worldwide, and 100% of the soybean grown in Argentina. The adoption rate of Roundup Ready soybean in Brazil is also increasing dramatically since it was registered for use there. In addition, 70% of the corn and cotton grown in the United States is Roundup Ready, and 75% of the canola grown in Canada and the United States is Roundup Ready (Duke and Powles 2008). There are also widely planted cultivars of alfalfa that are Roundup Ready. As a result of its use with Roundup Ready crops, as well as its many other uses in other crop and non-crop areas, glyphosate accounts for 60% of the volume of herbicides used in the United States (Duke and Powles 2008).

  In sum, glyphosate's unique properties historically made it one of the most popular and effective agricultural herbicides available, and those same properties have led to its expanding, successful use, particularly in agricultural/soil conservation systems and, more recently, in Roundup Ready crops.

- **Use of glyphosate in sensitive environments.** Outside the agricultural setting, glyphosate formulations are commonly used by the U.S. Department of Interior (i.e., U.S. Forest Service, Bureau of Land Management ("BLM")), and other state and local entities for weed control and invasive plant species management in wildland areas, such as forests, woodland, grasslands, deserts, aquatic areas, wetlands, and riparian areas.

[3] Incidentally, many glyphosate formulations are labeled for use in and around tropical crops.

Furthermore, glyphosate formulations are often used in directed treatments to control plant species that threaten unique environments or endangered species. For example, in North Dakota, the endangered black tern habitat was threatened by overgrown populations of cattails. The use of glyphosate controlled the cattails, creating more open habitat which was positively correlated with an increase in the endangered tern population (Linz et al. 1994). Glyphosate is also used in the Ecuadorian Galapagos Islands to control invasive plants. The Galapagos Islands are 1,000 km west of the Ecuadorian mainland and are renowned for their animal and plant diversity, as far back as the days of Charles Darwin. This sensitive archipelago has also had a serious influx of invasive plant species that threaten its native ecosystems and wildlife habitat. Glyphosate has played an important role in managing and eradicating some of the most serious of the invasive plants on the islands, including *Pueraria phaseoloides* (a close relative of kudzu), *Cinchona pubescens*, and *Rubus glaucus* (Gardener et al. 1999, Soria et al. 2002, Tye et al. 2002, Buddenhagen 2006). Importantly, glyphosate is used in these environments with no deleterious effect on the sensitive ecosystem.

- **Use of glyphosate by everyday homeowners.** As further evidence of its favorable safety profile, glyphosate is registered in the United States for homeowner use in a number of brands and formulations, and it is widely available to - and widely used by - the general public for all manner of weed control projects. The manufacturers and product names of more than forty glyphosate-containing products are listed in Table 1, attached to this report as **Exhibit C**. Many consumers are undoubtedly familiar with one or more of these various glyphosate formulations.

Glyphosate has been widely studied. The duration and scope of use of glyphosate has produced a vast body of knowledge concerning its properties, effects, and use. As a result, the properties of glyphosate are well known. Indeed, glyphosate has been studied extensively – perhaps more extensively than any other herbicide – over the last 30 or more years.[4] In addition to the U.S. EPA's registration documentation,[5] recent reviews by Williams (2000) and Giesy (2000) evidence the impressive amount of studies concerning glyphosate and its various formulations.

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[4] A simple literature search within the Thomson Reuters ISI Web of Science using the term "glyphosate" revealed more than 4,000 papers published in peer-reviewed, high impact factor journals. (This database does not include non-peer reviewed literature, newer journals, or journals with lower status.)

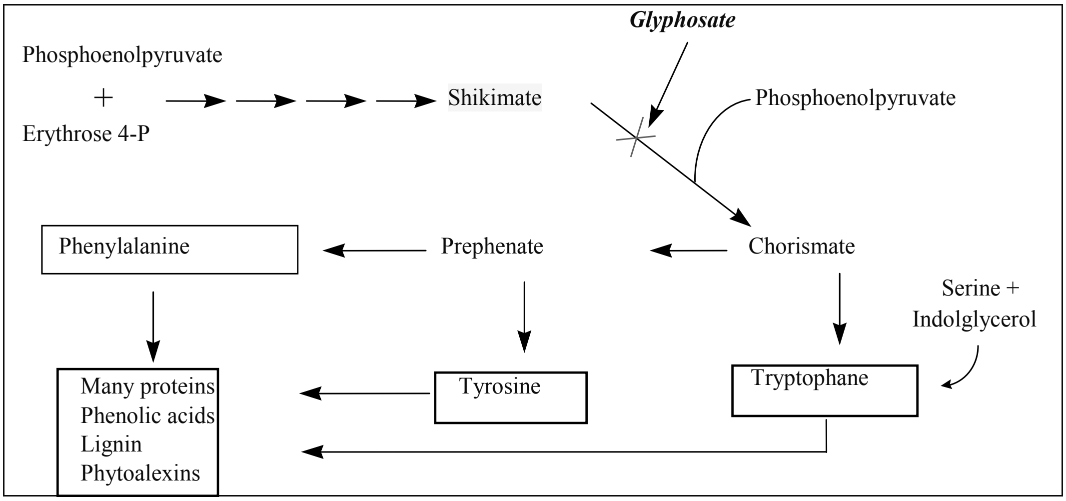
[5] In the United States, every pesticide/herbicide must be "registered" for use. The registration process is comprehensive and requires that numerous toxicological studies be performed – many of which are conducted by independent labs – and thoroughly reviewed by the U.S. EPA prior to approval.

THE MODE OF ACTION AND EFFECTS OF GLYPHOSATE AND ITS SURFACTANTS

Glyphosate's mode of action. Glyphosate is the active ingredient in the Plan Colombia spray mixture. Glyphosate is a foliar-applied herbicide that translocates in the living phloem (cells that transport sugars to growing points or storage organs such as roots crowns, rhizomes, tubers and bulbs) of treated plants. This means that once applied to plant leaves, glyphosate moves throughout the plant (i.e., translocates) to reach the plant's meristems (growing points), young roots and leaves, storage organs, and other actively growing areas of the plant. At these locations, glyphosate produces its phytotoxic effects via disruption of functions critical to plant growth.

In more technical terms, glyphosate inhibits the activity of the enzyme 3-phospho-5-enolpyruvyl shikimate (EPSP) synthase in the shikimic acid pathway. This enzyme is essential to the plant's synthesis of the aromatic amino acids phenylalanine, tyrosine, and tryptophane (Gresshoff 1979) (Figure 1), all of which are implicated in the plant growth processes.[6]

Figure 1: Pathway for synthesis of aromatic amino acids and site of inhibition by glyphosate.



In plants, stores of aromatic amino acids (e.g., phenylalanine, tyrosine, and tryptophane) are critical to maintaining protein synthesis, a process which is necessary for the plant's growth and survival. When glyphosate inhibits the plant's biosynthetic/shikimic acid pathway, these stores of amino acids are eventually depleted, leading to a disruption of the plant's growth processes and an unregulated accumulation of shikimate within the plant (see highlight in Figure 1).

[6] Convincing evidence that EPSP is the sole site of herbicide action can be inferred from the fact that Roundup Ready crops, i.e., plants genetically transformed with a glyphosate-insensitive form of EPSP synthase, tolerate applications of glyphosate (at reasonable/commercial levels).

Shikimate is an important biochemical intermediate used in the synthesis of proteins, amino acids, and many other necessary plant products. However, a very high level of shikimate in the plant leads to a shortage of free carbon that in necessary for the synthesis of many other important compounds, including amino acids, proteins, and enzymes.[7] In essence, following a lethal exposure to glyphosate, the plant starves to death from both a lack of aromatic amino acids and available soluble carbon needed for other metabolic processes.

Because all plants contain a glyphosate sensitive form of EPSP synthase, the herbicide is considered non-selective and has activity on nearly all plants (Duke and Powles 2008). Furthermore, the metabolic pathway affected by glyphosate is unique to plants (Giesy 2000; Solomon 2007). No animal systems are capable of producing amino acids, and as such, these must be obtained either directly (eating plants) or indirectly (eating animals that have eaten plants). Because animals do not possess the ability to synthesize amino acids, including the aromatic amino acids, the target site for glyphosate is not present in any animal system.

Use of surfactants to enhance efficacy of glyphosate. The Plan Colombia spray mixture contains several components (often characterized as "inactive" ingredients) in addition to glyphosate, including relatively large amounts of water and relatively small amounts of POEA and Cosmo-Flux. Combined, POEA and Cosmo-Flux comprise approximately 8% of the overall spray mixture (74% is water, and the 18% remainder is glyphosate).[8]

POEA and Cosmo-Flux are chemical "surfactants" added to enhance the activity of glyphosate within the formulation. POEA is contained in the glyphosate formulation purchased for use in Plan Colombia, and Cosmo-Flux is added in Colombia immediately prior to application.[9]

Surfactants generally. An adjuvant is any material added to an herbicide spray solution to enhance or modify the performance of the solution.[10] The most common type of

[7] Following glyphosate treatment, as much as 10% to 20% of the plant's total soluble carbon (carbon in a soluble form that is available to the plant for biochemical activity) can be found to accumulate in shikimate. Shikimate accumulation is an indication of the activity of glyphosate in plants (Gravena et al. 2009).

[8] POEA makes up 15% of the glyphosate formulation. Because 44% of the Plan Colombia spray mixture is the glyphosate formulation, the resulting amount of POEA in the total Plan Colombia spray solution is approximately 6.6%. Added to that is Cosmo-Flux, which makes up 1% of the total Plan Colombia spray solution.

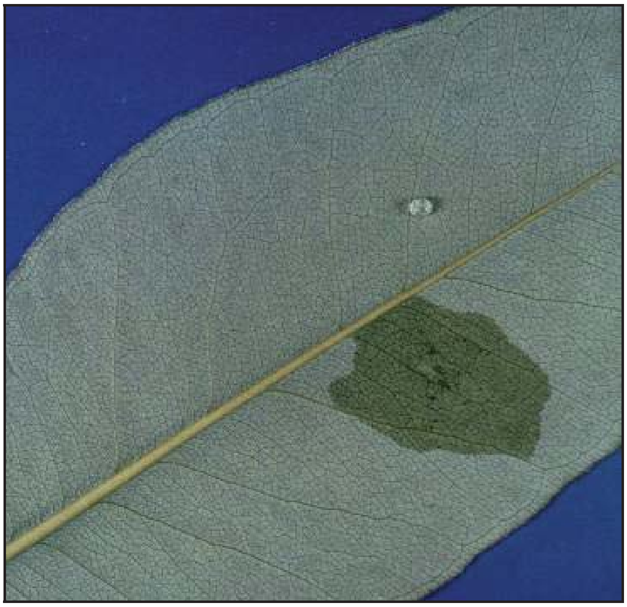
[9] In all, the Plan Colombia spray mixtures consists of 55% water, 44% formulated glyphosate, and 1% Cosmo-Flux.

[10] The history of adjuvants in agriculture is long. More than 200 years ago, growers used adjuvants such as tar, sugar, or tree sap to stick Bordeaux mixture fungicide to grapes. In the late 1880s, soap was used with kerosene to destroy insect eggs and later to increase arsenical insecticide activity. Today, there are thousands of different adjuvants registered for use in many products, including household products such as detergents. The adjuvants/surfactants in detergents improve water's ability to wet things, spread over surfaces, and seep into dirty clothes fibers, equipment, or body tissues. To remove grease and oils in

adjuvant used in herbicide spray solutions is a surfactant (a combination of the words "surface active agent"). Numerous studies have shown that surfactants are necessary to achieve maximal activity of the herbicide, and in my experience all foliar applied herbicides contain a surfactant in the spray formulation.

Surfactants facilitate or enhance the emulsifying, dispersing, spreading, sticking and/or wetting properties of liquids. When added to an herbicide solution, surfactants lead to more uniform deposition of the spray solution on the plant; they increase the retention of spray droplets to the plant; they prevent evaporation and crystallization of the spray droplet to allow longer time for herbicide penetration; and they increase penetration through hairs, scales and other leaf surface structures (Hess and Foy 2000). The increased spreading ability of surfactants is accomplished by reducing the surface tension of water which allows greater contact with the leaf surface (Photo 6).

Photo 6. Comparison between a drop of water without (top) and with (bottom) the addition of a surfactant. Addition of the surfactant greatly increased the spreading ability of the water droplet.



In addition to their effect on surface tension on plant leaves, surfactants can also directly influence the absorption of herbicides by changing the cuticle (waxy leaf surface) characteristics of the plant. Riederer and Schönherr (1990) demonstrated the increase in water permeability of the cuticle after application of surfactants. This is thought to be

clothing, dishes, skin or hair, one end of surfactant molecule is attracted to water while the other end is attracted to dirt and grease. The surfactant molecules help water to get hold of grease, break it up, and wash it away. Pure water cannot do this alone.

due to a change in the melting point of wax. A reduction in the melting point and increase in water permeability allow for greater penetration of the herbicide solution across the leaf cuticle.

In essence, surfactants provide better control of weeds (with lower rates of herbicides) not by changing the activity or structure of the herbicide, but rather by enhancing the ability of the active ingredient to contact the plant surfaces and move into the translocating tissues.

Surfactants in the Plan Colombia spray mixture do not exert independent phytotoxic effects. As noted above, the spray mixture used in Plan Colombia contains the surfactants POEA and Cosmo-Flux.

POEA is a component of a number of pesticide formulations available here in the U.S. (including a number of glyphosate formulations such as Roundup), and its properties are well known (Collins and Helling 2002; Sherrick et al. 1986; Williams et al. 2000).

Although Cosmo-Flux is not available here in the U.S., it is similar to any number of other surfactants used here in the U.S. (Cosmo-Flux Safety Information Sheet (Cosmoagro 2003)), and so its properties and effects are easily characterized.[11]

Consistent with the known properties of surfactants, studies have demonstrated that the addition of these surfactants enhanced control of illicit coca beyond that achieved with glyphosate alone (Collins and Helling 2002). And, consistent with the properties of surfactants, the addition of POEA and Cosmo-Flux to the Plan Colombia spray mixture would be expected to do no more than enhance the activity of the herbicide through better wetting, retention, and penetration into the plant. They exert no phytotoxic effects independently or through some synergistic combination with glyphosate. As evidence of this, formulations of Roundup containing surfactants are widely applied to Roundup Ready (glyphosate resistant) crops around the world, as previously discussed. While Roundup Ready crops are genetically modified to resist the phytotoxic effects of glyphosate, they are no different from other plants in their lack of resistance to surfactants. However, applications in Roundup Ready crops have never been reported to cause any surfactant-related injuries to the crops.

Characteristic phytotoxic effects of glyphosate formulations. To a large extent, glyphosate's unique mode of action defines the phytotoxic effects of its formulations, and therefore an accurate understanding of glyphosate's effects in plants is essential to the evaluation of the test plaintiffs' crop damage claims.

[11] Solomon et al. (2005) describe Cosmo-Flux as a typical "agricultural adjuvant containing non-ionic surfactants (a mixture of linear and aryl polyethoxylates – 17% w/v) and isoparaffins (83% w/v)." In fact, Cosmo-Flux was selected for use in the Plan Colombia aerial eradication program precisely because it "most closely matched the most effective U.S. products that had been tested by the USDA-ARS in Beltsville, MD, and Hawaii as additives to glyphosate for use against coca." (U.S. Dept. of State Report to Congress, 2002).

- **Delayed effects in plants.** Because glyphosate translocates throughout the plant (including the below ground reproductive tissues) and ultimately acts at its growing points, glyphosate produces delayed effects in exposed plants. One simple reason for this is that translocation of the herbicide throughout the plant takes time. In addition, the activity of glyphosate (inhibition of EPSP synthase, which in turn leads to a reduction in aromatic amino acids and an increase in shikimate, which in turn ultimately starves the plant of important compounds necessary for growth and the maintenance of metabolic activity) takes additional time to unfold. This process requires far more time than that observed for "contact" herbicides. Therefore, unlike common contact herbicides (e.g., paraquat, diquat, pelargonic acid, and all the organic foliar applied herbicides) which produce rapid effects within a couple of hours to a day, glyphosate produces delayed effects in treated plants.[12]

  Even in plants most vulnerable to glyphosate (*e.g.*, smaller, annual species), the first effects will not be seen until several days following exposure, at the earliest, and plant death typically occurs after approximately one week. In larger plants, mature perennial species, and woody plants (such as coca), the effects of glyphosate are even slower: Effects typically become evident a week or more after exposure, and a lethal dose may take many weeks up to a couple of months to produce plant death.[13]

  In an attempt to capitalize upon the delayed action of glyphosate, I understand that growers of illicit coca often prune or defoliate their coca crops immediately following aerial eradication missions in an attempt to save the plant from the effects of the herbicide (Collins and Helling 2002; Solomon 2005).

- **Universal, dose-dependent effects in plants.** Given that the site of action (EPSP synthase) is common to all plant species, glyphosate is known to be a non-selective herbicide with activity on nearly all plants, including crops, non-crops, temperate plants, and tropical plants alike.[14] Consequently, once exposed to sufficient amounts of glyphosate, all plants would be expected to exhibit some symptoms of exposure.

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[12] The rapid effect of contact herbicides is due (in part) to their mechanism of action, which generally acts to destroy plant cell membranes quickly, leading to cell leakage and rapid symptoms of wilting and necrosis (browning of tissues). See the Weed Science Society of America website (http://wssa.net/Weeds/Tools/Herbicides/HerbicideMovies.htm) for time-lapse photography of the effects of paraquat on bean or corn and glyphosate on cowpea and grasses (barley and oat). Paraquat is a contact herbicide used in agriculture. See the video available at http://www.youtube.com/watch?v=zdJTtrvkGWg for a time-lapse comparison of glyphosate and glyphosate plus SureGuard, another contact herbicide. The activity of glyphosate in the smaller, annual species depicted in these videos would be considered rapid compared to its slower response in larger, perennial species and woody plants (such as coca).

[13] Collins and Helling (2002) and Ferreira et al. (1997) demonstrated that varying rates of glyphosate took months to adequately control illicit coca.

[14] Exceptions to this rule include plants that have developed a resistance to glyphosate and Roundup Ready crops with a genetically modified resistance to glyphosate.

The question is what amount of the herbicide is necessary to produce effects? As with all "toxic" exposures, the response of a plant to glyphosate is generally dependent upon the concentration to which the plant is exposed. Very low exposures can produce no effects or even stimulation in growth.[15] Higher sublethal doses can produce transient symptoms from which plants will eventually recover, and still higher doses will produce symptoms that will kill plants. Ultimately, there are many potential variables to consider when discussing the dose-dependent effects of glyphosate, but the general rules can be stated as follows. Because glyphosate exerts its effects upon a plant's biosynthetic/growth processes, the growth dynamics of each plant will predict its reaction to a particular concentration of glyphosate. Annual species have limited sources of stored carbon and nutrients compared to larger perennial species, meaning that during periods of active growth their biosynthetic processes are far more active and, consequently, more greatly disrupted by glyphosate. Thus, annual species, such as corn, generally exhibit the effects of glyphosate much more quickly than larger perennials, and after exposure to lower doses of the herbicide. Similarly, herbaceous perennial plants (e.g., pasture grasses) will show the effects of glyphosate more quickly than larger perennial plants (e.g., plantain), which have more reserve storage materials that may be utilized for growth. For largely the same reason, woody species (e.g., coca, cacao, coffee, citrus) respond even slower than herbaceous perennials and require higher concentrations before they can be killed.

Although it is true that plants demonstrate varying levels of susceptibility to glyphosate (meaning that smaller amounts of glyphosate may affect one plant species more than another[16]), the variation in response between plant species is much smaller than it would be with more selective herbicides. This is because leaf uptake rates are considered the primary variable accounting for differences in glyphosate susceptibility (Duke and Powles 2008), and not target site sensitivity or the rate of herbicide degradation in the plant, which can also contribute to selectivity differences among plants treated with other

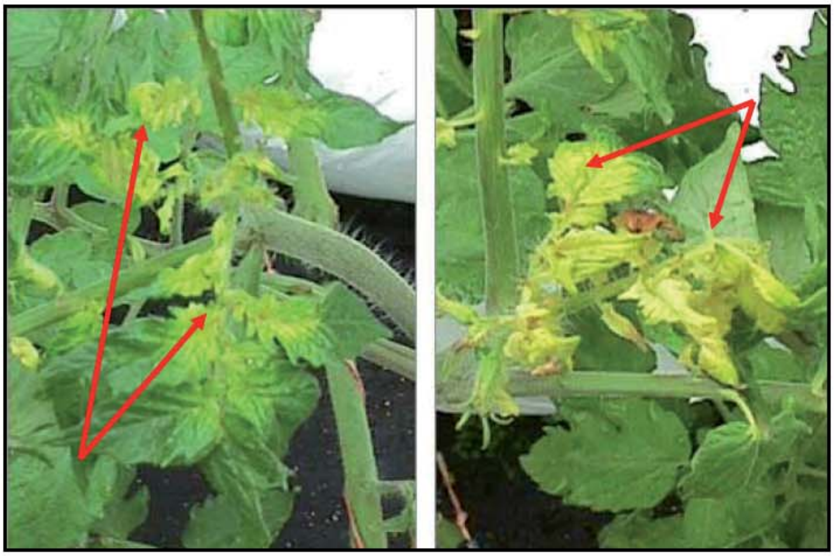
[15] It should not be surprising that nominal exposures to glyphosate often prove inconsequential, considering that glyphosate was first discovered and favorably utilized as a sugarcane ripener. In addition, recent studies have shown that low-level glyphosate exposure can actually stimulate plant growth through the phenomenon known as "hormesis." Hormesis is defined as a growth stimulatory effect in organisms, including plants, due to low-dose chemical stress. Numerous studies have reported hormesis in plants (*i.e.*, barnyardgrass, corn, barley, grain sorghum, soybean, pine and eucalyptus trees, and coffee) following low-level glyphosate exposure (Schabenberger et al. 1999; Duke et al. 2006; Cedergreen et al. 2007, 2009; Cedergreen 2008a, b; Velini et al. 2008).

[16] For instance, a plant's response can be affected by the amount of herbicide that is absorbed by the plant, which can depend upon certain physical variables such as herbicide deposition (more upright, narrower leaves intercept less herbicide compared to flat broad leaves with a parallel orientation to the soil surface) and the ability of the plant to absorb the herbicide (for example, the amount of waxy cuticle or surface hairiness can inhibit herbicide absorption). Likewise, a number of other physiological or biochemical characteristics can affect plant response, including age or stage of development of the plant, stress conditions at the time of treatment (drought, nutrient deficiencies, etc.), individual translocation rates (which can depend on photosynthetic rates in the plant), or other morphological or physiological differences among plant species.

herbicides. In addition, there is no evidence showing that tropical plants are more or less sensitive to glyphosate than temperate plant species. Therefore, if application/exposure rates are available, it is possible to predict with some confidence glyphosate's likely effects across a range of plant species, with reference to or extrapolation from known/standard plant toxicity data/rates. For this reason, herbicide labels typically indicate the rate of glyphosate application necessary to achieve effective control of a large number of annual and perennial plant species.[17]

- **Nature of effects in plants.** One of the first noticeable effects following glyphosate exposure is yellowing (chlorosis), particularly in the young developing leaves and tissues. Although glyphosate does not directly inhibit chlorophyll synthesis (the main factor in chlorosis), symptoms of glyphosate exposure can include chlorosis (Vencill 2002), probably due to the buildup of shikimate in the chloroplast (i.e., the plant cells responsible for photosynthesis). Accumulation of shikimate can alter the pH balance of the chloroplast and cause loss of membrane integrity and chlorosis (Photo 1a, 1b).[18]

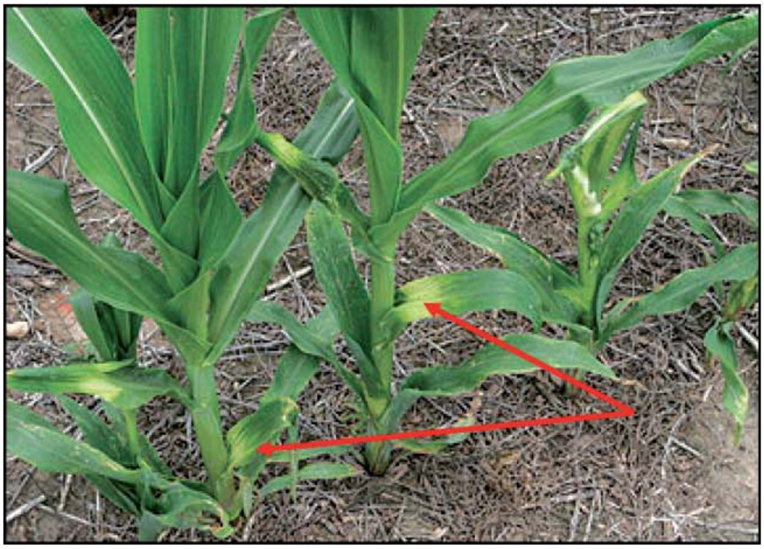
Photo 1a. Chlorosis in tomato leaves following glyphosate exposure. Symptoms occur most noticeably in new leaves closest to growing points.



[17] For example, the label for Roundup Pro (a common glyphosate formulation which contains the same amount of glyphosate per gallon as the glyphosate formulation used in Plan Colombia) gives recommended rates for control of a range of perennial weeds (64 species or genera listed) as well as numerous woody brush and tree species (over 80 species or genera listed). (See the Roundup Pro label, available at http://www.afpmb.org/pubs/standardlists/labels/6840-01-108-9578_label_roundup_pro.pdf.)

[18] Chlorosis (yellowing) is commonly observed in plants. It may be caused by a wide variety of herbicides, particularly photosynthetic inhibitors. It is also a common symptom with a variety of pest or environmental stress conditions, such as pathogen diseases and nutrient deficiency.

Photo 1b. Chlorosis in the elongation zone of corn leaves following glyphosate exposure.



Glyphosate also interferes with normal carbohydrate translocation in plants. Owing to this characteristic, glyphosate exposure can gradually produce a red or orange coloration on leaves and stems of some treated plants. This is due to the accumulation of the pigment anthocyanin, a typical symptom of an interference in carbon metabolism (Photo 2). Interestingly, anecdotal reports indicate that wildlife prefer to forage on glyphosate-treated plants. This may be due to the increased levels of carbohydrates and sugars in the foliage. In any event, this change in coloration can serve as another indicator of glyphosate exposure in some plants.

Photo 2. Glyphosate symptoms in the meristematic region of a grass species. Note injury near meristematic region and reddish coloration of leaves.

Having pointed out some of the discoloration that glyphosate exposure can produce in plants, it must be repeated that glyphosate primarily disrupts the plant's growth processes. Consequently, deformed-growth symptoms are hallmarks of glyphosate exposure in plants before they are killed by the herbicide, and in plants that have received a sublethal dose of exposure to the herbicide.

In many cases, new growth will occur (following either lethal or sublethal rates of glyphosate exposure) as the plant continues to grow using its stored growth materials. However, the effects of glyphosate will be evident in the new growth, as the developing leaves will be stunted, narrowed, and often severely distorted or puckered (photo 3a, 3b, 3c, 3d).

Photo 3a. Injury to ginseng treated with glyphosate. Note distorted appearance of plant in center compared with surrounding plants. Also note symptoms are more pronounced in newly developing leaves.

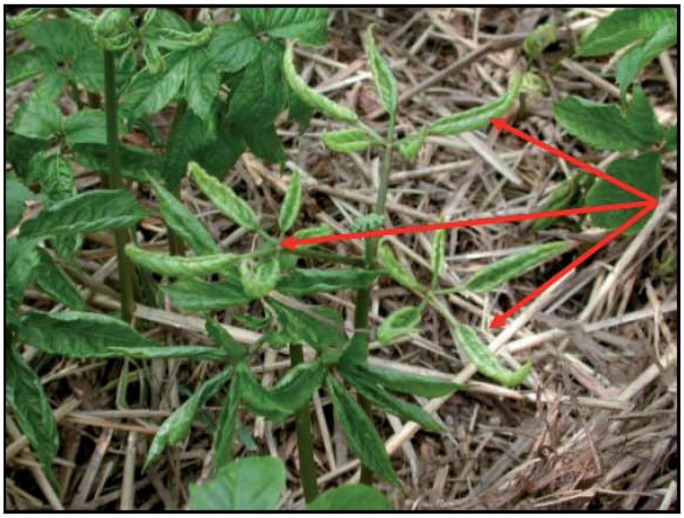


Photo 3b. Normal coffee shrub (left) compared to leaves of coffee plant treated with glyphosate (right). Note distorted and chlorotic appearance of leaves, with effects most pronounced in newly developing leaves (circled).

Photo 3c. Normal plantain (left) compared with new-growth deformity in plantain leaves following exposure to glyphosate from plants treated in Hawaii.

Photo 3d. Close-up photo of new-growth deformity in plantain leaves following glyphosate exposure.

Depending upon the type of plant and the dose of glyphosate applied, new-growth deformities may be even more striking than the examples provided above. One of the most striking is "witch's broom," a symptom observed when (1) young, developing leaves are stunted and reduced, and (2) the plant loses what is known as apical dominance (i.e., the ability to suppress the development of another stem in that region). As new stems develop, they are also stunted, and they display shortened internodes (i.e., a shortened distance between the "nodes" where buds and leaves develop). As this unregulated growth pattern continues, new growth results in an abnormal stem proliferation that resembles the twisted straw-like end of a witch's broom (Photo 4a, 4b, 4c).

Photo 4a. Depicts normal growth in coffee plant. Note regular internodes (distance between plant leaves).

Photo 4b. "Witch's broom" appearance in coffee plant following glyphosate exposure. Note severe deformity in growth caused by loss of apical dominance.

Photo 4c. "Witch's broom" appearance in peach stems following glyphosate exposure. Note severe deformity in growth at each node caused by loss of apical dominance.

The witch's broom appearance would be most common in woody plants (like coca,[19] coffee, and other trees and shrubs) and in perennials, although it would not be exclusive to these varieties. Witch's broom would also be more common in plants recovering from a sublethal glyphosate exposure (e.g., drift rates of exposure), although it can be observed following lethal rates of glyphosate exposure as well, before the plaint is eventually killed. In temperate climates, witch's broom is often most pronounced in the following growing season (as plants regenerate after dormancy), but in tropical regions with warmer temperatures and a continuous growing season, deformed re-growth like witch's broom would be evident within months of exposure to glyphosate.

In summary, the effects of glyphosate from both a lethal and sublethal application are initially similar, and often include stunting of growth, chlorosis, and abnormally developed new growth, as described above. With lethal doses, however, the symptoms caused by glyphosate's growth-disruption will progress, necrosis (browning) of tissues will occur, and growth from both above- and below-ground reproductive tissues will not recover.

- **Nature of effects on fruit.** Drift rate exposures to glyphosate are not known to adversely affect fruit. In experiments where we have exposed fruit trees to drift rates of glyphosate, it is difficult, if not impossible, for trained scientists to distinguish between treated and untreated fruit (Photo 5).

Photo 5. These pear fruit were exposed to glyphosate drift, and yet they show no distinct symptoms from drift exposure.

[19] The witch's broom symptom has even been observed in experiments where sublethal rates of glyphosate were applied to coca (Ferreira et al. 1997)

Based on my personal observations of demonstration experiments conducted at my university and a review of the relevant literature (or lack thereof), glyphosate does not produce distinctive symptoms on the surface of the fruit itself at any level of exposure. For instance, glyphosate does not cause spotting, either black or brown.

Similarly, based on my personal observations of demonstration experiments conducted at my university and a review of the relevant literature (or lack thereof), excessive exposures to glyphosate may impact fruit development (e.g., delay fruit maturity, cause a slight reduction in size of the fruit, and produce some reduction in fruit yield), but glyphosate exposure would not cause the fruit to dry up or become brittle inside, and even if it did (and it does not) it would not produce this symptom in the absence of glyphosate's more noticeable and more characteristic effects.

In my experience, "fruit drop" is not a typical symptom of glyphosate exposure, and even despite glyphosate's wide use in orchards and similar settings there is a dearth of literature discussing – much less documenting – this particular symptom. In a published scientific study with coconut (tropical species), glyphosate applied to the trunk, to the soil around the trunk, and to a combination of both did not cause fruit drop (Procopio et al. 2009). In another study (Erickson 1996), glyphosate applied by a dropper method directly to citrus fruit (a tropical and subtropical species) caused varying amounts of fruit drop. However, the application method in this study is unlike what would occur in an aerial spray/drift scenario, where the same (lethal) rate would be more broadly applied and, therefore, it would also cause the foliage to die as well as the plant's new growing points. As a general proposition, rates high enough to cause fruit-related symptoms such as fruit drop will produce severe damage to the foliage and growing points of the plant. In realistic scenarios, glyphosate could not affect fruit to the exclusion of the other parts of the plant.

- **Effects produced only after foliar application.** Glyphosate is well recognized to have no soil residual activity, meaning that glyphosate herbicides are effective only when applications are made directly to a plant's foliar/leaf surface (Giesy 2000; Williams 2000; Solomon 2007). This is because the herbicide binds tightly to soil constituents and thus is not available for uptake by plants or capable of moving through soil to groundwater. This very characteristic permits the use of glyphosate in agricultural, field-preparation settings (Williams 2000). In these applications, glyphosate is applied to fields prior to planting to clear any undesirable crops or weeds; then, only days later, the intended crops are planted in the same field, tended normally, and ultimately harvested normally without any ill effects (Sprankle 1975).

PLAINTIFFS' ALLEGED CROP DAMAGES ARE INCOMPATIBLE WITH THE KNOWN PHYTOTOXIC EFFECTS OF GLYPHOSATE, AND THEREFORE PLAINTIFFS'ALLEGED CROP DAMAGES WERE NOT CAUSED BY THE PLAN COLOMBIA SPRAY MIXTURE

In reviewing the crop damage allegations of the seven test-plaintiff families, it is clear that if their allegations have any consistency whatsoever,[20] they consistently fail to demonstrate the types of effects that would be expected from exposure to a glyphosate-based herbicide such as the Plan Colombia spray mix.

As an initial matter, the test plaintiffs uniformly claim that the herbicide was deposited in amounts sufficient to cause widespread toxic effects (including death) in their livestock, yet nearly all of the plaintiffs explain that the herbicide selectively targeted their crops in some manner or spared native vegetation. Claims such as these are completely at odds with the established mode of action of glyphosate because plant species are by far more sensitive to glyphosate than animals (to the extent animals are sensitive at all), and glyphosate is known to be a non-selective herbicide that affects all vegetation.

Likewise, none of the test plaintiffs describe the pattern of injury that would be produced by glyphosate drift. Given glyphosate's non-selective quality, in a typical drift pattern one would see injury to all plants throughout the drift zone. Therefore, if one credits the test plaintiffs' allegations, one would expect to see the effects of the herbicide across wide tracts of land, originating from the intended spray zone (in Colombia) and – in the case of many of the test plaintiffs – extending downwind several kilometers (into Ecuador) to the plaintiffs' property and, perhaps, beyond. But, none of the test plaintiffs describe this drift pattern (in fact, they typically describe injury just to their crops and not to the surrounding vegetation), nor was it depicted in any of the visual evidence (photos and videos) produced in the litigation. Furthermore, the joint Republic of Colombia and U.S. Department of State documentation on the effectiveness of the Plan Colombia aerial eradication missions (i.e., the "Verification Mission Reports") indicates a very high level of success in terms of eradicating the target crop (coca). This high success rate would not be possible in a situation where herbicide drift was significant over such a broad area. Considerable herbicide drift away from the target area would result in poor coca control at the application site, but this did not occur, further supporting my opinion that glyphosate drift away from the spray zones did not occur to any significant extent.

If one assumes that the Plan Colombia herbicide could and did reach the test plaintiffs' property, even then the effects allegedly observed in the test plaintiffs' crops are not consistent with the known phytotoxic effects of glyphosate. In many cases, the alleged timing of the development of symptoms is far too rapid to be attributed to glyphosate. In addition, the typical symptoms associated with glyphosate are not apparent in any of the videos, photos or testimony. Indeed,

[20] It is difficult to credit much of what the test plaintiffs have said, given that the test plaintiffs' allegations vary wildly from one submission to the next (e.g., questionnaire responses are often at odds with deposition testimony) and from one family member to another.

the types of effects commonly described by the test plaintiffs – for instance, descriptions of black or brown spotting on leaves and fruit, immediate leaf drop and/or fruit drop – combined with the lack of any observed growth deformation strongly indicate that none of the farms were exposed to glyphosate. Furthermore, although nearly all families indicate it was impossible to re-plant and re-grow their crops for years following the alleged exposures, it is well established that glyphosate does not have soil residual activity, and for this very reason it is frequently used in cropping systems around the world to clear/prepare fields just before planting.

Finally, although tests can detect exposure to glyphosate (through residue testing or testing for shikimate accumulation) – and certain testing was conducted at various times by local groups – I am not aware of any testing here that demonstrates that the test plaintiffs' crops were exposed to a glyphosate-based herbicide such as the Plan Colombia spray mixture.

Based upon the above, it is my overall opinion that, to a reasonable degree of certainty, the test plaintiffs' alleged crop damages were not caused by the Plan Colombia spray mixture. Brief comments on each test plaintiff family that further support this conclusion are set out below.

- **Salas Family**

  For a number of reasons, the deposition testimony[21] of the three Salas family shows that their alleged crop damages could not have been caused by the Plan Colombia spray mixture. For example:

  1. The head of the household, Jorge Salas, testified that immediately after one alleged spray event (May 2001) the "little leaves" fell from some of his crops (Dep. 43). This is not consistent with the activity of glyphosate, which does not act that quickly.

  2. Each member of the Salas family indicated that distinctive spots appeared on their plants following exposure to the Plan Colombia spray, but this symptom is not consistent with the known effects of glyphosate. For instance, while Jorge Salas testified that brown spots appeared (Dep. 43-44), his wife, Laura Sanchez, testified that no spots were observed following the initial exposure (supposedly June 2002), but then following a second exposure (supposedly Jan. 2003) the leaves contained "spots like burning" (Dep. 96). And their son, John Salas, testified that the plantains in particular showed black spots before the leaves would shrivel up and drop off (Dep. 22). Glyphosate does not cause the leaf spotting described by the Salas family's testimony. In my experience, symptoms such as these are more typical of a contact herbicide or a pathogen, not glyphosate.

[21] In light of the test plaintiffs' widely varying descriptions in terms of the amount and nature of the crop damages allegedly observed on their property, I have chosen to rely primarily upon their sworn deposition testimony.

3. The family testified that some plants did not die (e.g., Jorge Salas Dep. 46; Laura Sanchez Dep. 82-83), and yet there is no mention of the typical growth deformities (such as witch's broom in woody plants, like coffee), which are characteristic of sublethal glyphosate exposure.

4. Jorge Salas testified that none of the wild plants/grasses were affected by the supposed glyphosate/drift (Dep. 52). However, in a drift/spray scenario it is impossible for a non-selective herbicide such as glyphosate to impact only the crop plants growing on the Salas property and have no impact on the natural vegetation surrounding it. All of the surrounding plants would be expected to develop symptoms in response to glyphosate.

5. For the same reason, the photos presented by the Salas family (and discussed at their depositions) provide some of the best evidence that their crop damages are inconsistent with the effects of glyphosate. Although the photos are not of optimal quality, they clearly show effects in a single plant – or even a *part* of a single plant – rather than widespread injury or death to a broad spectrum of the surrounding plant species.

6. The Salas family also testified that the Plan Colombia herbicide adversely impacted the soil and prevented them from successfully re-planting and re-growing crops (such as rice, corn and even cacao) in the years subsequent to the alleged exposure(s). For instance, Laura Sanchez claims that after the final alleged exposure in October 2003 they did not replant crops because the land was "no longer producing" (Dep. 111). Jorge Salas claims that in 2009 – more than *six years* after that final alleged exposure – they could not produce crops on the farm, and that certain pastures are "not good anymore" (Dep. 47, 113-14). Allegations such as these are plainly inconsistent with glyphosate, which – as described above – has no soil residual activity and is therefore the most widely used, pre-planting herbicide in agricultural settings today. Likewise, it is wholly inconsistent with the known mode of action of glyphosate when Jorge Salas claims that the sprayings forced him to abandon certain (infertile) fields only to later observe that the same fields – once abandoned by him – became populated by trees and other plants of a secondary forest (Dep. 47). If glyphosate prevented future plantings of agricultural crops (and it clearly does not, due to its lack of soil residual activity), as a non-selective herbicide it would have the same effect on other non-crop seedlings, thus adversely impacting the re-vegetation that he described. In my experience, if the Salas family's crops experienced symptoms like the ones that they described, those symptoms are more consistent with poor fertilization or pathogens.

7. The Salas family's testimony concerning when they observed spray planes does not match the dates during which Plan Colombia eradication missions occurred near the Colombian border. In their deposition testimony, the family alleged exposures in December 2000 (Jorge Salas), May 2001 (Jorge Salas), June 2002 (Laura Sanchez), January 2003 (Laura Sanchez), and October 2003 (Jorge Salas

& Laura Sanchez). This is contrary to spray/flight data, which shows that there were no Plan Colombia spray missions conducted within more than 20 km of the Salas property during any of those months.

- Witness 37 **Family**

Like the Salas family, the deposition testimony from the three members of the Witness 37 family describes symptoms that are completely inconsistent with the activity of glyphosate. For example:

1. The head of the Witness 37 family, Witness 37, claims to have seen spray planes on approximately three consecutive days in 2003, and he testified that by the third day all of his plants were already dead and "falling down" (Dep. 74). In fact, Witness 37 testified that the plantain leaves "were down" and that "they got tired from the very first moment that the liquid came down" (Dep. 63-64), i.e., within 1 to 1.5 hours after the application (Dep. 64). Elaborating on this testimony, the adult son Witness 33 agrees that the plantain leaves "started to fall down, to bend down" the very same day of the alleged spraying (Dep. 29). Even the 14 year old son, Witness 37's son, indicates that all of the crops on the farm were dead after the <u>first day</u> of spraying in 2003 (Dep. 66). The rapidity of this response simply is not possible with glyphosate. Indeed, glyphosate does not produce effects at this rate in even the most susceptible plants, which are annual seedlings – and the response to glyphosate in large, perennial plants and woody species (like plantain) would be far slower yet.

2. Witness 37 testified that bananas did not regrow when replanted, and he also claims that plantains, sugarcane, yucca, cacao, and coconuts did not do well after replanting. For example, he claims that even today the crops that he grows do not produce as much or as quickly; in his words, "the earth doesn't have the same strength" (Dep. 109). Echoing the testimony of his father, Witness 33 says that after a year had passed, they replanted plantain, but it did not grow like it used to prior to the sprayings; "very little grew" (Dep. 66). Witness 33 testified that even at the time of his deposition (2009) – six or seven years after the family's claimed exposure – the crops on the family farm are not healthy or productive (Dep. 86). Contrary to claims like these, it is well known that glyphosate has no residual activity, and therefore the Witness 37 family's alleged ongoing inability to replant crops would not be caused by the activity of the herbicide.

3. Witness 37 Questionnaire response indicates that he saw a yellow oily liquid on the ground after the alleged spray events. Then, in his deposition, he testified that he saw a white oily liquid (Dep. 41). Neither could be true. Glyphosate is a water soluble solution, and its formulations would appear clear and non-oily. Furthermore, given the rate of application for the Plan Colombia spray mixture (approx. 2 ml per square meter in a direct application), it would be

difficult if not impossible to assign any characteristics to the spray, particularly in the circumstances alleged by [redacted] (drift overspray).

4. Finally, the available flight/spray data show that from September through December 2003 (i.e., "late 2003," the timeframe the [redacted] provide for their alleged exposure(s)) the closest Plan Colombia aerial eradication missions took place more than 30 km from the [redacted] property.

- **Calero Family**

The deposition testimony of the Calero family members who are test plaintiffs provides considerable evidence that their alleged crop damages were not caused by the Plan Colombia spray mixture. For example:

1. Santos Calero testified that his rice, corn, peanuts, coffee, cacao, cassava and grass all started to die (and the "leaves started falling") the day after the alleged exposure (Dep. 24). As discussed extensively above, this response is far too rapid to be attributed to glyphosate, which is a much slower acting herbicide.

2. Santos Calero's wife (Calixta Pineda) and grown daughter (Betty Calero) testified that many different crops (corn, rice, peanuts, cassava, plantain, and coffee) developed black or brown spots within two days of the alleged exposure (Calixta Pineda Dep. 19, 39; Betty Calero Dep. 30-31). Black/brown spotting is not consistent with glyphosate activity, as noted above. Furthermore, the timing in the development of these symptoms is far too rapid to be associated with glyphosate.

3. Calixta Pineda testified that following the alleged exposure, coffee bushes developed fruit, which then fell to the ground when the fruit became large (Dep. 21-22). But glyphosate is not known to cause fruit drop in aerially sprayed coffee plants or other species, nor would this be observed in the absence of other significant effects. But, conspicuously absent from her (or any other family member's) testimony is any mention of the most obvious symptoms typical of glyphosate activity: symptoms like discoloration at the plant's growing points and – particularly in woody plants such as coffee – deformed growth like the witch's broom phenomenon. Likewise, Calixta Pineda's explanation of how her coffee plants (which did not die right away) grew weaker from year to year (Dep. 39-40) is precisely the opposite of what one would expect from a sublethal dose of glyphosate. Following application, glyphosate would translocate through the plant, collect at its growing points, and exert its effects. Over time, as the plant recovered from this exposure, the glyphosate would be lost due either to degradation of the herbicide in the plant (a slow process), but more likely through loss of herbicide from the plant tissues (as affected leaves decayed and were lost). Therefore, the typical response observed in woody species like coffee is for the plant to recover over time, as less and less glyphosate would be present in the plant tissues in the days and months following a sublethal application.

4. Santos Calero claims that "at four years [after the spray event] we're able to plant again," but he goes on to say that even after four years "it doesn't give us the good product we had before. We only harvest one-quarter of the product we used to harvest" (Dep. 26). He also claims that in the intervening years they would sow the plants, but the plants would "come up yellow" (Dep. 27). However, glyphosate does not have soil residual activity, and therefore it would not detrimentally affect any crop planted mere days after glyphosate treatment, much less one to four years after treatment.

5. The testimony of the Calero family made no mention of any effects in the surrounding/native vegetation. Indeed, the color photographs provided by the Calero family were of poor quality, but from them it is evident that the surrounding vegetation is green. It is inconsistent with glyphosate activity for it to produce a quick and deadly response in the crop plants within the farm, but not in the natural vegetation surrounding the area.

6. Santos Calero essentially claims that a single spray event in August 2003 destroyed all of his crops. However, the available spray/flight data show that no Plan Colombia aerial eradication missions were conducted near his property at that time.

- **Balcazar Family**

Edgar Balcazar's claim that his family's two farms – which are located 5 km from the border with Colombia – were devastated by the Plan Colombia aerial eradication missions is completely inconsistent with the known effects of glyphosate.[22] In fact, the video footage and other visual evidence provided by Mr. Balcazar provides perhaps the best evidence that glyphosate was <u>not</u> the cause of his alleged crop damages. For example:

1. The portion of the June 14, 2001 video narrated by Mr. Balcazar opens with Mr. Balcazar explaining how the Plan Colombia spraying has totally destroyed cacao and fruit trees on his farm, which is located approximately 5 km from the Colombian border. However, this monologue is set against a backdrop of green vegetation that would be impossible if glyphosate had reached Mr. Balcazar's property via an aerial/drift application pattern in amounts sufficient to "totally destroy" his crops.

2. As another example, the video goes on to show Mr. Balcazar standing next to a cacao tree/shrub, pointing out dried cacao pods (approximately 2:10). Again, as he does this he is surrounded by greenery in the background, including trees and grasses. Furthermore, although the cacao tree/shrub he selected seems to show

[22] Mr. Balcazar was unable to testify to the date of his farm's alleged exposure to the Plan Colombia herbicide.

some dead branches, the same tree also contains far more green – apparently healthy – leaves, including healthy new growth. Assuming a drift/aerial application of glyphosate reached this cacao tree/shrub to the exclusion of the surrounding vegetation, glyphosate would not produce effects in only a few, selective branches (a more uniform response would be expected, especially in emerging growth), nor is glyphosate known to cause the type of leaf drop depicted in the video. Finally, the cacao shows none of the typical growth deformities associated with sublethal glyphosate exposure, such as witch's broom. The same can be said of the lemon (3:45), lime (4:20), and mango trees (7:05) that Mr. Balcazar selects as examples later in the video.

3. Mr. Balcazar shows some "common grass" (pasture grass, 4:55) that he claims was affected following sprayings several months prior to the date of the video (June 2001), but once again surrounding vegetation is green, including similar grasses directly behind Mr. Balcazar, and the same is true with the woody vegetation in the distance.

4. The June 14, 2001 video concludes with a news-segment style piece (7:45) that, among other things, shows "burned" or spotted cacao leaves, and blackened "rotted" cacao pods. But burned/spotted leaves are not symptomatic of glyphosate exposure, nor is the blackened fruit.

In his deposition, Mr. Balcazar describes additional effects that are inconsistent with glyphosate exposure, and therefore his deposition testimony bolsters the visual evidence described above. For example:

1. When asked to describe what happened to his cacao plants after the alleged exposure, Mr. Balcazar testified that first the flowers "fell down," and then the cacao "seed" or "bean" "got dried and fell down" (Dep. 64). Glyphosate is not known to selectively target flowers or cause fruit drop, nor would these be the first symptoms of glyphosate exposure.

2. Although Mr. Balcazar testified that not all of his exposed plants died (Dep. 65 (cacao), 67 (coffee)), in his descriptions he never mentions any new growth deformation (e.g., witch's broom appearance), which is characteristic of glyphosate exposure in recovering plants.

3. Mr. Balcazar testified that his rice was affected for three years following the spray drift due to soil contamination (Dep. 68), but this is not possible with glyphosate. Similarly, the claim that pastures replanted after the alleged drift grew "with difficulty" (Dep. 68) cannot be due to glyphosate, which has no soil residual activity.

- **Alvarez Family**

Elvia Alvarez's alleged crop damages are inconsistent with glyphosate exposure for a number of reasons. For example:

1. Glyphosate does not produce a black coloration of any kind, but Ms. Alvarez testified that the spray event(s) produced black spots in her yucca and plantain crops (Dep. 49-50). Meanwhile, there is no mention of growth deformation, which is the primary and most noticeable symptom of glyphosate exposure.

2. Ms. Alvarez testified that she cannot keep pasture "the way [she] used to. [She] plant[s] it, [she] grow[s] it, it dies" (Dep. 93). She testified that, even today (i.e., 2009, the date of her deposition), once re-planted, her pastures grow for three months and then die – and *all that is left is weeds* (Dep. 93).[23] For one, glyphosate has no soil residual activity, and therefore her claimed inability to successfully re-plant her pastures (or any other crop[24]) cannot be attributed to glyphosate. In addition, her claims only beg the question: Why would the native weeds grow and not the crop? As a non-selective herbicide, if glyphosate had any soil residual activity (and it does not) then the native plants and weeds would be equally susceptible. The symptoms she describes appear more closely related to fertility issues or pathogens.

3. The photos provided by Ms. Alvarez show an abundance of green and apparently healthy vegetation that clearly was not affected by an aerial/drift application of glyphosate.

4. Like many of the other test plaintiffs, Ms. Alvarez's property is located several kilometers from the Colombia/Ecuador border (in her case, anywhere from 3 to 7 km), and the available spray/flight data show that no Plan Colombia spray missions were conducted within at least 10 km of her property on the dates she alleges she was exposed.

- **Quevedo Family**

The deposition testimony from the Quevedo family members is not consistent with the known response of glyphosate in crops or non-crop plants. For example:

1. As is the case with all of the test plaintiffs, there is no mention of the primary symptoms of glyphosate phytotoxicity, which include growth deformation at the

[23] Ms. Alvarez goes so far to say that every time any of her plants die today, she believes it must be related to Plan Colombia spraying somewhere (Dep. 78).

[24] Ms. Alvarez also claims that for a period of six months following the April 2001 spray event nothing would grow on the farm: "During those six months I got nothing. I mean, the land was not producing, nothing would grow. We were planting, but it was not producing" (Dep. 52). Clearly this effect is not consistent with glyphosate activity because the herbicide does not have soil residual activity.

growing points – common growth effects that should be easily noticeable. The Quevedos variously mention yellowing (both the husband, Luciano Quevedo, and the wife, Rosa Altamirano), reduced yield, and death, but these symptoms, if they occurred, cannot be attributed exclusively to glyphosate or any other herbicide, for that matter.

2. The Quevedos allege that the majority of their crops were destroyed by the Plan Colombia spraying. However, when asked if the wild plants around their fields died, Ms. Altamirano testified: "A few. Just a few" (Dep. 58). Ms. Altamirano then testified that the "weak ones [died] because some are strong" (Dep. 58). It is inconsistent with the response of glyphosate for the herbicide to kill all of the crops with little or no activity on the wild vegetation.

3. Glyphosate has no soil residual activity, and therefore Ms. Altamirano's claim that even today the corn grown on her property is "not really normal" (Dep. 66) cannot be attributed to glyphosate.[25] Likewise, glyphosate could not cause Ms. Altamirano's replanted plantain to die, nor could it have caused the surviving replanted plantains to produce only "a little" (Dep. 57).

4. The Quevedo property is somewhere between 3 and 4 km from the river/border, far enough in fact that in her deposition Rosa Altamirnao admitted she's never in her life seen a Plan Colombia spray plane (Dep. 30-31).[26]

- **Mestanza Family**

The Mestanzas allege that their crops (and livestock) were devastated following four separate spray events in (1) "late 2000," (2) January 2002, (3) September 2002, and (4) October 7th and October 10th, 2002. Like the Balcazar family, Mr. Mestanza's video evidence provides the most compelling refutation of his family's claims.

The video shot in November 2002 – i.e., one month after the October 7th and 10th spray events that Mr. Mestanza claims supposedly devastated his "project"[27] – shows time and again that the Plan Colombia spray missions could not have affected his property as the family claims. Most significantly, every segment of this video demonstrates the lack of damage to the vegetation surrounding the specimens that Mr. Mestanza selected to display and discuss in front of the camera. Because glyphosate is a non-selective

[25] Luciano Quevedo's Questionnaire responses indicate that he noticed injury to pasture and coffee one year after exposure. However, this too is far too long after treatment to be due to glyphosate.

[26] Luciano Quevedo provided conflicting statements about the distance of the property from the border with Colombia, but his wife testified that it is between 3 and 4 km from the border (Rosa Altamirano Dep. 18).

[27] In his deposition, Mr. Mestanza testified that the October 2002 spray events were so devastating to his property that he believes they utilized an "extremely strong poison that the other [prior] sprayings did not use" (Dep. 177).

herbicide, if it reached the Mestanza property by a direct aerial application or by drift from an application in neighboring Colombia, it would be impossible for the effects of glyphosate to be observed only in isolated plants (or portions of plants). Rather, wide swaths of the Mestanza property would show the effects of the application, and so it is quite telling that this obviously is not the case. Some additional examples include:

1. Approximately 10 minutes into the 2002 video featuring Mr. Mestanza talking about his alleged damages, Mr. Mestanza is seen leading the cameraman through relatively dense vegetation to reach an example of a plantain plant that, according to Mr. Mestanza, was damaged from the Plan Colombia sprayings. This segment of the video is notable because of the abundance of healthy vegetation leading into and then surrounding the plantain example selected by Mr. Mestanza. Such selective effects would be impossible in an aerial/drift application scenario. As Mr. Mestanza continues the tour through his allegedly decimated orito/plantain crops, the same is true: No widespread damage is evident. Furthermore, no growth deformities characteristic of glyphosate exposure are observed.[28] In fact, it becomes increasingly evident that Mr. Mestanza's plantains were not immediately "burned" as he testified in his deposition (Dep. 76).[29]

2. Approximately 14 minutes into the video, Mr. Mestanza is explaining that an orito/plantain plant may look fine, but the Plan Colombia spray has prevented the fruit or "product" from fully maturing, and it will dry out on the inside. As noted above, glyphosate is not known to cause fruit to dry out as Mr. Mestanza claims. Moreover, if a plant is exposed to glyphosate the effects of the herbicide would be evident throughout the plant. Effects in fruit (if any) would not be the first symptom, nor would they be the only symptom of exposure.

3. Approximately 17 minutes into the video, Mr. Mestanza is explaining how the orito/plantain leaves are folded over or bending, the product is turning black, and the plants are becoming dry. Again, these are not symptoms of glyphosate exposure, and no characteristic symptoms from an alleged month-old exposure are observed. (Glyphosate does not cause black spots on fruit, and although I am not an expert in this area, this appears to be a pathogen symptom.)[30]

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[28] Like the other test plaintiffs, symptoms suggestive of growth deformation are conspicuously absent as well from Mr. Mestanza's description of his crop damages, despite the fact that this is the most characteristic symptom of glyphosate exposure.

[29] Mr. Mestanza testified that the day following the October 2002 spray event "[e]verything got burned the next day. It was as if we had set out a fire over there" (Dep. 76; Ercilia Bozquez Dep. 71). Later in his deposition, Mr. Mestanza testified that when he described the plants as "burned" he meant to say that everything turned yellow and the leaves fell off the plants (Dep. 176). Regardless of the exact manifestation of this "burning," the one-day timeline provided by Mr. Mestanza conclusively establishes that glyphosate could not have been the cause.

[30] Similarly, in his deposition Mr. Mestanza testified that following the October 2002 spray event, black spots developed on the plantain, and he stressed that the pictures discussed in his deposition attest to this

4. Approximately 20 minutes into the video, Mr. Mestanza pauses to explain that his orito/plantain and sugarcane have been most affected because they are the most sensitive to the Plan Colombia spray. However, the response to glyphosate would be far less selective, and one would certainly expect smaller crop and herbaceous non-crop plants to exhibit more drastic effects than either plantain or sugarcane. It is also interesting to note that glyphosate was initially developed as a sugarcane ripener, and so small doses of glyphosate would be expected to produce relatively beneficial effects in that crop species.

5. Approximately 25 minutes into the video, Mr. Mestanza is shown standing on the banks of the San Miguel river, explaining how the Plan Colombia planes allegedly flew over the river/border into Ecuador. As the camera pans to the left, the video clearly shows undisturbed vegetation on the Colombian side of the river, and as the camera continues its turn it reveals equally undisturbed vegetation on Mr. Mestanza's property on the Ecuadorian side of the river. If spray drift from the aerial eradication missions on the Colombian side of the river had somehow devastated Mr. Mestanza's property as he alleges, then this segment of the video – shot so close to the Colombian/Ecuadorian border – should show effects originating on the Colombian side and extending across the river onto Mr. Mestanza's property. But, it shows nothing of the sort.

6. Approximately 31 minutes into the video, Mr. Mestanza directs the cameraman to photograph bay trees that, according to Mr. Mestanza, have been practically killed by the Plan Colombia spraying. Due to video quality and distance, it is difficult to discern what, if anything, might be wrong with the bay tress, but as the camera pans out the video clearly reveals abundant greenery at the base of and surrounding the trees, which is again contrary to what one would expect if the trees had been exposed to glyphosate via an aerial/drift application.

7. Approximately 33 minutes into the video, Mr. Mestanza is showing one of the fish ponds where he claims that thousands of fish were killed by the Plan Colombia spraying only one month earlier (Dep. 79). Assuming glyphosate could adversely affect fish, plants are the most sensitive species to glyphosate, and therefore it would be impossible for the spray to reach the fish pond in an amount sufficient to wipe out Mr. Mestanza's fish and yet preserve the vegetation surrounding/adjacent to the pool. But, again, none of the plants surrounding or adjacent to the pool show any symptoms of glyphosate phytotoxicity.

8. Nearly 42 minutes into the video, Mr. Mestanza pulls up a piece of sugarcane to demonstrate the disease that goes directly to the base. Glyphosate accumulates in plants at the growing points, and therefore a sufficient dose of glyphosate should

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(Dep. 147-48). Although the pictures do depict necrotic/black lesions on the plantain, this is not characteristic of glyphosate exposure, and so his testimony and the exhibits do not support his claim.

produce symptoms at the top of the plant rather than at the base of the stem (called a culm in grasses)

9. Approximately 43 or 44 minutes into the video, Mr. Mestanza is pointing out fruit trees (which appear to be lime trees, once again surrounded by fully green and apparently healthy trees contrary to what one would expect from an aerial/drift exposure) that according to him have been affected by the Plan Colombia spray. Mr. Mestanza says that the fruit appears on the tree, but then it dries up and drops to the ground. This does not appear evident in the video, and in any event the fruit drying/drop that he describes is not a symptom of glyphosate treatment. More importantly, although the quality of the video is poor, the trees seem to show new growth that does not appear to exhibit any growth deformities, which would be characteristic of glyphosate exposure.

10. Finally, at approximately 45 minutes into the video, the segment closes with a panoramic shot across Mr. Mestanza's property. This scene depicts animals moving about, green grasses, green trees, etc., and no damage (much less the type of widespread devastation testified to by Mr. Mestanza and his family) indicative of an aerial/drift application of glyphosate.

In a video dated August 2009, Mr. Mestanza generally attempts to depict the effects of glyphosate on his property seven years after the last alleged spray event. In the video (approximately 3:35), for instance, he claims that coconut trees planted two years after the final alleged spray event show the lasting effects of glyphosate exposure. However, persistent effects like this cannot be associated with glyphosate, which has no soil residual activity.[31] Furthermore, the video shows lush greenery in nearly every direction the camera turns. Of course, this would be impossible with glyphosate even if it had soil residual activity because it is a non-selective herbicide, and so all of the plants on the Mestanza property would be affected, not simply the random examples on Mr. Mestanza chose to focus in the video.

[31] In his deposition, Mr. Mestanza testified that the "poison" is still in the soil because, although native plants grow, their leaves fall off (Dep. 177). Mr. Mestanza also testified that two years after the October 2002 spray event he planted 10 hectares of coconut which grew but then died (Dep. 80-81). And he testified that he planted African palm after the alleged exposures that, despite his attempts to fertilize the crop, grew well but died when "they were supposed to give fruit" (Dep. 178). Allegations such as these are inconsistent with glyphosate, which does not have soil residual activity, and even if it did, the mode of action (growth disruption) would mean that the plants would not grow well and then suddenly lose leaves or die during the reproductive stage as Mr. Mestanza alleged.

THE EXPERT REPORT SUBMITTED BY DR. WOLFSON ON BEHALF OF THE TEST PLAINTIFFS IS INCORRECT IN SEVERAL OF ITS FUNDAMENTAL ASSUMPTIONS

Plaintiffs' expert, Dr. Michael Wolfson, opines that the herbicide spray mixture used in Plan Colombia is contrary to the manufacturer's label for Roundup Ultra because of the addition of Cosmo-Flux and because of the concentration of Roundup in the spray mixture. This opinion is simply wrong, and it demonstrates Dr. Wolfson's lack of understanding of the Roundup Ultra label (and herbicide labeling in general) and the well-accepted usages of Roundup-based herbicides.

The addition of Cosmo-Flux to the Plan Colombia spray mixture. The report submitted by Dr. Wolfson quotes the Roundup Ultra label[32] and concludes that the Plan Colombia spray mixture "fails to follow [the] manufacturer's label directions for the use of this [Roundup] herbicide" because the spray mixture contains Cosmo-Flux in addition to the specified glyphosate formulation (Wolfson Rpt. 3). Dr. Wolfson appears to completely misunderstand the meaning of the manufacturer's statement in the Roundup Ultra label that a surfactant need not be added to Roundup Ultra. Dr. Wolfson presents this statement as a requirement of safe use, but it is in fact only an optional statement that EPA allows the manufacturer to include in the label in describing its herbicide product. In my experience, manufacturers often include statements in the product labeling like that highlighted by Dr. Wolfson to remind the user that Roundup formulations already include a surfactant and to suggest (subtly or not) that it is unnecessary to purchase additional surfactants and additives (from other chemical manufacturers) to effectively control weeds or other undesired plants.

Dr. Wolfson's flawed interpretation is made clear both by the placement of the quoted language in the product label and the EPA's treatment of the language in its approval of the product label. The language quoted by Dr. Wolfson is found in the "Product Description" section of the labeling, not in the section of the label discussing potential product hazards or user precautions. The language thus appears in the same section of the label in which the manufacturer states, for example, that the product is a "non-selective" herbicide, is "water-soluble," and "may be applied through most standard industrial or field-type sprayers." The language regarding surfactants is not required by EPA (as it would be if based on any safety concern) but rather, as explained in the EPA-approved master label[33] for Roundup Ultra (and several other glyphosate formulations registered under the same number), it is merely permitted by EPA at the option of the manufacturer:

> **Product Description:** This product is a postemergence, systemic herbicide with no soil residual activity. It is non-selective and gives broad-spectrum control of many annual weeds, perennial weeds, wood brush and trees. It is formulated as a

[32] Dr. Wolfson points out that the Roundup Ultra labeling includes the following statement: "Do not add surfactants, additives containing surfactants, buffering agents or pH adjusting agents to the spray solution when Roundup Ultra herbicide is the only pesticide used" (Wolfson Rpt. 3).

[33] The Master Label for Roundup Ultra, EPA registration number 524-475 (and several other glyphosate formulations registered under the same number) is available via a search of EPA's Pesticide Product Labeling Database, at http://oaspub.epa.gov/pestlabl/ppls.home.

water-soluble liquid. It may be applied through most standard industrial or field sprayers after dilution and thorough mixing with water or other carriers according to label instructions.

OPTIONAL STATEMENT: No additional surfactant in the spray solution is needed. This includes additives containing surfactants, buffering agents or pH adjusting agents when [**INSERT BRAND NAME**] is the only pesticide used unless otherwise directed.

Ammonium sulfate, drift control additives, or dyes and colorants may be used. See the "MIXING" section of this label for instructions.

Dr. Wolfson's suggestion that there is a labeled directive that surfactants not be added to Roundup Ultra is also completely contrary to the real world use of that product. It is common to add another surfactant to Roundup Ultra or other formulations of glyphosate. For example, in a study by Ferreira et al. (1997) for the control of coca, they added 0.25% of a non-ionic surfactant called Induce to their Roundup formulation. Similarly, the US Department of Agriculture conducted studies to identify the type of surfactant that *should be added* to Roundup as part of the Plan Colombia spray mixture (Collins & Helling 2002). Furthermore, university scientists and PCAs (Pest Control Advisors) often recommend the addition of buffers and pH adjusters to glyphosate formulations when the water carrier is very alkaline.

The concentration of Roundup in the Plan Colombia spray mixture. Dr. Wolfson's opinion that "the coca spray mix contains concentrations of Roundup that greatly exceed concentrations recommended by the manufacturer" (Wolfson Rpt. 3) is also incorrect. To the contrary, the rates used in Plan Colombia are precisely those reported to be effective on coca in published literature (Ferreira et al. 1997). And, as certified by the United States Department of State: "Th[e] application rate is within the glyphosate manufacturer's recommendations for both the amount of concentrated formulation per acre and the amount of total spray volume per acre for wood plants and hard-to-control species. Coca is a hardy, woody bush that falls into this category." (U.S. Dept. of State Report to Congress, 2002).

Dr. Wolfson's incorrect opinion appears to be based upon the statement in the Roundup Ultra label that "*unless otherwise specified*, Roundup Ultra should be used at a rate of 1 quart per acre," which would be mixed with between 3 to 15 gallons of water to allow for the transport of the herbicide to the plant surface. Dr. Wolfson fails to recognize, however, that the recommended concentration of Roundup Ultra for use against woody plants (like coca) *is otherwise specified* in the label. Immediately below the sentence upon which Dr. Wolfson relies, the label refers the user "to the individual use area sections of this label for recommended volumes, application rates and further instructions." The "WOODY BRUSH AND TREES RATE TABLE" begins at page 14 of the Roundup Ultra label, and the label there sets forth Roundup Ultra application rates ranging anywhere from 2 to 5 quarts/acre in a variety of woody plant species. Roundup (which comprises 44% of the Plan Colombia spray mixture, as Dr.

Wolfson points out) is aerially applied to coca at a rate of 4.45 quarts/acre, and therefore the application is within the labeled rates for the product.[34]

Dr. Wolfson's linking of the recommended concentration levels of Roundup to his opinions on human toxicity demonstrates a further misunderstanding of the product label. The recommended concentration rates in the label are designed to provide instructions on the effective use of the product against different plant species; they have nothing to do with potential exposures to humans. Indeed, it is fully recognized and expected that the human users of the product will be exposed to a 100% concentration of Roundup when they are handling or mixing the product before using it in the field. Moreover, while only 1 to 5 quarts of Roundup Ultra should be applied to any given acre for optimal plant control, the same human applicator would be expected to apply the herbicide over numerous acres. Dr. Wolfson's suggestion that the test plaintiffs were therefore "subjected . . . to concentrations of … glyphosate and POEA, which were apparently never contemplated by the manufacturer of Roundup" (Wolfson Rpt. at 3) is also wrong.

Dated: 1-20-2011

Joseph M. DiTomaso

Joseph M. DiTomaso

CR Note: Dr DiTomaso's CV (Exhibit A), found in CD - Original Annexes

[34] Dr. Wolfson also notes that the Roundup Ultra label directions include the following statement: "DO NOT APPLY THIS PRODUCT USING AERIAL SPRAY EQUIPMENT EXCEPT UNDER CONDITIONS AS SPECIFIED WITHIN THIS LABEL." To the extent Dr. Wolfson believes that the aerial application of the Plan Colombia herbicide is in some way inappropriate under the label, he is again incorrect. The Roundup Ultra label not only clearly specifies that aerial applications can be conducted by fixed wing airplane or helicopter, but it also indicates the rates and volumes that the herbicide can be applied. Applications made in Plan Colombia were within the specifications of the label, as noted above.

EXHIBIT B
(Materials Considered)

Publications

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Other Materials Considered

1) Joint Mission Verification Reports of Flights in Colombia by USDS and Colombia National Government: 10th-13th and 15th-19th Reports

2) Cosmo-Flux Safety Information Sheet (Cosmoagro 2003)

3) Master Label for Roundup Ultra, EPA registration number 524-475, available via EPA's Pesticide Product Labeling Database)http://oaspub.epa.gov/pestlabl/ppls.home)

4) Roundup Pro label available at Armed Forces Pest Management Board website (http://www.afpmb.org/pubs/standardlists/labels/6840-01-108-9578_label_roundup_pro.pdf)

5) Relevant videos available at Weed Science Society of America website (http://wssa.net/Weeds/Tools/Herbicides/Herbicide Movies.htm)

6) Glyphosate/SureGuard time lapse video available at YouTube website (http://www.youtube.com/watch?v=zdJTtrvkGWg)

7) Glyphosate usage rates available at California Department of Pesticide Regulation website (http://www.cdpr.ca.gov)

8) Test Plaintiff Depositions

9) Binders for each Test Plaintiff family, provided by defense counsel, including:

    a. A table with citations to claims of crop damages in certain evidentiary submissions of the test plaintiffs (initial disclosures, questionnaire responses, declaration of Marco Campana, deposition testimony excerpts, Accion Ecologica toxicology sheet and survey)

    b. the following information for each test plaintiff (if applicable to the test plaintiff and/or family):

        i. initial disclosure

        ii. questionnaire responses

        iii. excerpt from the Marco Campana declaration specific to each plaintiff

        iv. all deposition testimony excerpts re alleged crop damages

        v. other test plaintiff-specific information relating to their alleged crop damages (e.g., testimonials, photographs and/or video, etc.)

vi. excerpts of certain non-governmental organization and other third party reports that mention the test plaintiffs or the areas in which they live with respect to crop damages or related issues

vii. a map showing the approximate location of the test plaintiffs' farm and spray lines (if any) for the dates of spray exposure alleged by any of the family members in their depositions

10) Expert report prepared by Plaintiffs' expert, Dr. Michael A. Wolfson

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EXHIBIT C

(Table 1)

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Table 1. Household products available with glyphosate as the sole active herbicide or in combination with other herbicide product or products.

Manufacturer	Trade name of product	Glyphosate as sole active ingredient (AI) or in combination with another AI*
Ace	Ready-to-Use Weed & Grass Killer 2	Sole AI
	Concentrate Weed & Grass Killer	Sole AI
Bayer Advanced, LLC	Bayer Advanced Garden Power Force Kills Weeds Fast Grass & Weed Killer RTU	Sole AI
Bonide Products, Inc.	KleenUp Grass & Weed Killer	Sole AI
	Orchard Est. 1931 Grass & Weed Killer Concentrate	Sole AI
	Orchard Grass & Weed Killer Ready-to-Use	Sole AI
Chemisco	Ultra-Kill Weed & Grass Killer and America's	Sole AI
	Groundskeeper 41% Glyphosate Concentrate	Sole AI
	Shoot Out Weed & Grass Killer Concentrate	Sole AI
Enforcer Products	Enforcer Roots & All Ultimate Grass & Weed Killer RTU with 1.92% Glyphosate	Sole AI
Excel Marketing	Easygone Super Concentrate 41% Weed & Grass Killer	Sole AI
Green Light	Green Light Com-Pleet Systemic Grass & Weed Killer	Sole AI
	Green Light Com-Pleet 41% Systemic Grass & Weed Killer 2	Sole AI
Gro Tec, Inc.	Eliminator Weed & Grass Killer II Ready-to-Use	Sole AI
	Eliminator Weed & Grass Killer Super Concentrate and	Sole AI
	Maxide Ready-to-Use Weed & Grass Killer II	Sole AI
Lawn and Garden Products	Remuda Full Strength	Sole AI
	Monterey Remuda Plus	Combination with other AIs (contact herbicide)
Monsanto	Roundup Weed & Grass Killer Ready-to-Use Plus	Combination with other AIs (contact herbicide)
	Roundup Concentrate Poison Ivy & Tough Brush Killer Plus	Combination with other AIs (contact herbicide)
Monsanto Co. Lawn & Garden Products	Roundup RTU Poison Ivy & Tough Brush Killer 3	Sole AI
	Roundup Weed & Grass Killer Super Concentrate	Sole AI
	Roundup Ready-to-Use Poison Ivy & Tough Brush Killer Plus	Combination with other AIs
	Roundup Poison Ivy Plus Tough Bush Killer Ready-to-Use	Combination with other AIs
	Roundup Poison Ivy Plus Tough Brush Killer Concentrate	Combination with other AIs
	Roundup Weed & Grass Killer Concentrate Plus	Combination with other AIs
	Roundup Concentrate Extended Control Weed & Grass Killer Plus Weed Preventer	Combination with other AIs (contact herbicide)
	Roundup Ready-to-Use Extended Control Weed and Grass Killer Plus Weed Preventer	Combination with other AIs
	Roundup Ready-to-Use Extended Control Weed & Grass Killer Plus Weed Preventer II	Combination with other AIs
Ragan and Massey, Inc.	Compare-N-Save Grass & Weed Killer 41% Glyphosate+	Sole AI
Solaris Group	Basic Solutions Weed & Grass Killer Concentrate	Sole AI

The Ortho Group	Ortho Season-Long Max Grass & Weed Killer Plus Preventer RTU Concentrate	Sole AI
	Total Kill Brand Weed & Grass Killer Super Concentrate	Combination with other AIs
	Ortho Groundclear Complete Vegetation Killer Concentrate	Combination with other AIs
	Ortho Groundclear Vegetation Killer Concentrate	Combination with other AIs
	Ortho Groundclear Vegetation Killer Ready-to-Use	Combination with other AIs
	Total Kill Brand Weed & Grass Killer Ready-to-Use	Combination with other AIs (contact herbicide)
	Ortho Season-Long Grass & Weed Killer RTU	Combination with other AIs (contact herbicide)
	Ortho Season Long Max Weed & Grass Killer Plus Preventer Concentrate	Combination with other AIs (contact herbicide)

* Because glyphosate is a relatively slow acting herbicide, homeowner formulations often contain an additional fast-acting contact herbicide to give homeowners a more immediate result and the sense that the formulation is working quickly.

Annex 10

Expert Report of Dr K.R. Solomon, Ph.D. on Behalf of the Defendants in *Arias/Quinteros v. Dyncorp*, 18 January 2011

(United States District Court for the District of Columbia,
Cases No. 1:01-cv01908 (RWR-DAR) and 1:07-cv01042 (RWR-DAR).
Cases consolidated for Case Management and Discovery)

EXHIBIT 13

EXPERT REPORT OF KEITH R. SOLOMON ON BEHALF OF THE DEFENDANTS IN *ARIAS/QUINTEROS V. DYNCORP*

1 Credentials and Disclosures

1.1 Expert Credentials

My name is Keith R. Solomon. I am an Emeritus Professor in the School of Environmental Sciences at the University of Guelph, where I have served as a member of the faculty for over thirty years. I have a BSc degree in Chemistry and Zoology (Hons) from Rhodes University (1967), MSc degrees in Zoology and Entomology from Rhodes University (1971) and the University of Illinois (1973) respectively, and a PhD in Entomology from the University of Illinois (1973). I have more than 40 years of experience in research and teaching in pesticide science and toxicology and have contributed to more than 350 scientific publications and reports (more than 240 in the peer-reviewed literature) in the fields of pesticides, environmental toxicology, and risk assessment. I am a member of the Society of Environmental Toxicology and Chemistry, the American Chemistry Society (Agrochemistry), and the American Association for the Advancement of Science. I am the recipient of the 1993 Society for Environmental Toxicology and Chemistry-ABC Laboratories award for Environmental Education, was elected as a Fellow of the Academy of Toxicological Sciences in December 1999, and am a recipient of the 2002 American Chemical Society International Award for Research in Agrochemicals. In 2006, I was awarded the SETAC Europe Environmental Education Award and the Society for Environmental Toxicology and Chemistry Founders Award. I have served on and provided expertise on pesticides via advisory panels to the US EPA, the Institute of Life Sciences, the Pest Management Regulatory Agency in Canada, and various panels in Europe. A book of which I am a co-author, Pesticides and the Environment, has been translated into Spanish and Portuguese and is distributed worldwide. In addition, I have been asked for advice, written reports, and testified at permitting hearings related to the use of glyphosate in forests and rights of way in Canada.

Prior to 2003, my research into the use and effects of glyphosate herbicides in the environment resulted in two publications, "Giesy JP, Dobson S, Solomon KR. 2000. Ecotoxicological Risk Assessment for Roundup® Herbicide. *Reviews in Environmental Contamination and Toxicology* 167:35-120" and "Solomon KR, Thompson DG. 2003. Ecological Risk Assessment for Aquatic Organisms from Over-water Uses of Glyphosate. *Journal of Toxicology and Environmental Health B*, 6:211-246." A complete listing of my publications over the last 10 years and a more complete discussion of my expert credentials are set forth in my curriculum vitae, attached hereto as Exhibit A.

In 2003, I was contacted by the Inter-American Drug Abuse Control Commission ("CICAD") section of the Organization of American States ("OAS") to serve as the lead investigator on an independent Scientific Assessment Team ("SAT") for what became a series of studies investigating the potential environmental and human health impacts of the herbicide spray mixture used in the Plan Colombia aerial eradication operations. These studies, each of which were subsequently submitted to the OAS and published in the scientific literature, are described and discussed in this expert report (Solomon et al. 2007b, Solomon et al. 2007a, Solomon et al. 2009, Solomon and Marshall 2009, Bernal et al. 2009b, a, Brain and Solomon 2009, Bolognesi et al. 2009, Marshall et al. 2009, Sanin et al. 2009). The complete titles of these cited works and of the other materials cited through the body of this expert report are set out in the References section immediately following the text of this report. Other materials which I reviewed are set out in Exhibit B of this report.

1.2 Compensation and Prior Expert Work

I am being compensated for my work in this matter at a rate of $250 per hour. I have not served as a testifying expert in any other litigation during the past 4 years.

1.3 Sources, Facts and Data Considered in Connection with my Expert Report

The sources considered in connection with my expert report are the books, chapters, reports, and papers cited herein and in the References section immediately following the text of this report. Additional facts and data obtained during my work with the SAT that I considered in rendering my opinions in this case are summarized in the text of this report.

2 Summary of My Opinions

I am generally familiar with the allegations made by the Ecuadorian plaintiffs in this litigation. Based upon the extensive analyses conducted from 2003-2009 by myself and by CICAD expert teams that I supervised, as well as the broader scientific literature regarding glyphosate, formulated glyphosate (Roundup®) and Cosmo-Flux®, it is my opinion that there is no valid scientific basis upon which one could opine that Plan Colombia aerial eradication operations could have caused the adverse human health effects, animal deaths, and off-target crop damage that the plaintiffs allege.

3 CICAD's Formation of an Independent Scientific Advisory Team Under My Leadership to Investigate the Alleged Environmental and Health Risks of Plan Colombia's Aerial Eradication Operations

In the summer of 2003, I was contacted by CICAD to participate in an independent analysis of the Plan Colombia spraying operations. This initial telephone call was followed by a meeting in OAS HQ in Washington DC on August 5, 2003. At this meeting, I was interviewed by David Beale and other members of CICAD. I was told that I had been selected for the interview after an extensive search of the scientific literature and that several other candidates had been considered for membership, as well as the chair, of the Scientific Assessment Team (SAT). Following this interview process, I was offered the position of chair of the SAT, which position I accepted.

My original charge from CICAD was as follows:

1. To serve as leader/coordinator of the SAT.

2. To prepare and submit to CICAD an Operational Plan that would guide the work of the SAT. The operational plan would include a budget and cost estimates, milestones and timelines, and methodologies required to execute a study of the potential risks of environmental and health effects from the Plan Colombia spraying operations.

3. To identify, interview and select the individual members of the SAT, based on the needs identified to properly undertake the risk assessment.

4. In collaboration with the other members of the SAT, to coordinate the formulation and development of a scientific protocol to guide the Operational Plan for the requested risk assessment.

5. To gather information and scientific literature available on aerial spraying of glyphosate (including any glyphosate spray mixture used in the Colombia Program) from all possible sources.

6. To establish a Permanent Technical Mobile Monitoring Group (PTG) in Colombia capable of periodic random evaluations and on-site investigations of specific allegations and controversies relating to the Plan Colombia spraying operations, as directed by the SAT.

7. To be responsible for publicly presenting and defending the results and conclusions of the Evaluation after the work has been completed. There were to be no public comments from the SAT Coordinator or Team unless otherwise approved by CICAD. Results would be presented to the international press, media and all other organizations interested in the Evaluation. Presentations would be made in Colombia and the United States and possibly in Europe.

8. To conduct at least four on-site visits to Colombia to areas that had been the subject of the Aerial Spray Program.

9. To provide quarterly reports on the progress of the study to CICAD.

10. To provide the Final Report of the risk assessment by October 15 of 2004 to CICAD. The report was to be prepared in English and Spanish in both hard copy and electronic format.

Because of the political sensitivity of the allegations that had been made regarding the Plan Colombia aerial eradication operations and to ensure both the fact and appearance of independence, CICAD decided that all members of the SAT would have to be from countries other than the United States and Colombia. The members of the team were selected based on CICAD's initial search of the relevant scientific literature and my own personal knowledge of specific individuals. The final team consisted of the following five scientists:

Dr. Keith R Solomon, University of Guelph, Canada – Ecotoxicology and risk assessment.

Dr. Arturo Anadón, Universidad Complutense de Madrid, Spain – Mammalian toxicologist.

Dr. Antonio Luiz Cerdeira, EMBRAPA, Brazil – Technology of application of herbicides and their fate in tropical regions.

Dr. Jon Marshall, Marshall Agroecology Limited, UK – Agroecologist and expert on the use of pesticides in management of pests.

Dr. Luz-Helena Sanin, University of Toronto, Canada – Epidemiology and expert on the effects of pesticides in humans.

The SAT operated independently of the US and Colombian governments (and of the U.S. State Department contractor DynCorp). None of these entities had input or editorial control of the reports of the SAT, except insofar as various reports published by the governments of the Colombia and the United States were used as references, where appropriate. No specific information was provided to the SAT by DynCorp except in the course of visits to Colombia, when the SAT met with various DynCorp employees engaged in the operations in Colombia and asked them technical questions about the mechanics of the aerial eradication program.

4 The Scientific Advisory Team's Work in Conducting the 2005 Risk Assessment of the Plan Colombia Herbicide Spraying

The process used by the SAT to address the charge given by CICAD is illustrated in (Figure 1) and is discussed in more detail below.

4.1 Review of existing scientific studies, government regulatory assessments, verification reports, and damages claims regarding the Plan Colombia herbicide spray mix

Glyphosate is one of the most widely-used herbicides in the world, and there were many existing studies of its potential toxic effects, as well as risk assessments conducted for the purposes of registration, including, *e.g.*, the US EPA's Reregistration Eligibility Decision documents (USEPA 1993 *et seq.*). Most of these studies and assessments were conducted in connection with the active ingredient and/or glyphosate formulations available in the United States. The spray program in Colombia made use of a generic formulation of glyphosate sold in Colombia. This formulation contains glyphosate (IPA) as the active herbicidal ingredient and a surfactant (ethoyxylated tallowamine or POEA) to aid in penetration into the leaves of target plants. The proportion of the POEA in the spray mixture is slightly less than the 15% (Edginton et al. 2004) found in commercial formulations of glyphosate used in the US (discussions with the Instituto Colombiano Agropecuaria (ICA)). In addition to this generic formulation, an adjuvant, Cosmo-Flux – which is frequently added to a variety of other pesticides in Colombia as well – is mixed with the glyphosate to improve efficacy. Cosmo-Flux is an agricultural adjuvant containing non-ionic surfactants (a spray mixture of linear and aryl polyethoxylates – 17% w/v) and isoparaffins (83% v/v) (Cosmoagro 2004).

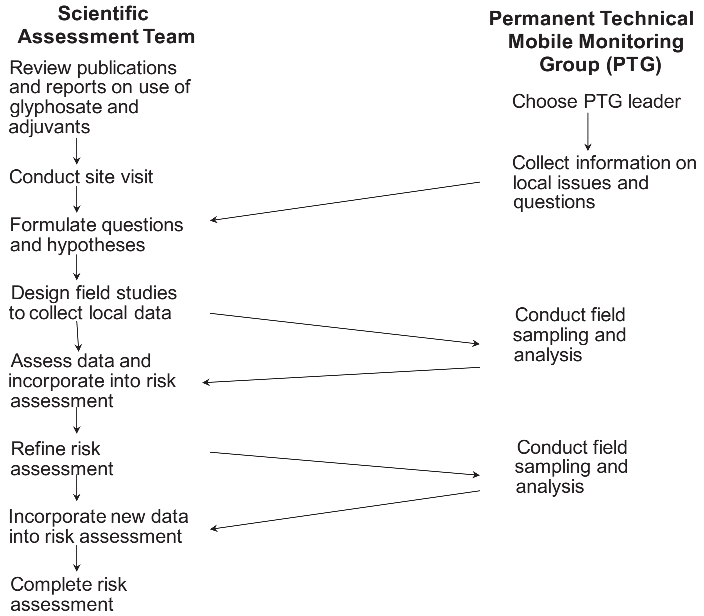

Figure 1. The process used by the SAT

As an initial step in its assessment, in addition to reviewing the general literature regarding glyphosate and formulated glyphosate, the SAT reviewed the following sources of information regarding the Plan Colombia herbicide spray mixture used in the aerial eradication operations in Colombia.

4.1.1 Mammalian toxicity studies of the Plan Colombia herbicide spray mixture conducted for the U.S. and Colombian governments

Two series of mammalian toxicity tests had been conducted on the formulation of glyphosate and Cosmo-Flux used for eradication of coca in Colombia. One set of studies was conducted for the United States Department of State under good laboratory practices (GLP) and using the quality control assurance as appropriate for regulatory decision making (Springborn 2003b, c, e, f, d, g, a - Springborn studies). The other set of studies was conducted for the Colombian government, also in compliance with GLP and according to US EPA guidelines (Immunopharmos 2002g, e, f, d, h, i, j, a, c, b - Immunopharmos studies). Both series of mammalian studies employed generally accepted methodologies and are of the type relied upon by experts in the field in assessing the toxicity of a test substance. The mammalian studies assessed acute oral toxicity, acute inhalation toxicity, acute dermal toxicity, skin irritation, eye irritation, and skin sensitization. Based on the review of the results of these studies, the SAT reached the following conclusions:

- The acute oral and dermal LD50 value of the Plan Colombia herbicide spray mixture was estimated to be greater than 5,000 mg/kg body weight in rats. In other words, it was not possible to observe toxicity, even at the greatest dose tested. The greatest dose tested (5,000 mg/kg) is equivalent to more than 350,000 mg in a 70 kg adult (3/4 of a pound in a 150 lb adult human). Therefore, the Plan Colombia herbicide spray mixture was found to be practically non-toxic by the oral and dermal route.

- The acute inhalation LC50 value of the Plan Colombia herbicide spray mixture was estimated to be greater than 2.60 mg/L in rats. In one study, rats showed breathing abnormalities after exposures at 2.6 mg/L for 4 hours. In two other studies, the spray mixture was shown to not be harmful at exposures up to 20 mg/L for 4 hours. Based upon these LC50 values, which show that the spray mixture is less toxic than common bathroom cleaners and air fresheners (S C Johnson 2008, 2009a, b, c), the acute toxicity of the Plan Colombia herbicide spray mixture is classified as "non-hazardous".

- The Plan Colombia herbicide spray mixture was found to be a slight and moderate irritant to the skin and eyes of rabbits, respectively, with a calculated Primary Irritation Index for the spray mixture of 0.25. The eye irritation finding is similar to the irritation caused when shampoo gets into a person's eyes.

These studies demonstrated that the hazards to humans and other mammalian life via application or bystander exposures to the Plan Colombia herbicide spray mixture were limited to slight to moderate skin and eye irritation from direct exposures, which could be resolved if the affected areas were rinsed with water shortly after exposure. Moreover, by comparing the study results to similar studies from the literature and for registration purposes conducted solely on formulated glyphosate (Roundup) (referenced in Solomon et al. 2005), it was shown that the addition of the adjuvant Cosmo-Flux to the glyphosate formulation used Colombia did not change its toxicological properties to mammals.

4.1.2 United States and other government regulatory analyses and findings for glyphosate and for the Plan Colombia herbicide spray mix

Extensive testing is required for pesticides to be registered for use in the United States and most other countries (Stephenson and Solomon 2007). This testing comprises detailed information on the product chemistry, toxicology to mammals, metabolism, environmental chemistry, and toxic effects on aquatic and terrestrial animals and plants. These tests must be carried out under Good Laboratory Practice (GLP) guidelines with Quality Assurance (QA) and the full and complete reports must be submitted to regulators for a detailed and critical review. In the United States, the Environmental Protection Agency ("USEPA") issues a Registration Eligibility Decision (RED) for approved pesticides, which is updated at regular intervals or when changes in use of the product are proposed.

The USEPA has repeatedly approved glyphosate for use in the United States and has concluded that glyphosate has low toxicity to humans and animals.(USEPA 1993, 1997, 1998b, 1999, 2000). Similar conclusions have been reached in other jurisdictions (NRA 1996, World Health Organization 1994).

The United States Department of State ("DOS") has consulted with USEPA on the safety of the specific herbicide spray mixture used in the Plan Colombia aerial eradication operations. USEPA concluded that the application rate being used in the aerial eradication operations was within the manufacturer's label, that the spray mixture was unlikely to cause adverse effects to humans or to terrestrial or aquatic animals, and that there was no evidence of significant human health or environmental risks from the spraying (USEPA 2004). The United States Department of Agriculture ("USDA") likewise has advised DOS that "it is USDA's determination that the risks involved in using glyphosate with commercially available adjuvants for narcotics eradication are minimal" and that "no unreasonable risk to non-target plant or animal species have been detected" from the aerial spraying in Colombia (USDA 2002).

4.1.3 Plan Colombia aerial eradication verification missions conducted by the U.S. and Colombian governments and findings of minimal off-target impacts

Each year, on-site verification missions are conducted by a team of scientists and specialists from the U.S. and Colombian governments to review the efficacy of the Plan Colombia aerial eradication spray operations. Because not all spray sites can be visited, a statistically derived sub-sample is selected from across the country and these sites are visited from the air and sometimes on the ground. Photographs and visual observations are used to assess the efficacy of the spraying operations in eradicating coca and to look for evidence of off-target damage that would be indicative of drift or other off-target deposition of herbicide. The resulting data are summarized in reports that are provided to the relevant governmental agencies in the United States and Colombia (*see e.g.*, Helling 2003).

Based upon the findings in these verifications missions, the SAT estimated that off-target impacts from Plan Colombia spraying were minimal, constituting less than one-half of one percent of the total area sprayed (see Figure 2). Moreover,

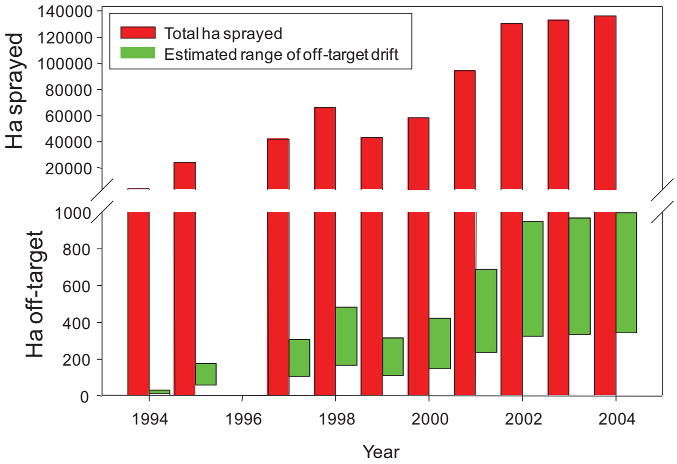

Figure 2. Areas of coca sprayed and areas affected by off-target deposition

from the SAT's direct observations as guests on verification missions, the SAT concluded that damage caused by off-target deposition of the spray was generally limited to small areas of vegetation at the start and at the end of the spray swath, within meters of the targeted coca fields. This type of off-target deposition is indicative of too early initiation of the spray or continuation of the spraying for too long a time rather than drift of the herbicide spray.

4.1.4 Allegations that Plan Colombia aerial eradication operations had caused property damage and personal injuries

The SAT also reviewed allegations that had been made by individuals in Colombia claiming damage as a result of the spraying operations. Pursuant to Colombian law, the Colombian government has set up a claims process whereby individuals can seek compensation for alleged damages to crops, animals, and humans from spraying operations.

With respect to crop damage, the SAT was informed that when a complaint is lodged, the spray data (date, time and location as recorded by the GPS systems on board the spray planes) are reviewed, and if the date and location of the alleged damage were consistent with the spray data (<100 m difference) and if an on-site team then confirmed the damages to lawful crops, compensation was provided. Because the Plan Colombia herbicide spray mixture would be expected to cause damage to lawful crops that might be accidently sprayed, the SAT did not analyze these data.

The SAT did seek to analyze data submitted with respect to claims of alleged adverse effects in humans (and animals) arising from the spraying operations, both as submitted to the Colombian government and as reported in news-media or on websites of various interest groups. In reviewing these claims, however, the SAT found that the reports of these events were all anecdotal, that there was no documentation or measures of exposure to spraying operations, and that, with the possible exception of minor short-term skin- or eye-irritation, the allegations were inconsistent with the scientific research and the documented toxicological profiles of glyphosate and the Plan Colombia herbicide spray mix. Because it was not possible for the SAT to verify the accuracy of these reports or to analyze them in a scientific manner, the SAT concluded that the reports did not provide any scientific data that could be used in its assessment.

4.2 Visits to Colombia to understand the aerial eradication program

From the beginning of the process, it was recognized that the SAT would need to visit Colombia to observe firsthand how the coca fields were identified, how the herbicide was applied, and the locations and habitats where the spraying occurred. The first site visit took place in February 2004 with several members of the SAT. Spray operations in the Popayan region, in southwestern Colombia, were observed in detail during this visit. During this and subsequent visits (Jun. 2004, Aug. 2004, Feb. 2005, Jun. 2005, Jul. 2005, Jun. 2006, Oct. 2006, Dec. 2006, Feb. 2007, May 2007, Jul. 2007, Oct. 2007), members of the SAT were given complete freedom to observe all operations related to the spray program and were allowed to photograph all operations except those related to the gathering of intelligence about guerilla groups. We were allowed to travel with the spray operators and with the team that evaluated efficacy and off-target effects, but for safety reasons, we were accompanied by the Colombia National Police and their elite unit, the "Junglas," where appropriate. During these visits, we personally collected samples of the glyphosate formulation as well as the adjuvant, Cosmo-Flux, for the purposes of testing. These visits also provided us with the opportunity to meet with and interview potential leaders of the PTG, as well as to visit several Government agencies in Colombia where additional data for the assessment could be obtained.

4.3 Additional scientific studies of the Plan Colombia herbicide spray mixture conducted by the CICAD Scientific Advisory Team

To expand upon the existing scientific research regarding the Plan Colombia herbicide spray mix, the SAT decided to conduct a number of additional studies, including wildlife ecotoxicity tests to assess the potential ecological impacts of the spray mix, a Time-To-Pregnancy ("TTP") study to address potential questions regarding any impact of the spray mixture on human reproductive health, and a series of surface water tests to evaluate the persistence of the spray mixture in the environment. In all of these studies, the SAT and the PTG were allowed free access to all relevant information and data sources and conducted their work without hindrance or interference. Each of these studies is discussed below.

4.3.1 Wildlife ecotoxicity studies in aquatic algae, fish, aquatic invertebrates, and honey bees

To complement the mammalian toxicity studies discussed in Section 4.1.1 above, the SAT conducted a standard panel of ecotoxicity tests of the Plan Colombia herbicide spray mixture using samples of the formulated glyphosate and Cosmo-Flux, collected by the SAT on one of its site visits. These tests were conducted under good laboratory practice (GLP) using standard procedures by a consulting company in Guelph, Ontario (Stantec). The tests employed generally accepted methodologies and are of the type relied upon by experts in the field in assessing the toxicity of a test substance.

The tests on multiple aquatic organisms (Stantec 2005d, e, c, a, b) demonstrated that the toxicity of the Plan Colombia herbicide spray mixture was similar to that of other formulated glyphosate products tested in the same species (Table 1). From these studies, the SAT concluded that the addition of Cosmo-Flux did not enhance aquatoxicity of the spray mixture and that the spray mixture did not pose a significant risk to fish or other aquatic wildlife. This finding is consistent with other observations that Cosmo-Flux is of low toxicity to fish with an acute LC50 of 4,418,000 μg/L (Rondon-Barragan et al. 2007).

Table 1. Toxicity values obtained from toxicity tests conducted on a spray mixture of glyphosate and Cosmo-Flux

Test species	Common name	96 h LC/EC50 in µg/L (as glyphosate a.e.)	Reference
Selenastrum	Algae, based on cell numbers, area under the growth curve and growth rate.	2,278-5,727[a]	(Stantec 2005e)
Daphnia magna	Water flea, mortality.	4,240 (3,230-5,720)[b]	(Stantec 2005b)
Onchorynchus mykiss	Rainbow trout, mortality.	1,847 (1,407-2,425)[b]	(Stantec 2005c)
Pimephales promelas	Fathead minnow, mortality.	4,600 (1,805-11,700)[b]	(Stantec 2005a)

[a] Greatest and smallest effect measures in the study. [b] LC/EC50 and 95% Confidence Interval

A toxicity test was also conducted with honeybees (as surrogates for beneficial insects) using the spray mixture of glyphosate and the surfactant Cosmo-Flux® 411F (Stantec 2005d). The results of this study showed that the spray mixture was not toxic via acute 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 63.9 µg a.e./bee. These results are similar to those for glyphosate and formulations from the US EPA ECOTOX data base (USEPA 2001) and show that the Plan Colombia herbicide spray mixture is not hazardous to bees or, by extrapolation, to other beneficial insects.

4.3.2 Time to Pregnancy study

The SAT decided to conduct an investigatory Time to Pregnancy (TTP) study because, at the time the SAT was formulating its study objectives (2004-2005), there were studies in the literature suggesting an association between pesticide use on farms and reproductive outcomes. The TTP study was conducted to explore possible effects on reproductive health from exposure to the Plan Colombia herbicide spray mixture by assessing any delays in fecundity among women living in different areas of the country with different pesticide use patterns. The design was analogous to a retrospective cohort study of populations from different regions and with different exposures to the Plan Colombia spray mix. The study population consisted of 600 women of reproductive age in each of five different regions (Figure 3): two regions where Plan Colombia spraying took place (Nariño and Putumayo), two regions where there was no Plan Colombia

Figure 3. Locations for the sampling for the TTP study

spraying but where there were other uses of glyphosate (Boyacá and Valle del Cauca) and one region in which no pesticides were used at all (Sierra Nevada). Possible confounders or independent predictors of the reproductive variables were also considered.

The TTP study failed to find any association between TTP and Plan Colombia aerial eradication operations. In particular, the TTPs in the two regions in which Plan Colombia spraying occurred (Nariño and Putumayo) were shorter than the TTP in Sierra Nevada, where there was no spraying and no use of pesticides. The longest TTP was found in Valle de Cauca, where much lower levels of glyphosate are sprayed on sugar cane to accelerate maturation of the crop (Sanin et al. 2009).

4.3.3 Water sampling studies

In parallel to the TTP study, the SAT collected samples from surface waters and adjacent sediment at each of the five study locations to test for the presence of glyphosate and AMPA (a glyphosate metabolite). Water samples were taken at weekly intervals for a period or 24 weeks, frozen and held at -17°C until shipped to Canada for analysis using a glyphosate Method Detection Limit (MDL) of 25 µg/L (Thompson et al. 2004). Sediment samples were also taken (at monthly intervals) for analysis of potential transport of glyphosate and/or AMPA from treated areas to surface water.

In all locations and on most occasions, residues of glyphosate and AMPA were not detected (present at concentrations above the detection limit of 25 µg/L). There was no detection of glyphosate above the MDL in either Putumayo or Nariño, the two tested locations in Colombia where Plan Colombia aerial eradication operations were taking place. On one occasion each in Valle del Cauca and Boyacá, minor glyphosate concentrations of 30.1 and 25.5 µg/L, respectively, were found. No Plan Colombia spraying for coca control was carried out in these locations, and the only use of glyphosate was in agriculture. These data suggested that, at the watershed level, little or no contamination of surface waters with glyphosate at significant concentrations has resulted from the use of glyphosate in either agricultural or eradication spraying in Colombia. Because no meaningful detections were identified in surface water samples – and accordingly there was no occasion to analyze potential transport of glyphosate from sediment to surface water – the sediment samples taken from areas adjacent to the surface waters were not analyzed.

5 Conclusions Reached in the CICAD 2005 Risk Assessment of the Plan Colombia Herbicide Spray mix

After completing its investigation of the Plan Colombia herbicide spray mixture and the aerial eradication operations in Colombia, the SAT conducted a risk assessment to determine whether the spraying operations posed a risk to human health or the environment. The SAT's risk assessment methodology and findings are set forth below.

5.1 Basic principles of risk assessment

All toxicological risk assessment methods are similar (National Academy of Sciences 2008, USEPA 1992, 1998a), although they may vary somewhat based upon the purpose of the analysis. A key variable is whether the assessment is being used for prospective regulatory purposes or for a concurrent or retrospective analysis of specific exposure situations. In the former case, the risk assessment is geared at setting a regulatory exposure level that provides a margin of protection against all potential hazards, while in the latter case, the risk assessor will be seeking to determine whether measured or estimated exposures to a potentially hazardous substance are causing unacceptable risks.

Risk assessments are normally conducted in a series of steps or tiers. As one progresses through the tiers, the estimates of exposure and toxicity become more realistic as uncertainty is reduced through the use of more or better quality data. Tiers are normally designed such that the lower tiers in the risk assessment are more conservative (i.e., provide greater margins of safety), while the higher tiers are more realistic, with assumptions more closely approaching reality.

5.1.1 Assessment of risk

In a lower tier risk assessment, the values for exposure and toxicity are compared by simple division using a quotient, called a hazard quotient (HQ). The result is a ratio of toxicity to exposure (margin of exposure) or of exposure to toxicity (level of concern), as defined below:

Margin of Exposure (MOE) = Toxicity value/exposure value

Level of Concern (LOC) = Exposure value/toxicity value

If the MOE is greater than 1.0, *i.e.*, the exposure value is less than the toxicity value, then the conclusion is that the exposure would not give rise to any hazard to health. If the margin of exposure is less than 1.0, *i.e.*, the exposure value is greater than the toxicity value, then the potential for hazard cannot be rebutted. It is important to note, however, that because of the conservative assumptions used in setting toxicity and exposure values for a lower tier risk assessment, an MOE less than 1.0 does not mean that the exposure poses an actual hazard to health. Rather, this finding may trigger higher tier risk assessments that include more realistic analyses of the probability of exposure and the probability of toxicity to characterize the likelihood (risk) that harm will occur (ECOFRAM 1999a, b, EUFRAM 2006, Solomon 2010). (For LOC, the variables are reversed, so a value less than 1.0 indicates safety and a value greater than 1.0 requires further study or refinement of data).

5.1.2 Toxicity values used in risk assessment

In human health risk assessment, the no-observed-adverse-effect level (NOEL) for the most sensitive response (*e.g.*, loss of weight, increased liver weight, etc.) in the most sensitive mammalian test species is used as a point of departure (POD) for setting a toxicity value, that is, the highest level of exposure at which there is no observation of the adverse response (e.g., loss of weight) in the most sensitive animal tested. For risks from daily exposures over a lifetime, the POD is normally derived from the NOEL from long-term studies in animals and an uncertainty factor of 100 is used to calculate an acceptable daily intake (ADI) or reference dose (RfD). In other words, the ADI or RfD is set at 100 times less than the NOEL. For short term exposures, such as in applicators or people exposed infrequently during spraying, the POD may be derived from acute toxicity studies with uncertainty factors smaller than 100.

In ecological risk assessment, a similar approach is used. In the case of glyphosate, acute data are normally used because glyphosate and its surfactants are not persistent in the environment and acute exposure is thus the most appropriate comparison to the infrequent exposures that would occur with the use of glyphosate and its formulations in the control of plants. As in human health risk assessment, the most sensitive response in the most sensitive plant organism may be used as the POD. However, if more data are available, distributional analysis may also be used to characterize an exposure that is protective of a proportion, such as 95%, of plant species (CCME 2007).

5.2 Toxicity values for Plan Colombia herbicide spray mixture

In the 2005 CICAD risk assessment, both the NOEL and the RfD were used to assess the health risks to humans of exposures to the Plan Colombia herbicide spray mix. Based upon the findings in the mammalian studies of the Plan Colombia herbicide discussed in section 4.1.1 above that the Plan Colombia spray mixture had the same toxicity as formulations of glyphosate from the U.S, the SAT concluded that it was appropriate to use the USEPA's NOEL and RfD for glyphosate for purposes of the assessment. The USEPA NOEL for glyphosate is 175 mg/kg/day based on maternal toxicity in an assay of developmental toxicity in rabbits (Williams et al. 2000). The USEPA RfD for glyphosate is 2 mg/kg/day (USEPA 1993), the same value used by the World Health Organization (World Health Organization 1994).

Assessment of the environmental risks to aquatic organisms was based on toxicity data from the literature and from studies conducted on the Plan Colombia herbicide spray mixture (Solomon et al. 2005, Solomon et al. 2007b).

5.3 Calculation of potential exposure scenarios from the Plan Colombia aerial eradication operations

5.3.1 Estimates of potential human exposures

In calculating potential human exposures to herbicides and pesticides in the agricultural setting, the standard methodology is to separate the analysis into two groups – applicators and bystanders. The group that experiences the greatest probability of exposure is the applicator group, which, in the case of the Plan Colombia aerial eradication operations, includes the mixer-loaders, the spray-plane pilots, and mechanics who work on and service the aircraft. The second group is made up of bystanders who could potentially come into contact with the sprayed herbicide (1) via direct deposition if they are within the spray swath, are directly exposed to spray drift, or are exposed to deposits of spray when they reenter treated fields, or (2) indirectly through the consumption of food items that have been sprayed or drinking water that has been impacted. The SAT's charge focused on assessing risks to the bystander group.

Bystanders were classified by the SAT into several classes, depending on their route of exposure. Although the SAT understood that it would be unlikely for people to be present in a coca field during a spraying operation, for purposes of the risk assessment, the SAT estimated potential exposure to a person who was standing directly in the spray swath and received a direct application of the spray solution to the body. The most likely scenario was judged to be a partially clothed human with a cross-sectional area of 0.25 m^2 exposed to the spray. Given that glyphosate penetrates poorly through the skin with maximum penetration of about 2% (Williams et al. 2000), the body dose under a reasonable worst-case exposure was estimated to be 0.04 mg/kg body weight.[1] This exposure estimate is greater than that which could occur from exposure to spray drift, which would involve deposition rates lower than that directly within the spray swath. Because the salt forms commonly used in glyphosate formulations have very low vapor pressure, potential additional exposure to glyphosate via vapor is negligible. (Giesy et al. 2000)

For other bystanders such as children exposed via reentry into a field or bystanders exposed via, water, diet, and wild foods, exposure values from the literature (summarized in Williams et al. 2000) were used to estimate exposures by multiplying the literature values by the ratio of the application rate used in coca and that used in agricultural settings assessed by Williams et al. (2000). This ratio was 4.982/1 = 4.982 and provided the acute values shown in Table 2. Acute values are most appropriate for assessment of infrequent exposures to glyphosate such as would occur in the spray program.

Table 2. Estimates of exposure of bystanders to glyphosate (IPA) during the spraying of coca in Colombia

Scenario	Exposure in mg/kg body weight	
	Adult	Child
Maximum re-entry exposure estimated for an adult human with a 10 hour day.	0.013	0.259
Drinking water	0.000179	0.00055
Diet	0.119	0.259
Wild foods	0.224	0.224
Total from diet and water	**0.343**	**0.483**

[1] The figures reported herein are based upon the application rate for the Plan Colombia herbicide spray mixture as used to eradicate coca. Note that exposures for humans are presented as glyphosate isopropylamine salt (IPA), the active ingredient used in toxicity testing in mammals.

5.3.2 Estimates of potential terrestrial animal exposures

Animals present during the spray may be exposed on skin, hair, fur, or feathers. Exposures via this route were not estimated as the presence of hair, fur or feathers, or an impervious cuticle (insects) would reduce penetration into the body to levels far below the estimated levels for humans in the bystander scenario above.

5.3.3 Estimates of potential exposures in surface water

If over-sprayed during application, surface waters could contain measurable concentrations of glyphosate for at least some period of time. Although the SAT did not detect glyphosate in surface waters located close to the sprayed coca fields in its own studies and was not aware of any other findings of detections following such spraying operations, the SAT calculated worst-case concentration levels, as set forth in Table 3 below, based on water depth assumptions used by the US EPA (Urban and Cook 1986) and the EU (Riley et al. 1991).

Table 3. Estimates of concentrations of glyphosate in surface water after a spray application for control of coca sprayed at 4.982 kg/ha (3.69 kg a.e./ha)[a] and assuming rapid mixing, no absorption to sediments, and no flow.

Scenario	Concentration in µg a.e. /L
Surface water, 2 m deep	185
Surface water, 0.3 m deep	1,229
Surface water, 0.15 m	2,473
Surface water, 0.15 m deep with 50% absorption to sediments	1,237

[a] Note that the concentration is expressed as glyphosate acid to allow comparison to exposures used in environmental toxicity testing. In both these exposures and in the toxicity testing Cosmo-Flux, proportional amounts are present and the exposure and toxicity values are thus directly comparable and can be used to assess the hazard of the spray mixture as applied in Colombia.

5.4 Findings of the Risk Assessment

The 2005 risk assessment used Margins of Exposure for both the NOELs and the RfD as a means of characterizing risk. Because potential bystander exposures to Plan Colombia herbicide spray mixture would be acute rather than continuing over one's lifetime, the NOEL is the more appropriate measure for assessing potential human health risk from the spraying operations and is itself conservative because the NOEL was determined based upon a maternal toxicity rather than acute toxicity study. As set forth below in Table 4, even combining the worst-case scenarios for all sources of exposure in a single individual, *the MOE based on the NOEL was significantly greater than 1.0, demonstrating that bystander exposure to Plan Colombia herbicide spray mixture did not present a risk to human health*. Notably, even as compared to the RfD, the worst case exposure scenario MOE exceeded 1.0. In other words, even if one were to assume that a bystander experienced a worst-case aggregate exposure to Plan Colombia herbicide spray mixture *every day over their entire lifetime*, that individual would not be exposed to any significant health risk. Because the MOEs were all in excess of 1.0, there was no need to move to higher tier risk assessments.

Table 4 Summary of reasonable worst-case estimated exposures of humans to the Plan Colombia herbicide spray mixture resulting from its use in the eradication of coca 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)[a]
Direct overspray	0.04	4,918
Reentry	0.26	676
Inhalation	0.01	28,226
Diet and water	0.75	234
Worst case total exposure from all sources	1.05	167
Source of exposure	**Exposure value in mg/kg**	**Margin of exposure for the US EPA RfD (2 mg/kg/day)[a]**
Direct overspray	0.04	56
Reentry	0.26	7.7
Inhalation	0.01	323
Diet and water	0.75	2.7
Worst case total exposure from all sources	1.05	1.9

[a] Based on NOEL and RfD from USEPA Registration Eligibility Decision (USEPA 1993).

For the environment, risks from the use of the Plan Colombia herbicide spray mixture to terrestrial mammals and birds were likewise judged to be negligible. From the worst-case estimated exposure values for surface waters (Figure 4), it was concluded that moderate risks might exist for certain aquatic organisms in shallow surface waters (*i.e.*, less than 30 cm = 1 foot deep) that are directly over-sprayed during the eradication program. Aquatic stages of amphibians were the organisms at greatest risk.

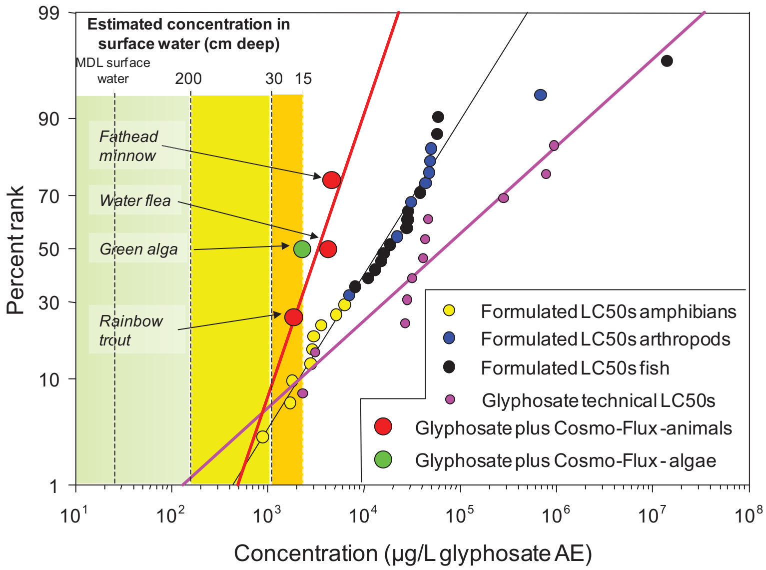

Figure 4. Cumulative frequency distribution of toxicity values for glyphosate technical, formulated glyphosate (Roundup) in all aquatic organisms and in fish and the toxicity values in four aquatic species for glyphosate and Cosmo-Flux spray mixture as used in Colombia.

5.5 Presentation of 2005 risk assessment findings

On behalf of the SAT, I presented the results of the risk assessment to officials from the Government of Colombia in Bogota on April 15, 2005, to CICAD/OAS and to representatives of the United States Congress in Washington, D.C. on April 19, 2005, to the public in Bogota on April 22, 2005, and to the OAS Assembly on April 26, 2005 in Santo Domingo. The Santo Domingo presentation was made to representatives from all OAS member-countries (including Ecuador) and included an opportunity for question-and-answer. I also presented the results of the risk assessment at scientific meetings and at universities, such as the Pan-Pacific Meeting in Hawaii on December 16, 2005; Queen's University on April 5, 2006; Baylor University on April 27, 2006; the Ontario Pesticides Advisory Committee on November 19, 2006; and the University of Costa Rica on December 15, 2006.

5.6 Publication of the 2005 risk assessment

As had been agreed with CICAD/OAS, the risk assessment report (Solomon et al. 2005) was formatted for publication in the scientific literature. The report was submitted to *Reviews of Environmental Contamination and Toxicology* and accepted for publication in Volume 190 of the journal (Solomon et al. 2007b). The objective of publishing the report was to make it more available to the scientific community.

6 The Scientific Advisory Team's Additional Investigation of Plan Colombia Aerial Eradication Operations Following the 2005 Risk Assessment

The 2005 risk assessment (Solomon et al. 2005) demonstrated that the Plan Colombia herbicide spray mixture did not pose a significant health risk to humans or land-based animals. However, as noted above, the assessment concluded that the herbicide spray mixture might pose moderate risks to amphibians. The SAT accordingly suggested to CICAD that additional studies be conducted to supplement the analysis of potential toxicity to amphibians (Solomon et al. 2005). In addition, the SAT recommended a human genotoxicity study to investigate data presented at meetings and later published in the literature (Paz-y-Miño et al. 2007) which suggested that exposure to drift from Plan Colombia spraying operations caused genotoxicity in humans via the formation of micronuclei in white blood cells. The SAT also recommended that a study be conducted to determine the potential extent of drift of the spray during aerial eradication operations.

Because of the narrower scope of the additional studies, the research was carried out under the direction of a smaller Scientific Advisory Team (SAT 2). Members of the new SAT were Gabriel Carrasquilla, MD, Ph.D.; John Marshall, Ph.D.; and Keith Solomon, Ph.D. As had the SAT with the 2005 risk assessment, the SAT 2 operated independently of the U.S. and Colombian governments, and of the contractor for the State Department, DynCorp. As before, none of these entities had input or editorial control of the reports of the SAT 2. However, the Colombian anti-narcotic Police and the Colombian Department of Health did provide logistical support for aspects of the additional studies that were carried out in Colombia. The findings from these additional studies are discussed below.

6.1 Toxicity of the spray mixture to amphibians

As there were no data on the susceptibility of amphibians to the spray mixture of glyphosate and Cosmo-Flux used in the Plan Colombia eradication operations, an initial laboratory study was conducted with larvae of the African clawed frog, *Xenopus laevis* (Wildlife International 2006b, a). This study showed that the Plan Colombia herbicide spray mixture was somewhat less toxic than reported values for other formulations of glyphosate. The LC50 for the spray mixture as used on coca was the equivalent of 1,100 µg glyphosate a.e./L (95% CI; 560-2,300), while the lowest LC50 previously reported for formulated glyphosate (Vision®) in larvae of the same species of frog was 800 µg a.e./L (Edginton et al. 2004). An important observation from this data is that the addition of Cosmo-Flux does not increase toxicity above those values reported in other frogs for studies using both Vision® and Roundup®. This is also consistent with the observation that Cosmo-Flux is of low toxicity to fish with an LC50 of 4,417 mg formulation/L (4,417,000 µg/L) (Rondon-Barragan et al. 2007). With these findings in mind, two studies were conducted with Colombian frogs.

The first toxicity study on Colombia frogs was laboratory-based and characterized the toxicity of the Plan Colombia spray mixture to eight species of Colombian frogs (Bernal et al. 2009a). The study was conducted in glass containers and in the absence of sediments and particulate matter. LC50 values for the eight species tested (Gosner stage-25 tadpoles of *Scinax ruber, Dendrosophus microcephalus, Hypsiboas crepitans, Rhinella granulosa, R. marina, R. typhonius, Centrolene prosoblepon,* and *Engystomops pustulosus*) ranged from 1,200 to 2,780 µg glyphosate a.e./L. The important observation from these results is that the data show that sensitivity to Roundup®-type formulations of glyphosate in the Colombian frog species is similar to that observed in other tropical and temperate species of frogs for which data have been published in the literature. That tropical frog species were of similar sensitivity to those from temperate regions is also consistent with observations with other pesticides and other organisms (Maltby et al. 2005) and therefore allows the combination of Colombian data with those from other regions for the purposes of risk assessment.

The second toxicity study in Colombia was designed to characterize the toxicity of the Plan Colombia herbicide spray mixture to tadpoles and terrestrial stages of frogs under field-relevant conditions. These experiments were conducted under realistic conditions with soil and leaf-litter present in the bottom of the exposure chambers. Experiments were conducted both in Gosner stage-25 tadpoles and in terrestrial stages of frogs (juveniles and adults) in 15-cm deep microcosms containing a 3-cm layer of sediment (Bernal et al. 2009b). The results demonstrated that toxicity of the spray mixture is reduced in the presence of sediments and particulates in the water column. The reduction in toxicity was similar to that observed by others (Tsui and Chu 2003, 2004, Tsui et al. 2005, Tsui and Chu 2008) and as discussed in Solomon and Thompson (2003) for the formulated product and also for the POEA surfactant, which contributes the greatest to the toxicity of the formulation (Wang et al. 2005). The LC50 of the Plan Colombia herbicide spray mixture was between 8.9 and 10.9 kg glyphosate a.e./ha in the tadpoles experiments and between 4.5 and 22.8 kg a.e./ha in the juvenile/adult frog experiments (consistent with the observations of Dinehart et al. 2009, Mann and Bidwell 1999) and thus were greater than the application rate of 3.7 kg glyphosate a.e./ha (2,473 µg/L) used in the Plan Colombia coca eradication operations (see Figure 5 below).

The findings of these studies indicated that, even with direct overspray of Plan Colombia herbicide spray mix, amphibians (representing the most sensitive aquatic organisms) in shallow water systems (ca. 15-cm deep) would be at low risk. Given further reductions in exposure through interception of spray droplets by the vegetative canopy, the overall conclusions of the studies on Colombian frogs are that, under worst-case exposure conditions, the spray mixture of glyphosate and Cosmo-Flux used for control of coca in Colombia is of low or negligible risk to aquatic and juvenile terrestrial stages of frogs.

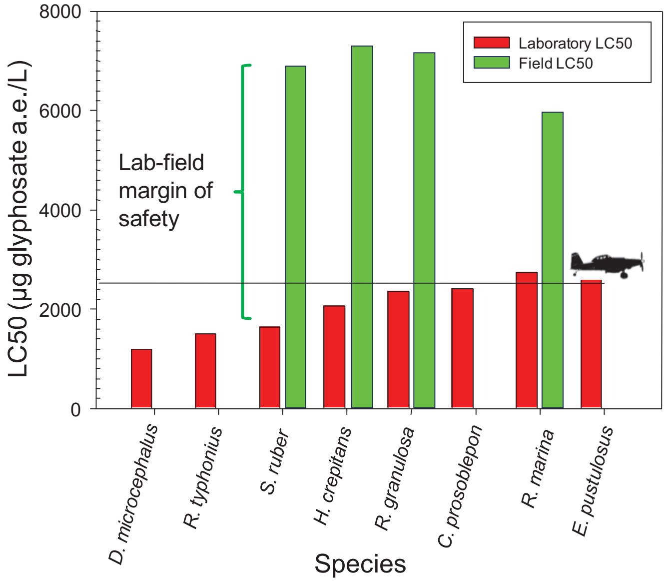

Figure 5. Comparison of the toxicity of glyphosate and Cosmo-Flux to tadpoles (Gosner 25) of Colombian frogs under laboratory and field conditions

6.2 Study of potential spray drift and characterization of risks of off-target deposition

The potential drift of herbicide spray from Plan Colombia aerial eradication operations was assessed via a wind tunnel analysis and AGDISP modeling conducted by Dr. Andrew Hewitt, who is a well-known expert in the field of pesticide drift. I do not have expertise in this analysis and accordingly do not address Dr. Hewitt's analysis in this report. It is my understanding that Dr. Hewitt is separately submitting an expert report in this litigation.

After Dr. Hewitt calculated the potential drift from Plan Colombia aerial eradication operations, the SAT 2 compared his findings with scientific data on toxicity values for the herbicide in humans, animals, and plant life to calculate a safety buffer for the spraying operations, *i.e.*, a distance from the end of the spray swath in which the level of potential exposure did not present any risk of damage or injury. As discussed above, the toxicity values for the Plan Colombia herbicide spray mixture in humans and terrestrial animals were well above the potential exposure levels even directly under the spray swath. Accordingly, a safety buffer would be necessary only for amphibians in shallow waters and for non-target plant life.

Using the findings in the amphibian studies discussed above, Dr. Hewitt's calculations of potential drift were compared with the toxicity values of formulated glyphosate to the most sensitive frog species (*Xenopus laevis*) under the worst-case exposure scenario (overspray of a 15-cm deep pool with no exposure reduction via adsorption to sediments and organic matter). For the worst-case spray drift from the AT-802 and the OV-10 spray planes, we calculated that a 5 m buffer from the end of the spray swath would be sufficient to protect 95% of amphibians.[2]

Not surprisingly, plants are the most susceptible terrestrial organisms to glyphosate. Data on the susceptibility of crop plants were obtained from the ECOTOX database (USEPA 2001). In addition to this, more recent data for wild plants from a presentation by Olszyk et al. (2009) at a meeting of the Society for Environmental Toxicology and Chemistry have been added to the data set. A commonly used measure of effect on plants is the EC25 based on growth, yield, or size (Suter et al. 2007). These data were characterized by the use of Species Sensitivity Distributions (SSDs) using procedures outlined in (Solomon 2010) and are presented in Table 5 and Figure 6 below.

Table 5. Regression coefficients and intercepts for the toxicity data distributions for exposures of terrestrial plants to glyphosate (Roundup®)

Herbicide	N	r^2	y = ax + b		5^{th} centile intercepts (g a.e./ha)
			a	b	
Glyphosate (Roundup® crop plants)	21	0.89	2.63	1.91	45
Glyphosate (Roundup® wild plants)	13	0.95	2.32	3.02	10

Crop plants are less sensitive to glyphosate than wild plants with a 5^{th} centile of 0.045 compared to 0.01 kg a.e./ha. Because of an error in the SAT 2's calculation of the susceptibility of crop plants to glyphosate, the estimates of glyphosate sensitivity in Hewitt et al. (2009) were overstated and the risks of spray drift to non-target plants were overestimated. Using new data and a corrected calculation, I calculate that a buffer of ~50 m would be

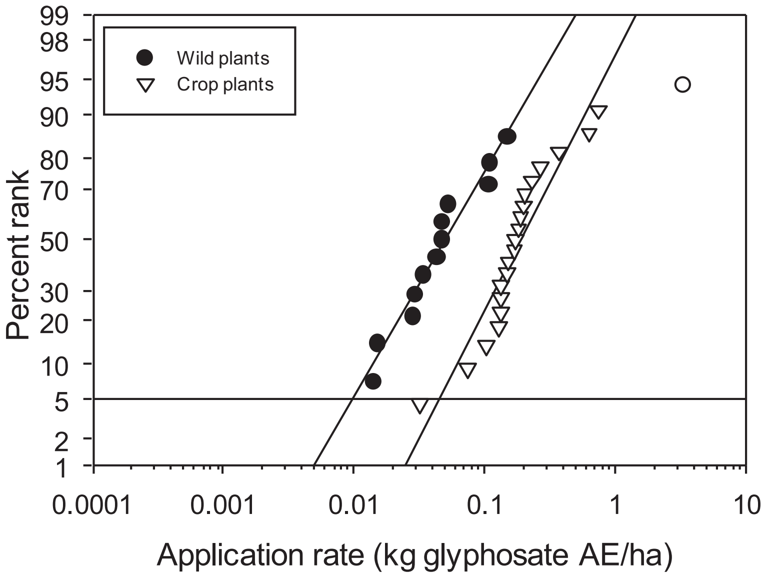

Figure 6. Distributions of EC25s for glyphosate in terrestrial plants

[2] Dr. Hewitt calculated that there would be somewhat less drift from T-65 spray planes. Accordingly, the necessary buffer for spraying operations using T-65 spray planes would be somewhat shorter.

protective of 95% of crop plants and a buffer of ~75 m would be protective of 95% of wild plants. These safety buffers are somewhat shorter than, but generally consistent with, the buffer of 50 to 120 meters calculated in Hewitt et al. (2009).

The overall findings of safety buffers are set forth below in Figure 7.

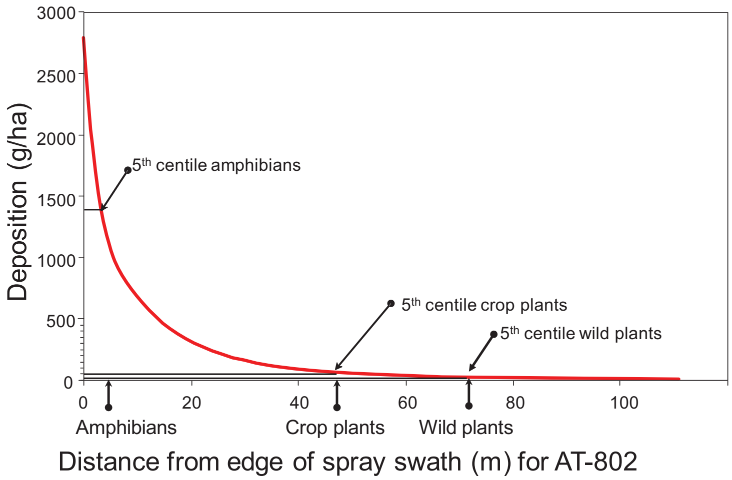

Figure 7. Modeled drift deposition values for glyphosate overlaid with the 5th centile toxicity values for amphibians, crop- and wild-plants.

6.3 Genotoxicity study

Claims of DNA damage in peripheral lymphocytes from a small group of subjects potentially exposed to glyphosate from Plan Colombia spraying operations were reported in (Paz-y-Miño et al. 2007). However, problems with the study design, including the fact that there were only a small number of subjects (21 control and 24 exposed) and the fact that random selection produced 23 females and one male in the exposed group, do not allow valid scientific conclusions to be drawn from the study.

To investigate whether the Plan Colombia spraying operations could, in fact, be associated with genotoxic effects, the SAT 2 carried out a study using the micronucleus-response in peripheral lymphocytes, an index of chromosomal damage, as a biomarker of potential genotoxicity (Bolognesi et al. 2009). The study was carried out on volunteers from five regions of Colombia in which the populations had different potential levels of exposure to glyphosate and other pesticides. The epidemiological design was a prospective cohort study but, for logistical reasons, without exposure biomonitoring. The study population was comprised of 274 persons; 137 women of reproductive age (15-49 years of age) and their spouses. Participants were interviewed to obtain relevant details about health status, history, lifestyle, past and current occupational exposure to pesticides, and factors known to be associated with increased frequency of micronuclei. In regions where glyphosate was being sprayed (by Plan Colombia aerial eradication spray planes in Nariño and Putumayo and by commercial spray planes in Valle del

Cauca), blood samples were taken prior to spraying, 5 days after spraying, and 4 months after spraying, and data regarding exposures were collected. Volunteers were asked if they entered the field immediately after spraying, if they felt spray drops in their skin, or if they thought they were exposed because they had contact with the chemical in the air. Lymphocytes were cultured and analysis of micronuclei performed using standardized techniques on binucleated lymphocytes with preserved cytoplasm.

As shown in Figure 8, although there was a transient increase in the frequency of bi-nucleated lymphocytes with micronuclei (BNMN) five days after spraying of glyphosate (diagonal pink arrows pointing up), there was no consistent pattern in BNMN four months after the spraying, with the only significant change being a *decrease* in BNMN in Nariño (diagonal green arrow pointing down). Moreover, the largest five-day increase in BNMN was in Valle del Cauca, where glyphosate was applied aerially for ripening of sugar cane at an application rate roughly 27% of the application rate of the aerial eradication operations in Putumayo and Nariño, a finding which is inconsistent with the hypothesis that glyphosate spray caused even this transient change. Furthermore, there was no significant association between self-reported direct contact with eradication sprays and frequency of BNMN at five days after spraying. The frequency of BNMN in participants who self-reported that they were exposed to glyphosate was not significantly greater than in subjects living in the same areas but who were not present during spraying.

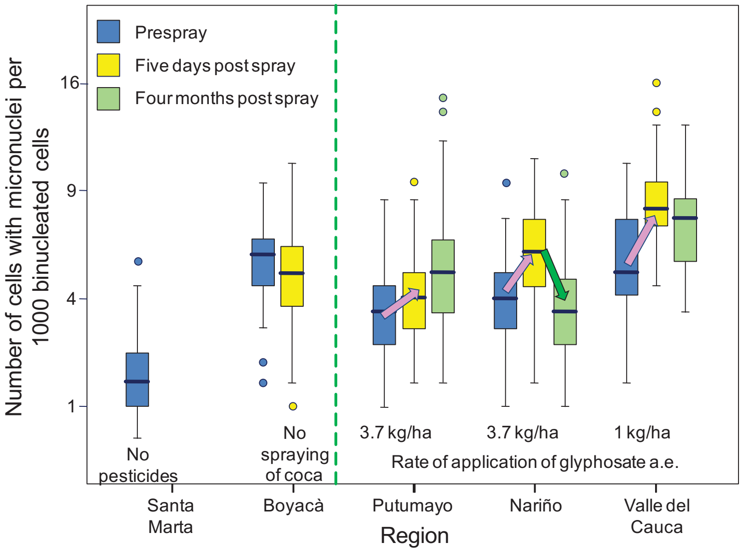

Figure 8. Frequency of micronuclei in white blood cells in relation to potential exposures to glyphosate spray used either for control of coca or for production of sugar cane

Overall, the SAT 2 concluded that any genotoxic risk potentially associated with exposure of humans to glyphosate in the areas of Colombia where the herbicide is applied for coca (and poppy) eradication would be small and transient at most and of low biological relevance.

6.4 Presentations of the results of the Phase-2 studies

The results of this second round of studies were presented to various officials and government representatives in Bogota on August 10, 2009. Additional presentations were made to the scientific community at the SETAC LA meeting in Lima, Peru on October 7, 2009; the SETAC NA in Tampa, Florida, on November 11, 2009; the XI ECOTOX meeting in Bombinhas, Brazil, September 19, 2010; and the Argentina Toxicology Association Meeting in Buenos Aires, on September 24, 2010.

6.5 Publication of the results of the SAT 2 studies

At the suggestion of CICAD/OAS, the results of the work conducted in the second round of studies were written up for publication in the scientific literature. The results were published in a series of articles in the *Journal of Toxicology and Environmental Health A* 72. Seven of the papers (Hewitt et al. 2009, Brain and Solomon 2009, Bernal et al. 2009b, a, Lynch and Arroyo 2009, Bolognesi et al. 2009, Marshall et al. 2009) were reports of the scientific work conducted by the SAT 2, one paper was the publication of the Time to Pregnancy (TTP) study conducted during the 2005 risk assessment (Sanin et al. 2009), one paper was an overview of the relevance of the findings (Solomon et al. 2009), and one paper was a preface explaining all of the papers (Solomon and Marshall 2009). These papers were submitted, and handled in the normal peer-review and editorial process, and were published in the journal in August of 2009. Spanish translations made by CICAD/OAS were made available via the website of the journal.

7 The Scientific Advisory Team's Comparative Hazard Assessment of the Cultivation of Coca vs. Aerial Spraying for Control of Coca

During the SAT's work in 2004-2005, it became apparent that the cultivation and processing of the illicit crops themselves posed a far greater risk to human health and the environment than did the Plan Colombia aerial eradication spraying. The risks from coca cultivation and processing were addressed in two reports prepared for CICAD (CICAD/OAS 2004, 2005), in a book chapter (Solomon et al. 2007a), and in a paper focused specifically on amphibians (Brain and Solomon 2009).

7.1 Impacts of coca cultivation and cocaine production on human health and the environment

The degradation of ecosystems associated with the production of coca and the processing of coca leaves into cocaine paste and then into cocaine hydrochloride has been identified as one of Latin America's most important current environmental issues (UNODC 2007, Karl et al. 2010, Bradford et al. 2010).

As was pointed by Brain and Solomon (2009) the production of illicit crops in regions of high biodiversity, such as in Colombia, results in clear-cutting and uncontrolled destruction of natural forests. The land area used for coca cultivation is significant. From 2000 to 2004, a total of 413,000 ha of coca were planted in Colombia, a quarter (97,622 ha) of which was established on land cleared from primary forest. Although the annual conversion rate has decreased steadily by 60% during this time, 13,202 ha of primary forest were still converted in 2004 (UNODC 2006). The amount of primary forest lost to coca production in Colombia between 1990 and 2004 has been conservatively estimated at 345,233 ha (UNODC 2006). Given the regional specificity of coca production, it is estimated that certain areas of intense cultivation, such as in the Colombian Departments of Nariño and Putumayo (UNODC 2006), may have experienced deforestation levels that caused extinction of animal species.

The cultivation of coca also gives rise to environmental and health risks because coca farmers use large quantities of fertilizers and agrochemicals, many of which, unlike glyphosate, are associated with significant adverse human health and environmental impacts. Moreover, there is little indication that farmers follow the labelled directions for use of these products. Formulated products are diluted with local sources of water from a nearby stream, river, or well. Mixing and loading of the herbicide sprayer usually takes place close to the water source and empty containers are discarded in the field. Pesticides are typically applied in coca fields with hand-operated backpack sprayers. Other than anecdotal information, there are little data on the use of protective equipment; however, from field observations it appears not to be widely used. (CICAD/OAS 2005).

The processing of coca leaves after cultivation into cocaine requires the use of a number of potentially toxic chemicals that also give rise to significant risks of adverse impacts on human health and the environment. The first step in cocaine production is converting the coca leaf into coca paste. This is accomplished by adding sodium carbonate, water, and an organic solvent, such as kerosene, to the leaves, crushing the leaves, and then extracting the cocaine alkaloids into an aqueous acid solution to which an alkaline material is then added. The next step is the conversion of coca paste to cocaine base, which is accomplished by dissolving the paste in an acid solution and then adding ammonia water to form another precipitate that is separated and dried. The third step is the conversion of cocaine base to cocaine hydrochloride, which requires the use of acetone to dissolve the cocaine base and hydrochloric acid to crystallize the cocaine (CICAD/OAS 2005).

Toxicity data for selected substances used in coca cultivation and processing (CICAD/OAS 2005) were used to prepare a comparative risk assessment of coca production for humans and for organisms in the environment. As there were no data or estimates of exposures to fuel oil, nitric acid, potassium chloride, and potassium permanganate, these chemicals were omitted from the assessment of the coca production risk and the assessment focused on pesticides used in coca cultivation. This comparative assessment of risks from coca cultivation and aerial coca eradication are set forth below. These results were presented at the PacifiChem Meeting in Honolulu in December 2005 and published as a Chapter in the ACS Symposium Series No 966 (Solomon et al. 2007a).

7.2 Comparative analysis of potential risks posed from coca cultivation and aerial coca eradications

7.2.1 Human health risks

Risks to humans from the cycle of coca production were estimated as discussed above and in (CICAD/OAS 2004, 2005) and (Solomon et al. 2007a), and are shown in Figure 9. For the purposes of this ranking process, the intensity score ranged from 0 to 5, with 5 being a severe effect such as a physical injury or toxicity. The recovery score also ranged from 0 to 5 and was based on the potential for complete recovery from the adverse effect. Frequency was based on an estimate of the proportion (%) of the total number of persons involved in coca and poppy cultivation, production, and the refinement of cocaine and heroin. The score for impact was the product of the individual scores and the percent impact is based on the sum of the impact scores.

IMPACTS ON HUMANS

IMPACTS	INTENSITY SCORE	RECOVERY SCORE	FREQUENCY %	IMPACT SCORE	% IMPACT
Clear cutting and burning	5	3	3	45	**16.7**
Planting the coca or poppy	0	1	100	0	**0.0**
Fertilizer inputs	0	0.5	10	0	**0.0**
Pesticide inputs	5	3	10	150	**55.6**
Eradication spray	0	0	10	0	**0.0**
Processing and refining	5	3	5	75	**27.8**

Figure 9. Ranking of risks to humans of the cycle of activities associated with the production and control of coca in Colombia

Note that in Figure 9 (and in Figure 10 below), "Pesticide inputs" refers to the pesticides applied by the coca farmers which, as noted above, included pesticides that are significantly more toxic to humans than glyphosate. The potential impact of the Plan Colombia spraying is set forth on the line titled "Eradication spray."

7.2.2 Ecological risks

A similar procedure to that described above was used for ranking ecological risks associated with the cycle of coca production (Figure 10). The intensity score was ranked from 0 to 5, with 5 being most intense, such as the total destruction of the habitat by clear-cutting and burning when clearing a natural area for agricultural use.

Intensity of effects in this case also included off-field effects such as harm to non-target animals and plants.

Recovery time in this scheme is the estimated time for the impacted area to recover to a state similar to the initial condition. In the case of the clear cutting and burning, it is recognized that succession will begin immediately; however, full recovery to a mature and diverse tropical forest may take considerably more than the 60 years estimated here. Similarly, in the absence of cultivation (*e.g.*, if fields are abandoned), it was estimated that invasive and competitive species will displace coca and poppy in several years and an estimate of four years was used in this case. Given the need to apply fertilizer and pesticides frequently because of utilization of nutrients and resurgence of pests, the recovery time for these ecological impacts was judged to be small. The scores were multiplied to give the impact score and the percent impact was based on the sum of the impact scores, as shown in Figure 10.

IMPACTS ON THE ENVIRONMENT

IMPACTS	INTENSITY SCORE	RECOVERY TIME (Y)	IMPACT SCORE	**% IMPACT**
Clear cutting and burning	5	60	300	**96.9**
Planting the coca or poppy	1	4	4	**1.3**
Fertilizer inputs	1	0.5	0.5	**0.2**
Pesticide inputs	5	0.5	2.5	**0.8**
Eradication spray	1	0.5	0.5	**0.2**
Processing and refining	2	1	2	**0.6**

Figure 10. Ranking of risks to the environment of the cycle of activities associated with the production and control of coca in Colombia

8 Opinions regarding test plaintiffs' allegations in light of CICAD risk assessment and studies

8.1 Scientific basis for claims of effects on human health

Based on registration reviews by a number of regulatory agencies in several countries, including the US and Canada, reviews of the scientific literature, and the multiple studies conducted on mammalian and human health outcomes of the spray program for control of coca in Colombia, there is no scientific basis to support an opinion that the spraying of glyphosate and Cosmo-Flux in Colombia was responsible for the alleged adverse health effects on the Ecuadorian test plaintiffs in this litigation.

8.2 Scientific basis for claims of animal death

Based on registration reviews by a number of regulatory agencies in several countries, including the U.S. and Canada, reviews of the scientific literature, and the multiple studies conducted on aquatic life, mammalian and human health outcomes of the spray program for control of coca in Colombia, there is no scientific basis to support an opinion that the spraying of glyphosate and Cosmo-Flux in Colombia was responsible for the alleged adverse effects on domestic animals reportedly owned by the Ecuadorian test plaintiffs. Given the low sensitivity of fish to the Plan Colombia herbicide spray mixture (Stantec 2005c, a) and rapid absorption of glyphosate and the surfactant POEA to sediment, there likewise is no scientific basis to support an opinion that the spraying of Plan Colombia herbicide spray mixture caused the alleged harm to fish reportedly owned by one of the Ecuadorian test plaintiff families.

8.3 Scientific basis for claims of injury to crops based upon drift study

Given the low potential for drift of the spray mixture as used for the control of coca in Colombia, the sensitivity of crop and wild plants to glyphosate, and visual observations during verification missions of healthy and undamaged forests adjacent to sprayed areas, there is no scientific basis to support an opinion that drift of the Plan Colombia herbicide spray mixture from spraying in Colombia was the cause of the alleged damage to crops in Ecuador reportedly being grown by the Ecuadorian test plaintiffs.

Respectfully submitted,

Keith R. Solomon

Dated: Jan 18 2011

CR Note: Dr Solomon's CV (Exhibit A), found in CD - Original Annexes

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Exhibit B

Dr. Keith Solomon Expert Report

Materials Considered

Exhibit B

Dr. Keith Solomon Expert Report

Other Materials Considered

The materials I considered in preparing my report are set forth in the references section at the end of my report. In addition, I have reviewed the following materials:

1) PLS00005881 Disk with Victor Mestanza's 2002 Video
2) PLS00005882 Disk with Victor Mestanza's 2009 Video

Annex 11

Expert Report of Dr A. Atalay, Ph.D., CPSS, prepared for the Defendants in Arias/Quinteros v. Dyncorp (D.D.C.), 19 January 2011

(United States District Court for the District of Columbia,
Cases No. 1:01-cv01908 (RWR-DAR) and 1:07-cv01042 (RWR-DAR).
Cases consolidated for Case Management and Discovery)

EXHIBIT 1

EXPERT REPORT OF ASMARE ATALAY, PH.D., CPSS
PREPARED FOR THE DEFENDANTS
IN ARIAS/QUINTEROS V. DYNCORP (D.D.C.)

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BACKGROUND & CREDENTIALS

My name is Asmare Atalay, and I submit this written report on behalf of the DynCorp defendants in the Arias/Quinteros v. DynCorp litigation.

I am currently Professor and Research Soil Scientist at the Virginia State University Agricultural Research Station in Petersburg, Virginia. I hold a Bachelor's Degree in Chemistry from the State University of New York at New Paltz (1977), a Master's Degree in Soil Chemistry from the University of Missouri-Columbia (1981), and a Ph.D. in Soil Science also from the University of Missouri-Columbia (1985).

I am certified nationally and internationally as a Certified Professional Soil Scientist (CPSS) by the American Registry of Certified Professionals in Agronomy, Crops, and Soils (ARCPACS); Certification No. 03371. I have been a member of both the Soil Science Society of America and the American Society of Agronomy since 1979.

At Virginia State University, I hold a 75% research and 25% teaching appointment. My current teaching responsibilities include undergraduate and master's level courses on general soil science, soil fertility and fertilizers, soil genesis and classification (pedology), and chemical/physical properties of soils. My courses in soil science include both laboratory testing and field experiences. The field experiences include profile description, soil formation, structure and texture verification, density analysis, and water content estimation. The soil fertility courses that I teach cover a range of topics, including laboratory analysis of plant tissue and soil samples for nutrients, nutrient uptake by plants, acidity (pH) and toxicity levels of soils as they relate to various macro- and micro-nutrient availability and uptake by plants, and fertilizer recommendations. My soil pedology course deals with soil genesis and classification of world soils using the U.S. classification method (the Comprehensive Soil Classification System), and the utilization of soil survey books for land use and productivity studies at the county level.

In conjunction with my research appointment at Virginia State University, I conduct funded research on soils, water, and the impacts of agricultural chemicals (such as fertilizers, herbicides, nutrients from applied animal manure, and biosolids) on soil productivity and water quality.

Although at Virginia State University I am formally designated as a research soil scientist, through my "extension" activities I routinely make my knowledge and expertise on issues related to farming and soil/water quality available to farmers and rural residents. As a result I spend a reasonable amount of time each spring and summer talking to underserved (particularly small and minority) farmers on soil fertility, fertilizer recommendations, and related issues. I also work with underserved rural communities in well water protection and drinking water assessment.

Because of my diverse expertise in soil, water, and environmental sciences, I have often been selected to serve on various federal, state and local committees that deal with these subjects. For the last eight years I have been serving on the Virginia Pesticide Control Board (representing the Dean of the School of Agriculture of Virginia State University). This is the body that enforces regulations on the proper use of registered pesticides in the state. I am an active member of the Nutrient Management Advisory Committee with the Virginia Department of Conservation and Recreation ("DCR"). I also serve on the Virginia Non-Point Source Pollution Advisory Committee, which provides scientific advice to DCR personnel on the potential impact of pollutants on rivers and bays, and recommends total maximum daily loads ("TMDL") of nutrients on rivers throughout the state and the Chesapeake Bay.

I have published 27 peer-reviewed scientific articles in reputable journals ranging from natural sciences to technical reports. I have published over 50 symposia articles and presented over two dozen invited presentations and lectures at various forums. My published works have been cited by many scholars in my area of expertise.

Additional honors, awards, and relevant experience are set out more fully in my curriculum vitae, attached to this report as **Exhibit A**, which includes a list of my publications.

Something not readily apparent from my curriculum vitae, however, is my recent work as a trainer/advisor to farmers, research technicians, and agricultural universities in my homeland, Ethiopia. For the last 6 years I have been traveling to Ethiopia, through a grant (Farmer-to-Farmer) from United States Assistance for International Development (USAID) to assist farmers in their efforts to grow crops of better quality and in greater quantities. The majority of my time in Ethiopia has been devoted to training technicians and research scientists on the operation of analytical equipment and on the interpretation of data from soils and plant tissue analyses. In addition, I have also worked extensively with extension workers and pedologists to diagnose soil-related fertility problems and then counsel farmers in the use of proper fertilizers and weed control methods. Interestingly, the soils in this tropical region of Ethiopia are similar to those in the relevant region of Ecuador; they are model tropical soils with very high clay and low fertility. The management of these types of soils for agricultural purposes, especially for crop growth, is known to be difficult, requiring large amounts of human and animal labor. This fact, coupled with the inherent low fertility of these soils, often leads to low yield potentials and other crop management problems. Only with proper testing, understanding, and management can such soils provide adequate yield for sustainable agriculture.

In addition to my recent work in Ethiopia, I lived in Ethiopia until the age of 17, and I grew up in a semi-rural environment there and witnessed firsthand the challenges that this tropical environment presented to the farmers. Much like Ecuador and Colombia, a large proportion of Ethiopia's population engages in subsistence farming, and I understand the extent of labor a farmer must devote to prepare a small parcel of land for crop production, all the while battling inherent soil fertility problems that are compounded by archaic farming practices, changes in rainfall patterns, water quantity and quality issues, and pre- and post-harvest crop infections and infestations.

In sum, I believe my experiences in Ethiopia have particular relevance to this litigation because the soils in this region of Ethiopia are tropical soils with characteristics very much like those in northern Ecuador, and the primitive farming methods in Ethiopia are similar to the farming methods utilized by the farmers of northern Ecuador.

STATEMENT OF COMPENSATION

I am being compensated for my work in this matter at a rate of $150.00 per hour, including deposition and trial testimony.

PRIOR TESTIMONY

I have not testified as an expert witness in litigation in the last four years.

SUMMARY OF EXPERT OPINIONS

I was asked to describe the soil characteristics for the soils encompassing the Ecuadorian test plaintiffs' farms, and then describe the likely impacts of the soil characteristics and the plaintiffs' farming practices upon their various agricultural endeavors. My opinions (summarized immediately below) are based upon my education, training, and experience, and a review of numerous materials provided to and/or obtained by me in conjunction with my work in this litigation, many of which are cited throughout this written report. A comprehensive list of materials considered is attached to this report as **Exhibit B**.

My opinions in this case can be summarized as follows:

1. It is widely known that tropical soils (such as those in northern Ecuador) are fragile soils, and when converted to agricultural use, tropical soils must be managed carefully if one hopes to maintain soil fertility and with it consistently healthy and productive tropical crops.

2. Based upon my understanding of the farming methods generally employed by the test plaintiffs, poor soil conditions combined with poor crop management techniques most likely explain many of the problems allegedly observed in the test plaintiffs' crops.

3. There is no valid scientific basis to conclude that the Plan Colombia spray mixture adversely impacts tropical soil fertility.

IT IS WIDELY KNOWN THAT TROPICAL SOILS (SUCH AS THOSE IN NORTHERN ECUADOR) ARE FRAGILE SOILS, AND WHEN CONVERTED TO AGRICULTURAL USE, TROPICAL SOILS MUST BE MANAGED CAREFULLY IF ONE HOPES TO MAINTAIN SOIL FERTILITY AND WITH IT HEALTHY AND PRODUCTIVE TROPICAL CROPS.

Despite their lush vegetation, most of the rainforests of the Amazon region grow on fragile tropical soils, which are acidic and lacking in nutrients and minerals essential to plant growth (Jordan 1985). The fragility of tropical soils is largely a byproduct of weathering – the process of breaking down inorganic material through heat, moisture, and other physical and chemical forces. Soils are formed through the weathering of bedrock over millions of years. This weathering process removes nutrients from the minerals that form the soil's parent material (Jordan 1985). Tropical soils tend to be older than other soils, and therefore they have been subjected to weathering for a longer time. In addition, tropical soils are subject to constant high heat and humidity, intensifying the weathering process. The high rainfall tends to leach many nutrients from the soil very quickly (Hilton 1987). The tropical soils' nutrients have been removed by millions of years of high temperatures and humidity and heavy rainfall (Jordan 1985).

Much of what little nutrition remains in tropical soil is unavailable for uptake by plants. Amazonian soils tend to be acidic (Jordan 1985), which promotes the accumulation of minerals such as iron and aluminum oxides. Weathering causes these oxides to release iron and aluminum to the soil solution to levels that are toxic to plants.[1] The acidic soils rich in oxides of iron and aluminum also bind with phosphorous, a necessary plant nutrient, rendering some of it unavailable for uptake by plants (Matson 1999). Thus, even soils rich in phophorous may have little of it that is available to plants (Matson 1999). This low availability of phophorous limits plant growth in many acidic tropical soils (Cardoso 2006), and it is a significant limitation on agriculture in the tropics (Oberson 2006). Moreover, because of intense weathering, tropical soils are generally low in other nutrients essential for plants, such as calcium, magnesium, silica, and several other essential micro-nutrients. The acidity of the soil inhibits absorbtion of these nutrients by plants, and the nutrients are thus more readily removed from the soil by heavy rainfall, facilitated by high temperature and humidity through the weathering process described above.

The rich vegetation of tropical rainforests gives the false impression that these rainforests have fertile soils. However, the growth of this lush vegetation despite poor soils is due to rapid nutrient cycling (Hilton 1987), combined with tropical tree and plant adaptations that allow them to survive under less-than-ideal soil conditions (Jordan 1985). A high proportion of the nutrients in the tropical rainforest ecosystem are contained in organic material, such as living plants and fallen leaves and bark, rather than in the soil (Hilton 1987). When these organic materials fall to the forest floor, two things happen. First, the layer of organic material provides a "buffer" for the plants by absorbing toxic metals in the soil like aluminum and iron. Second, the plant litter is

[1] These elements will also react with water to make the soil more acidic.

quickly decomposed,[2] thereby releasing nutrients to form a shallow layer of fertile soil on top of the weathered, infertile soil. The nutrients made available through this decomposition process are quickly absorbed by the living plants, which generally have high concentrations of roots near the soil surface that permit them to take advantage of the nutrient-rich layer of soil (Jordan 1985). Mycorrhizae, which are fungi that colonize the tree roots, also help the rainforest trees take up the plant litter's nutrients (Cardoso 2006). In the end, this nutrient cycling process provides an adequate supply of nutrients to support the plants of the rainforest, but it leaves very few nutrients to be absorbed by the soil, which thus remains deeply nutrient-deficient and ultimately dependent upon the cycling process.

Subsistence farmers in tropical rainforests, including the Amazon, often clear-cut or burn sections of the rainforest and then plant crops on the cleared land. This practice interrupts the nutrient cycling process. When tropical forests are cleared in this manner, plant litter is no longer produced, and the nutrients are quickly leached away (Jordan 1985). Furthermore, once cleared, the forest soil loses protection from the elements, making the soil susceptible to erosion and the weathering process, both of which can rapidly deplete the soil of its last remaining nutrients.

It is therefore widely known that the practice of clear-cutting or burning tropical forests adversely impacts the already-fragile tropical soils and, in time, will significantly reduce the ability of subsistence farmers to grow crops on the cleared land (Miller 2005). While some nutrients remain soon after clearing the land (allowing a few years of adequate farming yields), the nutrients are soon depleted.[3] The loss of the natural vegetation causes the soil to rapidly lose its fertility (Hilton 1987) and leads to a host of crop issues including reduced yields, crop disease, weed infestation, erosion, nutrient loss by leaching, and general environmental degradation. Within a few years after the forest is cleared, the soil's productivity decreases significantly (Jordan 1985).

To sustain the productivity of tropical soils after the trees have been cleared and planting has begun, farmers must engage in extensive soil management techniques. For instance, fertilizers are necessary to supplement the micro and macro nutrients needed for proper plant development. Lime must be added to counteract the high acidity of the soil and render nutrients available for plant uptake. For optimum results, these fertilizers and lime should be applied in precise amounts based on the individual characteristics of the soil, as determined through scientific soil sampling and testing. Farmers should also practice crop rotation, which involves the successive planting of different types of crops on the same piece of land. Crop rotation has several important soil management benefits, including improved soil fertility, reduced pest and disease problems, and reduced soil erosion.

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[2] Bacteria, fungi, and other organisms quickly decompose the plant litter. The high heat and moisture of the rainforest also contribute to the breakdown of the plant litter (Hilton 1987).

[3] When tropical forests are cleared for agricultural use, the chopped trees are generally either mulched or burned. The material from the chopped trees contained most of the nutrients that supported the rainforest plants. These nutrients will be available in the short term, but the nutrients eventually disappear due to the intense rainfall that sweeps them away and through the process of leaching that transports them deep into the subsurface soil.

In many tropical settings, however, the farmers who practice slash-and-burn or slash-and-mulch agriculture often do not understand the inherent soil fertility problems and the challenges they will face because of these problems. And when the farmers realize the problems with soil fertility, many choose to clear-cut or burn another section of the fragile tropical land rather than invest in the necessary education and training, fertilizers, and soil testing that might remedy the problems. As a consequence, the majority of subsistence farmers do not take the necessary measures to sustain their crops, and they therefore experience substantially lower yields and less healthy crops over time following the removal of the native vegetation.

POOR SOIL CONDITIONS COMBINED WITH POOR CROP MANAGEMENT TECHNIQUES MOST LIKELY EXPLAIN MANY OF THE PROBLEMS ALLEGEDLY OBSERVED IN THE TEST PLAINTIFFS' CROPS.

The soils in this region are inherently poor tropical soils. The soils in the region at issue are generally classified as Acrisols (also known as Ultisols), which are highly weathered acid soils (Quesada 2009).

Acrisols (Ultisols) are dominated by low activity clays (Quesada 2009), and they are therefore characterized as low activity clay ("LAC") soils (Kang 1992). LAC soils are known to be fragile soils (Kang 1992). They exhibit a very strong tendency to fix phosphorus (Dixon 1989) – a necessary plant nutrient – thus rendering it unavailable for uptake by plants. LAC soils also have low effective cation exchange capacity (Dixon 1989; Kang 1992; Brady 2008) due to reduced surface charge density (Quesada 2009), meaning that such soils have very low concentrations of basic cations, such as calcium, magnesium, and sodium; and soil-nutrient absorption and release is largely dependent upon the continuous addition of soil organic matter, a cycle that has been interrupted in tropical, clear-cutting settings. The loss of organic matter and the acidification of the soil result in a decreased exchange capacity, and further loss of additional plant nutrients (such as calcium and magnesium) (Kang 1992).

Several soil studies performed on the Mestanza family's farm support the classification of the soil and the inherent fertility problems associated with Acrisols. I concur with these conclusions reached in each of these soil studies.

- The first study is explained in a technical report made following a visit to the region near the border with Colombia, dated February 27-29, 2004. The study indicates that soil and plant samples were collected from the Mestanza farm.[4] The report concluded that the "soil of Puerto Mestanza is poor, showing a nutritional imbalance along with aluminum and iron toxicity." The report also noted that the soil was also acidic, which the report (correctly) explained is characteristic of the Amazon region, and that this acidity negatively impacted the soil's absorption of nutrients needed for fertility and "creat[ed] a low cationic exchange capacity typifying deteriorated soil." The soil had an excess of

[4] The report indicates that plant samples were also collected from two other communities in Northern Ecuador, Corazon Orense and Santa Marianita.

potassium as compared to other soil nutrients and deficiencies in zinc and boron. The soil also had a "very low" level of organic matter content. The report explained that these characteristics would significantly impact the performance and productivity of agriculture; the crops would not grow normally, would tend to be small and deformed, and would be "largely susceptible to damage by pathogenic microorganisms." The report determined that the deformities in the mandarin samples collected from Puerto Mestanza were caused by the nutritional imbalances of the soil. In summary, the report stated, "The soil of the Puerto Mestanza area is poor, showing a nutritional imbalance along with aluminum and iron toxicity. The acidity of the soil from the Puerto Mestanza area makes it indispensible to engage in fertility management practices that neither increase soil acidity nor deteriorate soil further." In short, the soil in Puerto Mestanza experienced fertility problems that are typical of LAC soils that are not properly managed through appropriate farming practices.

- A second soil study from Puerto Mestanza confirms the findings of the first one just discussed. The date of the sample was July 9, 2003, and the interested party was listed as Victor Mestanza. As with the February 2004 soil testing discussed above, the soil sampling in July 2003 shows acidic soil, low nutrient levels, and toxic levels of iron. The acidic soil decreases the levels of necessary nutrients while causing iron toxicity, as reflected in the soil sample results. In addition, the texture of the soil is clayish, which is unfavorable for agricultural production.

Although Victor Mestanza alleges that his soil was good and productive before the Plan Colombia spraying close to his farm from 2000 to 2002, the kinds of soil problems revealed in the soil samples taken from his farm in 2003 and 2004 are typical of the region and would have been present *long* before the above-described testing was conducted. Mr. Mestanza's allegation that his poor soil was caused by the spraying between 2000 and 2002 lacks any scientific foundation as discussed in Section 3 below.

The test plaintiffs' farming practices are inadequate. Although soil fertility problems of LAC soils like Acrisols can be corrected with a combination of practices including liming, appropriate fertilization, and other measures (such as crop rotation) (Kang 1992), socioeconomic constraints often limit appreciation and application of these crop management technologies. Here, the testimony of the test plaintiffs, combined with my background knowledge of the primitive farming methods typically employed in similar areas, demonstrates that their crop management techniques were inadequate to compensate for the inherently infertile tropical soil.

For example:

- Elvia Alvarez testified that she has never used any fertilizer product on her crops (Dep. 19-21).

- Jorge Salas testified that he attended farming classes, but he claimed that no one explained to him the importance of using fertilizers, pesticides, and herbicides to grow crops in the Amazon (Dep. 76). Mr. Salas testified that he did not use any kind of herbicide to protect or chemical fertilizer to sustain his crops (Dep. 75-76).[5] His wife Laura Sanchez confirmed that fertilizer was never applied on their farm (Dep. 101-02), and pesticides were used only for ants and mosquitoes and not for the protection of their crops (Dep. 102-03).

- Santos Calero apparently did not use any chemicals at all on the Calero family's farm prior to the alleged damage by Plan Colombia spraying operations (Santos Dep. 64; Calixta Pineda (his wife) Dep. 100-03). Interestingly, the Caleros testified that the family currently uses urea and flora as fertilizer (Santos Dep. 62; Calixta Dep. 100-03), but the recent addition of these chemicals alone would not create suitable conditions for the sustained production of healthy crops in this tropical environment.

- Luciano Quevedo testified that the Quevedo family did not use any chemicals on their crops and that they had never applied any compost or chemical fertilizer (Dep. 32-33). His wife, Rosa Altamirano, gave similar testimony (Dep. 66). Neither Mr. Quevedo (Dep. 33) nor his wife has attended any classes on growing better crops (Dep. 66-67).

- Witness 37 testified that he never used any chemicals on his crops (Dep. 105). His grown son W 33 confirmed this (Dep. 54). The elder Witness 37 also testified that he never took any classes on how to grow better crops (Dep. 109).

- Edgar Balcazar testified that he applied urea fertilizer to his crops beginning in approximately 2005 or 2006; he used no other fertilizer (Dep. 32, 34-35). Precise application of other fertilizers and other chemicals besides urea would be needed to create and maintain fertile soil and good crop yields.

- Mr. Mestanza testified that he did not use fertilizers, herbicides, or pesticides on his crops during the decade between 1990 and 2000 prior to his alleged Plan Colombia spraying events (Dep. 28). And, despite the comparatively large scope of the agricultural endeavors undertaken by the Mestanzas, neither Mr. Mestanza (Dep. 30) nor his wife, Ercilia Bosquez (Dep. 32), has ever taken any classes on farming. Mr. Mestanza's failure to employ any real crop management practices (particularly because Mr. Mestanza's operations had allegedly been ongoing since he bought the land 20+ years ago) means that the tropical soil simply could not adequately support his crops, as the soil study results obtained from his farm (and discussed above) show.

In sum, the soil conditions in northern Ecuador and the test plaintiffs' farming practices are exactly what I would expect to see with subsistence farming in the tropics. None of the test plaintiffs appears to have practiced the intensive soil and crop management techniques that would be required to counteract the inherently infertile tropical soils of northern Ecuador. Therefore, I would expect numerous problems with their ability to plant, maintain, and produce yields from their crops. In my opinion, the combination of poor farming practices and infertile soils offers the most likely explanation for the test plaintiffs' alleged crop damages.

[5] Mr. Salas testified that he used insecticide and organic compost on his farm (Dep. 75-76), but these measures alone would be insufficient to overcome the many deficiencies of tropical soils.

THERE IS NO VALID SCIENTIFIC BASIS TO CONCLUDE THAT THE PLAN COLOMBIA SPRAY MIXTURE ADVERSELY IMPACTS TROPICAL SOIL FERTILITY.

Some if not all of the test plaintiffs allege that, for years following the Plan Colombia aerial eradication missions purportedly conducted on or near their property, they were unable to successfully plant, replant, and maintain crops, and they variously speculate that the soil was adversely affected by exposure to the Plan Colombia herbicide. These speculations are groundless. Even assuming for purposes of this analysis that some amount of the Plan Colombia herbicide did reach the test plaintiffs' soil, it would not fundamentally alter the soil's fertility or their crops' ability to grow in that soil.

Glyphosate, the active ingredient in the Plan Colombia spray mixture, binds ("adsorbs") very strongly to soil particles and other organic matter contained in the soil (Sprankle 1975; Glass 1987; EPA RED 1993; Giesy 2000). Consequently, once applied to the soil, glyphosate is essentially immobile, meaning that it is unavailable for uptake by plants (Sprankle 1975; Prata 2005).[6] Following soil deposition, glyphosate is readily degraded by soil microbes to its main metabolite (AMPA) (Araújo 2003), which is then degraded into carbon dioxide (Sprankle 1975; EPA RED 1993; Giesy 2000). Given that glyphosate (and its metabolite) is bound in and/or degraded by the soil, it is widely recognized that glyphosate will exert no direct phytotoxic effects on any plant following deposition on the soil (Duke 2008). Indeed, glyphosate's inability to affect plants/crops following application to the soil explains the common use of glyphosate-based herbicides to prepare fields for planting (Giesy 2000). Surfactants like POEA and Cosmoflux are routinely mixed with glyphosate for such pre-till applications and likewise have no adverse impacts on the soil.

Although some have theorized that glyphosate can adversely impact soil microbes and disrupt the crops' ability to gather essential nutrients from the soil, reliable research has not borne out these theories. Such hypotheses are contradicted by a number of studies (Müller 1981; Bromilow 1996; Busse 2001; Haney 2002; Motavalli 2004; Ratcliff 2006; Weaver 2007) and disproved by (1) the routine use of glyphosate-based herbicides in field preparation activities and (2) the continued vitality of the U.S. commercial agriculture, which is dependent upon the regular use of glyphosate-based herbicides in Roundup Ready crops (Duke 2008).

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[6] Because glyphosate is immobile in soil, this also prevents it from leaching from the soil into groundwater. However, I understand that other experts will fully address the environmental fate and transport of glyphosate, and so I will limit my discussion in this area to glyphosate's (lack of) effects on soil.

Thus, the test plaintiffs' claims that the Plan Colombia herbicide somehow caused their soil to be less fertile, resulting in substantially lower crop production, is scientifically unsupported and unsupportable in my opinion.

Dated: 01/19/2011

Asmare Atalay
Asmare Atalay, Ph.D., CPSS

CR Note: Dr Atalay's CV (Exhibit A), found in CD - Original Annexes

EXHIBIT B

Asmare Atalay, Ph.D. Materials Considered

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Other Materials Considered

1) Binder of all Test Plaintiffs Full Deposition Transcripts.

2) Map showing approximate area of general test plaintiff location in northern Ecuador.

3) Mission Verification Reports on Illicit Coca Crop Spraying Operations. 10th-13th and 15th-19th Reports. Bates labeled DOS-00000054 through DOS-00000412.

4) A binder for each test plaintiff family, provided by defense counsel, containing:

   A) a table with citations to claims of crop damages in certain evidentiary submissions of the test plaintiffs (initial disclosures, questionnaire responses, declaration of Marco Campana, deposition testimony excerpts, Accion Ecologica toxicology sheet and survey)

   B) the following information for each test plaintiff (if applicable to the test plaintiff and/or family):

      i) initial disclosure

      ii) questionnaire responses

      iii) excerpt from the Marco Campana declaration specific to each plaintiff

iv) all deposition testimony excerpts re alleged crop damages and related issues

v) other test plaintiff-specific information relating to their alleged crop damages (e.g., photographs and/or video, excerpts from prior lawsuits, prior certifications, Accion Ecologica toxicology sheet and survey lab tests taken from their region and related government announcements.)

vi) excerpts of certain non-governmental organization and other third party reports that mention the test plaintiffs or the areas in which they live with respect to crop damages

C) soil and water sampling results relevant to each family

D) a map showing the approximate location of the test plaintiffs' farm and spray lines (if any) for the dates of spray exposure alleged by any of the family members in their depositions

Annex 12

Expert Report of Dr J.P. Giesy, Ph.D. on Behalf of the Defendants in *Arias/Quinteros v. Dyncorp*, 11 January 2011

(United States District Court for the District of Columbia,
Cases No. 1:01-cv01908 (RWR-DAR) and 1:07-cv01042 (RWR-DAR).
Cases consolidated for Case Management and Discovery)

EXHIBIT 6

Expert Report of John P. Giesy on behalf of the Defendants in *Arias/Quinteros v. DynCorp*

I Expert Credentials

A. General Professional Credentials

I am John Paul Giesy, Ph.D., FRSC. My business address is: Toxicology Centre and Department of Veterinary Biomedical Sciences, Western College of Veterinary Medicine, University of Saskatchewan, 44 Campus Drive, Saskatoon, Saskatchewan S7N 5B4, Canada. I am professor and Canada Research Chair in Environmental Toxicology at the University of Saskatchewan. I teach graduate-level classes, advise graduate students and post doctoral fellows and conduct my own research.

In addition to my primary position as professor and Canada Research Chair at the University of Saskatchewan, I hold the following appointments: 1) Emeritus Distinguished Professor of Zoology, Michigan State University; 2) Chair Professor at Large, City University of Hong Kong, Hong Kong, China; 3) Concurrent Professor, Nanjing University, Nanjing, China; 4) Guest Professor, State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China; 5) Distinguished visiting Professor, King Saud University, Riyadh, Saudi Arabia; 6) Honorary Professor, School of Biological Science, University of Hong Kong, Hong Kong, China.

I received my B.S., *summa cum laude*, with honors in biology, from Alma College, Alma Michigan in 1970. I then received my M.S. in fisheries and wildlife with a specialization in limnology, from Michigan State University in East Lansing, Michigan in 1971. I received my Ph.D. in fisheries & wildlife (limnology) from Michigan State University, East Lansing, Michigan in 1974. Limnology is the scientific study of bodies of fresh (inland) water for their biological and physical and geological properties with a specialization in environmental chemistry.

I have been working in the fields of environmental toxicology and environmental chemistry for 40 years. I am an ecotoxicologist and environmental chemist with particular expertise in the areas of environmental fates of pollutants, including both inorganic and organic residues.

I have published 712 peer-reviewed works: 78 book chapters, 560 peer-reviewed open literature journal articles, 5 feature articles, 3 theses, 7 books written, 10 books edited, 1 textbook chapter, 4 published reviews, 24 published reports, and 20 special reports. I am among the top 0.001% of most cited active authors in the world (ISI) and the 2nd most cited author in the world in the combined fields of Ecology and Environmental Sciences (during the last period the ranking was published: 1997-2007), with an h-index of 63, based on a total of over 15,000 citations to my published works. A complete listing of my publications is included in my CV, which is attached hereto as Exhibit A.

I have received a number of awards and distinctions. These are detailed on pages 5-9 in my CV. A few of the awards and distinctions that I have received include the *Founder's Award*, which is the highest recognition given globally by the Society of Environmental Toxicology and Chemistry (SETAC) for scientific excellence. I have also received the *Education Award from SETAC* for my impact on the global science of ecotoxicology. I am the recipient of the *Vollenweider Medal from Environment Canada* for excellence in environmental sciences and the *Sir John Randal Award* from the Royal Soil Science Society. Most recently I was elected to the status of *Einstein Professor* by the Chinese Academy of Sciences. A number of the papers that I have authored have been designated the best paper for a particular year by several leading journals. I am a fellow of the Royal Society of Canada, in the Academy of Sciences Division of Earth, Ocean and Atmospheric Sciences, Discipline of Earth Sciences.

B. Herbicide/Agrochemical/Glyphosate Expertise

I am an expert in the fates and effects of insecticides and herbicides. I was the director of environmental effects research in aquatic systems of the Pesticide Research Center at Michigan State University from 1981 until 1997. I have conducted a number of field and laboratory studies on the movement of herbicides in the environment and their potential for effects on wildlife including fish. I am also an expert on environmental risk assessments and in particular wildlife toxicology working with fish, mammals and birds. My attached CV contains the details of the studies I have conducted and the oral and written presentations that have resulted from that research.

In regard to the current issue, I am considered to be one of the world's authorities on the herbicide Roundup® and its active ingredient Glyphosate® and associated adjuvants. I published the following paper: Giesy, J. P., S. Dobson and K. R. Solomon. 2000. Ecological Risk Assessment for Roundup Herbicide. *Rev. Environ. Contam. Toxicol*. 167:35-120, which is paper number (JA-228) in my CV.

C. Environmental Fate and Transport Expertise

In addition to my work with herbicides and insecticides referenced above, I have conducted a number of studies into the fates and environmental distribution of contaminants, including both organic and inorganic chemicals. I have developed and applied models of environmental fates and applied these to assess the rate of dissipation of organic residues and the ultimate disposition of organic residues such as pesticides and herbicides in both the soil and aquatic environments. The specifics of my experience are listed in my CV.

D. Aquatic Toxicology Expertise

I was trained as a limnologist (the study of water) and fisheries biologist. Both my M.S. (1971) and Ph.D. (1974) are in the area of aquatic ecology and limnology. Subsequent to attaining my advanced degrees I have been working as an aquatic toxicologist for the last 36 years. I am considered to be one of the preeminent aquatic toxicologists in the world. In 2010 I received the Distinguished Honorary Professor Award from King Saud University, as the leading environmental toxicologist in the world. The details of my studies and publications on issues involving aquatic toxicity are set forth in my CV.

E. Compensation and Prior Expert Work

I am being compensated for my work in this matter at a rate of $350/hr. Over the past four years, I have served as a testifying expert in the following matters:

1. Expert witness for City of Prince Albert, in the Court of Queen's Bench for Saskatchewan Q.B. No. 852 of 2000 between Strand Theatre Ltd. (Plaintiff) and the City of Prince Albert (Defendant).

2. Expert witness for Monsanto Co., In the Circuit Court of Putnam County, West Virginia, in Zina G. Bibb et al., (Plaintiffs) Civil Action No. 04-C-465 Against Monsanto Co., Pharmacia Corp., Akzo Chemicals, Inc., and Flexsys America Co., (Defendants).

3. Expert witness for the Crown, in the case of Mary Williams (Plaintiff) vs. Attorney General of Canada and Minister of National Defense, in the Supreme Court of Newfoundland and Labrador, Canada (T2880 CP, 2006).

II. Summary of Expert Opinions

I have been asked to review the individual plaintiffs' claims of mortality of fish and domestic animals, with specific reference to claims made by the Mestanza family,[1] and based on the information presented by the plaintiffs and the scientific literature, to assess the likelihood that the alleged mortalities could have occurred due to spray drift or overspray with the Plan Colombia herbicide mixture used to control coca in Colombia. My assessment has focused on those species that I understand the Mestanzas and/or other test plaintiff families alleged were killed by the spraying operations. These include two species of fish, cachama and tilapia, and a variety of domestic farm animals, including chickens, ducks, sheep, pigs, cattle, dogs, and horses, among others.

[1] I focused my analysis on the Mestanza family because their farm was in the closest proximity to Plan Colombia spraying operations at the time of their alleged damages compared to the rest of the test plaintiffs. My opinions herein, however, are equally applicable to the other test plaintiffs, whose claims arise from even more distant Plan Colombia spray operations.

In response to this charge, I have reviewed the plaintiffs' claims and the available literature both in the peer-reviewed literature and government documents to assess both the potential duration and magnitude of exposure to and the potential toxicity of Glyphosate® and the associated adjuvants included in the Plan Colombia herbicide mixture. Where possible, I have used dose-response information for the same formulation used and for the species of concern. I have then compared the estimated maximal exposure to thresholds for adverse effects.

Based upon my review and analysis, I have reached the following opinions:

1. There is no scientific basis to opine that the herbicide mixture used in "Plan Colombia" would be transported through soil or water or would persist in the environment.

2. There is no scientific basis for the Mestanza plaintiffs' claims that the Plan Colombia spraying operations could have caused the alleged fish kill of cachama or tilapia.

3. There is no scientific basis for plaintiffs' claims that the Plan Colombia spraying operations could have caused the alleged deaths of farm animals.

The sources of information that I have considered in reaching my export opinions are cited herein and are listed in Exhibit B.

III. Fate and transport of the three ingredients in the Plan Colombia herbicide (Glyphosate® and its degradation product AMPA, POEA, and Cosmoflux 411F®) in the environment.

The fate or movement of a chemical in the environment is referred to as its chemodynamics and is determined by both the physical-chemical properties of the compound and the environment to which it is released. Here I discuss some of the properties of Glyphosate®, and associated constituents in the Plan Colombia herbicide mix, which determine its fate in air, as well as aquatic and terrestrial environments. I also discuss some of the properties of the specific environments to which it is alleged to have been released and the effect that those properties have on the biological availability and dissipation rates of Plan Colombia herbicide mix and its component parts.

The Plan Colombia herbicide mixture is 44% Roundup®, which includes 41% Glyphosate®, 15% POEA, and 44% water, to which 1% Cosmoflux 411F®, is added and the remaining 55% is made up of water (DOS 2002). The final Plan Colombia mixture contains 18% Glyphosate®, 8% surfactants (1% Cosmoflux 411F®, 7% POEA) and 74% water. *Id.* The available data on the physical and chemical properties of the active ingredient, Glyphosate®, have been reviewed extensively (Mackay et al. 1997).

A. Spray Drift

I understand that the potential drift of herbicide from Plan Colombia aerial coca eradication operations is being addressed by another expert. In light of this, and in light of the fact that my risk assessments demonstrate that even direct overspray of Plan Colombia herbicide could not have caused the alleged deaths in fish and farm animals, I will not address the issue of drift in this report.

B. Mobility in Soils and Water

1. Mobility of Glyphosate.

Although Glyphosate® is very soluble in water, its strong sorption to soil limits mobility (Giesy et al. 2000). Consequently, Glyphosate® is unlikely to leach into groundwater or runoff from soils into surface waters after application (Borggaard and Gimsing 2007). Glyphosate® is an amphoteric compound with several pK_a (acid dissociation constant) values. In other words, Glyphosate® can act as either an acid or a base and can be bound with either acids or bases of varying strengths. The amphoteric nature of Glyphosate® accounts for its relatively great K_d (strength of bond) for binding to soil particles. Primary sites of binding are aluminum and iron oxides. Because of this characteristic, Glyphosate® herbicides are effective only when applied directly to the plant surface. Once Glyphosate® enters soil it is essentially unavailable to plants due to its very high affinity for soil. This explains why Glyphosate®-treated areas can be planted with crops soon after application. For this reason Glyphosate® would not have residual effects on crops planted in soil that had been sprayed with Glyphosate®, and Glyphosate® bound to soils in this way is not mobile in the environment. Also, the very tight binding of Glyphosate® to soils limits its bioavailability to animals walking on or even ingesting soil.

The primary degradation product of Glyphosate® that is of any toxicological interest is Aminomethylphosphonic acid (AMPA). While Glyphosate® is tightly bound to soils and is not readily available to cause toxicity to plants or animals, it is still degraded by microbes to AMPA, which is in-turn bound to soils but also degraded.

2. Mobility of Poly-ethoxylated Tallow-amine (POEA).

Based on information on adsorption and degradation of the POEA adjuvant used in Roundup®, leaching and runoff potential is expected to be small. POEA strongly adsorbs to soil. When the binding of POEA is normalized to the carbon content of soils, the K_{oc} values in three different soil types were estimated to range from 2500 to 9600 (Marvel et al. 1974). POEA that was adsorbed to soil was not readily desorbed; even using ammonium hydroxide as the extracting solvent removed less than 20% of the POEA adsorbed to soil. Thus, the mobility of POEA in soil is expected to be less than 2% (Giesy et al. 2000).

3. Mobility of Cosmoflux 411F.

Cosmoflux 411F® is added to the Plan Colombia mix to facilitate penetration of Glyphosate® through the waxy cuticle of plant leaves. Cosmoflux 411F® is a mixture of surfactants, including linear and branched nonionic polyethoxylates and isoparafins (Solomon et al. 2007; CosmoAgro 2003). The active ingredients in Comsoflux 411F® are polyol, fatty acid esters and polyexothylated derivatives, which make up 17% of the product. The remaining 83% of the product is made up of liquid isoparaffins.

I do not have direct data on the mobility of Cosmoflux 411F® in soils and water. However, in general, non-ionic polyethoxylate based surfactants like Cosmoflux® would be expected to adsorb readily to soil and sediment and are unlikely to bioaccumulate because of their low solubility in water (Krogh 2003; R. Van Compernolle 2006).

C. Degradation.

1. Degradation of Glyphosate®.

Glyphosate® is fairly rapidly degraded in soil and the rate of degradation is directly proportional to temperature. Thus, at higher soil temperatures, the rate of degradation is greater. The results of both field and laboratory studies have demonstrated microbial degradation of Glyphosate® in water and rapid decreases in concentrations in both flowing (lotic) and standing (lentic) waters (Giesy et al. 2000). Glyphosate®, which consists of glycine and phosphono-methyl moieties, degrades to glycine, sarcosine and the primary Glyphosate® metabolite, AMPA (Giesy et al., 2000), which can also be degraded by microbes (Rueppel et al. 1977). While it is important to understand the degradation pathways of Glyphosate® in the environment, this information is not critical to address the issue of acute lethality alleged to have occurred at the Mestanza farm or the farms of the other plaintiffs. However, the rapid degradation of Glyphosate® to AMPA, which in turn is further mineralized to non-toxic constituents, is noteworthy in that it precludes the possibility of any residual effects. That is, any presence of Glyphosate® in soil would dissipate over a relatively short time after the initial application. Indeed, one of the most useful properties of Glyphosate® when it is used in agriculture and one of the reasons for its widespread use is that Glyphosate® is so rapidly deactivated on the surface of soils, that crops can be seeded directly with or shortly after the application of Glyphosate®.

2. Degradation of POEA.

When degradation of POEA was investigated in three soils (silt loam, silt-clay loam, and sandy loam), microbial degradation was the primary process of dissipation, with minimal degradation occurring under sterile conditions (Marvel et al. 1974). The estimated degradation half-life for POEA in soil was less than 1 week and possibly as short as 1 or 2 days. In natural water containing suspended sediment, such as lakes, ponds, and rivers, POEA is degraded through microbial processes (Banduhn and Frazier 1974). The general half-life of POEA has been estimated to be less than 3-4 weeks (*See also* Giesy 2000).

3. Degradation of Cosmoflux 411F®.

I am not aware of any degradation studies on Cosmoflux 411F®, but non-ionic nonionic polyethoxylate based surfactants like Cosmoflux 411F® have been found to be readily biodegradable (Jurado 2007; Krogh 2003; Řezníčková 2002).

D. Studies of Environmental Fate and Transport of the Plan Colombia herbicide mixture

1. Soil and Water Testing by the Colombian Government

There is an extensive quality assurance program in place to assure that the Plan Colombia aerial coca eradication operations are conducted in a manner that minimizes the potential for adverse effects of non-target plants and off-site wildlife and people (Colombia Ministry of Environment, Housing and Regional Development 2004). Monitoring has demonstrated that the program is being strictly managed to the specifications outlined in Ministry directives. When off-site effects have been reported, they have been either unsubstantiated or found to be minimal. The Colombian Ministry of Environment states that "The drift effects that were observed in areas visited on a random basis were temporary in nature and small in extent and basically consisted of partial defoliation of the canopy of very high trees. No complementary collateral damage from spraying activities was observed at the sites selected and verified" (Colombia Ministry of Environment, Housing and Regional Development 2004; *see also* DOS 2007).

During Plan Colombia operations, extensive monitoring of both soils and water has been conducted. These studies have examined concentrations of both the active herbicidal ingredient used in the Plan Colombia mixture, Glyphosate®, and adjuvants on soils and surface waters. During monitoring of locations where Plan Columbia herbicide mixture was sprayed to eradicate coca, concentrations of Glyphosate® and its degradation product AMPA in water have in all cases been less than the concentration established to protect human health (Solomon et al. 2007).

2. Soil and Water Testing by the Ecuadorian government

In 2004, the Ecuadorian government conducted sampling campaigns along the border with Colombia to determine if there was any migration of Glyphosate® from Plan Colombia aerial eradication operations near the Colombia-Ecuador border to either water or soils on the Ecuadorian side of the boarder. Glyphosate® was never detected in water or soils during any of this monitoring (Ecuador Atomic Energy Commission Reports 2004).

E. Conclusions on the fate and transport of Plan Colombia herbicide

1. Aquatic environments.

In aquatic environments Glyphosate® would be expected to rapidly bind to suspended solids and organic matter and become inactivated. This would be especially true in shallow ponds where the surface area of the sediments is large relative to the volume of water. Furthermore, in shallow fish ponds there is significant turbidity (cloudiness in the water), which would further reduce the available fraction of Glyphosate® and its associated adjuvants. In fact, due to dilution and the fact that Glyphosate® would not be able to be maintained at a sufficient concentration on the surface of aquatic macrophytes, Glyphosate® is generally considered to be ineffective against aquatic plants at concentrations used to treat terrestrial plants (McClaren Hart Environmental

1995). The primary degradation product of Glyphosate®, AMPA, would be expected to react similarly.

2. Terrestrial environments.

In terrestrial environments, Glyphosate® is quickly (within a few hours) tightly bound to soil such that it is not biologically available and thus not toxic. AMPA would be expected to behave in a similar manner.

Based on these observations and knowledge of the chemical/physical properties of the constituents in the Plan Colombia herbicide formulation, and the studies referenced above, there is no scientific basis to conclude that there was any meaningful transport of the Plan Colombia herbicide mixture outside the areas in which it was sprayed and certainly no scientific basis to conclude that there was any trans-boundary migration or accumulation of Plan Colombia herbicide mixture sprayed in Colombia in soils or water in Ecuador.

IV. Methodology of Toxicology and Hazard Assessments

Toxicity of chemicals to animals is a function of duration and intensity of exposure (the dose to which they are exposed). Reciprocity between duration and intensity of exposure exists such that organisms can be exposed to some concentration of chemical for some period of time without adverse effects. The reciprocity relationship states that there is some concentration for each duration of exposure and some duration for each magnitude of exposure that relates to the threshold for effects. The incipient lethal concentration is the concentration less than which an organism or population of organisms can be exposed for an infinitely long period of time without dying. The incipient lethal time is the duration to which an organism can be exposed to even the greatest concentration of chemical possible (water solubility limit) without adverse effects. The conclusion from this line of reasoning is that all animals can be exposed to any chemical for some period of time or to some concentrations without adverse effect. Said another way, simply because an organism is exposed to a chemical does not mean that there will be an adverse effect on that organism.

The strength of a toxicant is defined as its potency. Chemicals for which a greater concentration are required to cause the same level of effect during the same duration of exposure are less potent (less toxic), while those that require less are more potent.

Toxicity testing can be conducted in basically two ways. The first way is to determine the concentration required to cause some level of effect, such as 50% lethality at some set duration of exposure, such as 4 days (96 hr). The second way is to determine the duration to which an organism can be exposed to a defined concentration before an adverse effect occurs. In the United States, the standard method of reporting toxic potency of chemicals is to express the acute toxicity as the concentration required to cause 50% lethality. Shorter durations of exposure such as 96 hr are referred to as acute exposures, while longer durations of exposure, such as 21 or 28 days are referred to as chronic exposures. Similarly, toxicity can be defined as either acute or chronic depending on the duration of exposure. Greater concentrations of chemicals are required to cause toxicity in shorter periods of time. Because the effects claimed in this instance were stated to have occurred in a short period of time, the appropriate duration of exposure is acute or short-term. Thus, I will define the relevant duration of exposure as less than 96 hr or 4 days and use the results of acute lethality tests as the relevant toxicity information for my assessments.

There are a number of endpoints or measures of effect that can be used. These range from biochemical or molecular changes to histological changes or effects on growth or reproduction. To be an effective measurement endpoint, the response or effect must be ecologically relevant. The primary ecologically relevant endpoints are survival, growth, and reproduction. Because the effect claimed in this case for fish and animals was lethality, mortality is the most relevant endpoint to consider. For the purposes of this assessment, the measurement endpoint that is relevant is acute lethality. Other more subtle effects are not relevant and will not be considered.

Hazard is a property of chemicals and represents the toxic potency of a chemical. The relationship used to determine hazard is the dose-response relationship. This is a measure of how much effect was observed at a particular concentration for a specified period of time. If there is no exposure, even if a chemical is very hazardous, there is no response or effect. Alternatively, if there is exposure, but the exposure does not exceed the threshold for effect, there is no response. For a chemical to cause an adverse effect on an organism there must be an exposure at a level that gives rise to a hazard. In a risk assessment the probability of these two conditions occurring is investigated and it is determined if there is overlap between the two necessary conditions of exposure and hazard.

For this reason, estimated concentrations of the constituents of the Plan Colombia formulation will be compared to the median acute toxicity value (LC-50) which is the concentration of the constituent or mixture required to kill 50% of individuals exposed for 96 hr.

The process of assessing the likelihood that exposure to a chemical will affect an organism is referred to as a hazard assessment. In hazard assessments, point estimates of predicted concentrations in the environment are compared to the LC-50. Alternatively, in a risk assessment, the probability of exposure to a chemical resulting in an adverse effect is determined by estimating the probability of effects. Risk assessment is a more complicated assessment that determines the chance that a particular outcome will occur and is not relevant in the current case because the claimed effect was lethality of fish and animals. Here I will apply the methodologies for hazard assessments which include the following elements: (1) determination of exposure (duration and magnitude) and (2) hazard (potency of the chemical or mixture). Exposure is the determination of the concentration that would likely have occurred in the environment and for how long it would have occurred. Hazard is the relationship between exposure concentration and duration (*i.e.*, dose) and adverse effects. The hazard assessment determines the likelihood of the duration and magnitude of exposure exceeding the combination that will result in adverse effects.

The most basic form of hazard assessment is the calculation of the hazard quotient (HQ), which is the ratio of the measured or estimated (predicted) concentration of a chemical or mixture in the environment divided by the measure of potency such as the LC-50.

V. Toxicity of Plan Colombia Herbicide and Its Constituents to Vertebrate Animals

In its annual Certifications to the US Congress, the United States Department of State, in consultation with the US Environmental Protection Agency, has provided detailed information regarding the potential toxicity of the Plan Colombia herbicide. Certifications issued in 2002, 2003, 2004, 2005, 2006 and 2007 have all reported that "The herbicide mixture, in the manner it is being used, does not pose unreasonable risks or adverse effects to humans or the environment, including endemic species" (DOS 2007). While I concur with these conclusions, I will present my own site-specific analysis of the claims made by the Mestanza plaintiffs. This analysis applies as well to the claims made by the other test plaintiffs who were more distant from Plan Colombia spraying operations at the times of their alleged exposures. The characteristics of spray-drift deposition is such that the plaintiffs whose properties are further from the border, or from actual spray events, would be exposed to less deposition of Plan Columbia mix than the Mestanza property. Thus, if it is determined that there would be no effects on the Mestanza property, by logic there would be no effects on the other properties. As noted below, however, it is my opinion that the alleged deaths of animals could not occur even in the event of multiple direct over-sprays.

The standard herbicide formulation referred to as Roundup® is a mixture of the active herbicidal ingredient Glyphosate® and the adjuvant polyoxylated tallow-amine (POEA). POEA is a cationic surfactant that helps the Glyphosate® stick to and or penetrate the waxy surfaces of vegetation, thus making it more effective. The Plan Colombia formulation is made up of Roundup® and the surfactant Cosmoflux 411F®. Over time, Glyphosate®`, POEA, and Cosmoflux 411F® degrade and dissipate at different rates, so for longer-term or chronic exposures, it would be appropriate to consider the toxicity of the individual components separately. For short-term or "acute" exposures, such as those at issue in this case, however, it is more appropriate to consider the toxicity of the applied mixture as a whole. In my analysis, I have accordingly considered toxicity studies of the Plan Colombia herbicide mixture, of Roundup® (i.e., the formulation of Glyphosate® and POEA) and of the individual components of the Plan Colombia herbicide mixture. I will rely primarily on the threshold for acute (96 hr) lethality, but use the information on effects of constituents or chronic effects of the mixture or of individual constituents as collateral information as appropriate to inform my conclusions.

A. Toxicity of Glyphosate® and Roundup® (Glyphosate® plus POEA)

The toxicity of Glyphosate® and of Roundup® has been extensively studied and is well understood. The mechanism by which Glyphosate® is toxic to plants has been reported in detail (Franz et al. 1997; Cole 1985). Glyphosate® inhibits plant growth by inhibiting the production of essential aromatic amino acids through competitive inhibition of enolpyruvylshikimate phosphate (EPSP), a key enzyme in the shikimic acid pathway for the synthesis of chorismate, which is a precursor for the essential amino acids phenylalanine, tyrosine and tryptophan. While necessary for plant life, these amino acids are not synthesized by vertebrates, either aquatic or terrestrial. For that reason, Glyphosate® is toxic to plants, but is not toxic to vertebrate animals (Giesy et al. 2000; Williams et al. 2000).

Formulations of Glyphosate®, including Roundup® herbicide (Monsanto Company), have been extensively investigated for their potential to produce adverse effects in non-target organisms. Governmental regulatory agencies, international organizations, and others have reviewed and assessed the available scientific data for Glyphosate® formulations, and independently judged their safety. Conclusions from three major organizations are publicly available and indicate Glyphosate®-based herbicides can be safely used without effects on humans or wildlife. Glyphosate®-based herbicides such as Roundup® can be used with minimal risk to the environment (Agriculture Canada 1991; USEPA 1993; WHO 1994). These documents have been extensively peer-reviewed and the information and discussions in these reviews served as foundation for the current assessment. Several review articles on the fates and effects of Roundup® or Glyphosate® in the environment have been published (Carlisle and Trevors 1988; Smith and Oehme 1992; Malik et al. 1989; Rueppel et al. 1977). In addition, several books have been published about the environmental and human health considerations of Glyphosate® and its formulations (Grossbard and Atkinson 1985; Franz et al. 1997). In addition, Roundup® and other Glyphosate® formulations have been selected for use in a number of weed control programs for state and local jurisdictions in the United States. Many of these uses require that ecological risk assessments be conducted in the form of Environmental Impact Statements or Environmental Assessments. These documents are comprehensive and specific to local use situations. Documents are available for risk assessments in Texas, Washington, Oregon, Pennsylvania, New York, Virginia, and other States (USDA 1989, 1992, 1996, 1997; USDI 1989; Washington State DOT 1993). Finally, the properties and toxicity of Glyphosate® have been reviewed extensively (Giesy et al. 2000; Williams 2000).

B. Toxicity of Polyethoxylated Tallowamine (POEA)

Polyethoxylated tallow-amine (POEA) is the surfactant added to many formulations with Glyphosate®. Isoparaphyns are not very toxic to mammals (Mullin et al. 1990) and have been described as essentially nontoxic. Oral LD_{50} values have been reported to be in the range of 3 to 15 g/kg body weight. There is little dermal absorption and the most relevant pathway of exposure is through inhalation. Isoparaphyns are not genotoxic. While POEA can cause eye and skin irritation, it is fairly non-toxic relative to lethality. While POEA was found to not be genotoxic or cause developmental toxicity in rat pups, it did cause lethality to adult rats during chronic exposures to concentrations greater than 100 mg/kg, bw/day (Giesy et al. 2000).

C. Toxicity of Cosmoflux 411F®

Information on the toxicity of Cosmoflux 411F® is less extensive, but likewise indicates very low levels of toxicity to vertebrate animal life. As reported by the U.S. Department of State in consultation with the U.S. EPA, in acute toxicity studies on rats, the LD_{50} of Cosmoflux 411F® was determined to be 31,600 mg/kg, which is practically non-toxic. (Jacobson 2001). As discussed more fully below, in a separate study, Cosmoflux 411F® was found to be similarly non-toxic in the fish species cachama, with an 96-hr LC_{50} of 4,418 mg/L (Rondón-Barragán et al. 2007).

D. Toxicity of Plan Colombia Herbicide

The acute lethality of the Plan Colombia herbicide mixture to rats via acute dermal, oral and inhalation exposure was tested in two sets of studies conducted in the United States and Colombia (Bonnette 2003a-d; Cruz 2003a-b). The acute oral and dermal LD_{50} was > 5,000 mg/kg bw. This means that no toxicity was observed even at the greatest dose tested. The acute inhalation LC_{50} ranged from 2.5 to 20 mg/L, which similarly classifies the mixture as non-hazardous.

The acute lethality of the Plan Colombia herbicide to four standard aquatic organisms used in toxicity tests were determined for the green alga (*Selenastrum capricornutum*), the water flea (*Daphnia magna*), the rainbow trout (*Onchorhyncus mykiss*) and the fathead minnow (*Pimophales promelas).* The median toxicity expressed as the LC_{50} or EC_{50} (*S. capricornutum*) for these four organisms were 2.2-5.7 mg/L (Stantec, 2005e), 4.2 mg/L (Stantec 2005b), 1.8 mg/L (Stantec 2005d) and 4.6 mg/L (Stantec 2005c), respectively. These findings indicate that the Plan Colombia herbicide mixture has an aquatic toxicity profile similar to that of Roundup® formulations used in the United States.

A number of studies have been conducted of the effect of the Plan Colombia herbicide on frogs under controlled laboratory conditions and under field conditions or in mesocosms (experimental water enclosures) meant to be more realistic. Under laboratory conditions of constant exposure in the absence of any sediment substratum, when 8 species of frog endemic to Colombia were tested, the LC_{50} values for the Plan Colombia herbicide ranged from 1.2 to 2.8 mg a.e./L (Bernal 2009b). In the field or in mesocosms (in which the herbicide has the opportunity to become bound to sediments or otherwise be degraded or dissipated) the LC_{50} values ranged from 6.0 to 7.3 mg a.e./L (Bernal 2009b). Similarly, when frogs were exposed in smaller containers that also included sediment in the bottom, the LC_{50} ranged from 4.5 to 22.8 kg/ha, which is the equivalent of 3.0 to 15.3 mg/L, respectively (Bernal 2009b).

Based on this information, the Plan Colombia formulation would be classified as very low potency as a toxicant, relative to that of other chemicals, especially pesticides.

V. Toxicity of the Plan Colombia Herbicide and Its Constituents to the Fish at the Mestanza Fish Farm (Tilapia and Cachama)

The sensitivity to Roundup® varies among fishes with the four-day (96 hr) median tolerance limit (LC-50) ranging from approximately 2.3 to 54.8 mg/l (Folmar et al. 1979). A detailed discussion of mechanisms of toxicity and toxicity to other organisms can be found in a paper I published (Giesy et al. 2000). For purposes of this report, I will focus on the toxic potency of Glyphosate®, Roundup®, and the Plan Colombia mixture to the two fish species, tilapia and cachama, that are alleged by Mr. Mestanza to have been killed through exposure to the Plan Colombia herbicide. Because it was alleged that the fish died within less than a day of the alleged spray-drift events, I will focus on studies measuring acute toxicity.

A. Toxicity of Roundup® to Cachama and Nile Tilapia:

The toxicity of Roundup to tilapia has been studied in both acute and chronic exposure scenarios (Jiraungkoorskul et al. 2003). For acute exposures, the 96 hr LC_{50} was 16.8 and 36.8 mg/L Roundup® for young and adult Nile tilapia, respectively. For chronic toxicity, Jiraangkoorskul et al. (2003) exposed tilapia to 5 or 15 mg Roundup®/L for three months and examined some biochemical and histological responses. A range of effects were observed to occur that could be useful as forensic diagnostic tools, but these results are not germane to acute lethality, which I understand to be the issue in this case. What is an important result of this study is that exposure to concentrations of the formulation of Roundup® herbicide as great as 15 mg/L did not cause any ecologically relevant effects on either survival or even growth. The effects were more subtle effects on enzyme activities in the liver and changes in the cellular structures of liver, kidney and gills. These responses were likely adaptive in nature and are consistent with a lack of effects on survival or growth at concentrations of Roundup® as great as 15 mg/L. Relative to mortalities alleged to have occurred in the Mestanza fish ponds, even a prolonged exposure of at least 3 months to 15 mg/L would not have been expected to have caused any relevant effects that would have affected the number or mass of fish available for sale.

Other studies have reported similar findings. In one study, no acute toxicity (lethality) was observed in tilapia at doses of 1, 5, or 15 mg Roundup®/L (mg/l; ppm) but 100% mortality was observed at 45 mg Roundup®/ L, within a few hours (González, 2007). In another study, the 96 hr LC-50 for toxicity of Roundup® to tilapia was 7.4 mg Roundup®/L (Liong, 1988). These toxicities are expressed as concentrations of the active ingredient ("a.i.") Glyphosate® in the presence of POEA.

The acute lethality of Roundup® to cachama as well as other measurement endpoints, such as histopathology and physiological responses, was measured by Ramirez et al., 2008. The 96-hr LC-50 for cachama exposed to Roundup® was 97.47 mg /L Roundup®, which makes the cachama almost two times more tolerant of exposure to Roundup® than for most other fishes for which information is available (Giesy et al. 2000).

B. Toxicity of Cosmoflux 411F® to Cachama and Tilapia

I am not aware of any studies specifically measuring the toxicity of Cosmoflux 411F® alone to tilapia. However, the 96-hr LC-50 of Cosmoflux 411F® to cachama was reported to be 4,418 mg/L (Rondón-Barragán et al. 2007). Thus, Cosmoflux 411F® is much less potent at causing lethality than even Glyphosate®.

C. Toxicity of Plan Colombia mixture to Cachama and Tilapia

To my knowledge, the acute toxicity of the Plan Colombia herbicide has not been studied in tilapia. The acute toxicity of a mixture of Roundup® and Cosmoflux 411F® to cachama, has been measured, but using a different proportion of the two substances than is used in the Plan Colombia herbicide (125 to 1, instead of 44 to 1) (Ramirez 2009). The LC-50 was reported to be 23.42 mg/L Roundup® and 0.19 mg/L Cosmoflux 411F®. The investigators suggested that this result indicates a synergistic effect between Roundup® and Cosmoflux 411F®, but this conclusion is contrary to the findings by Bernal et al. (2009a) in their studies of amphibians.

When the toxicity of Roundup® to tadpoles was compared to that of the Plan Colombia herbicidal mixture, the ranges of toxicities overlapped (Bernal et al. 2009a). From this analysis, those authors determined that the presence of the 1% Cosmoflux 411F® did not alter the toxicity of Roundup®. In any event, an LC-50 of 23.42 mg/L (as reported in Ramirez 2009) demonstrates that cachama are fairly tolerant of Roundup® with added Cosmoflux 411F®.

D. Hazard Assessment for Tilapia and Cachama Allegedly Exposed to Plan Colombia Herbicide in the Mestanza Fish Ponds.

1. Exposure Assessment

Having identified the appropriate toxicity measures, the next step in a hazard assessment is to compare those measures with the potential concentrations of the Plan Colombia herbicide mixture in the Mestanza fish ponds. There is no evidence of exposure to or adverse effects of spray drift from coca eradication program to the Mestanza fish ponds. No measurements of Glyphosate or its major degradation product AMPA or any of the adjuvants were made in water or sediments at the time of the alleged fish kill. Nor are there any samples of fish in which Glyphosate®, AMPA or any other constituents of the herbicide mix were detected. In conducting this assessment, I have, accordingly used the methodology of what is referred to as a "Tier I" assessment, by use of "worst-case" assumptions to calculate a very conservative hazard quotient ("HQ"). The approach employed was similar to the hyper-conservative quotient method (Environment Canada 1997). Tier I hazard quotients are designed to be protective; where an extreme assumed exposure level does not affect the most sensitive species identified in laboratory tests, there is a high degree of confidence that no adverse effects, such as lethality in this case, would occur.

In my Tier I assessment, I have assumed, as a worst case scenario, that there was a direct overspray (not drift) of Plan Colombia herbicide into the Mestanza fish ponds. I have also assumed that the maximum application rate was applied to the entire surface of the ponds (an unlikely and thus worst-case assumption even for a direct over-spray incident).

In my assessment, I calculated concentrations of the Plan Colombia herbicide in the water in terms of the concentration of the active ingredient (a.i.) Glyphosate®, because this is the manner in which toxicity is reported in the studies discussed above. It must be noted, however, that both the toxicity studies and my concentration assessment reflect as well the presence of the associated adjuvants, such as POEA, which may in fact be contributing the greatest proportion of the aquatic toxicity of the formulation (Giesy et al. 2000). This method of reporting, *i.e.*, based upon the a.i. of Glyphosate®, allows direct comparison of the worst-case concentration of the Plan Colombia herbicide predicted to have been present in the Mestanza fish ponds with the LC_{50} concentrations at which one would expect 50% mortality in fish based on the findings of the toxicity studies.

To determine the exposure portion of the Tier I assessment, I have used an application rate of the Plan Colombia formulation of 3.69 kg Glyphosate® (a.i.) on each hectare ("a.i./ha"), which I understand is the standard application rate used in the coca eradication spraying operations. Since 1 ha is equivalent to 10,000 sq m (m^2), this application rate can be restated as 3.69 kg

Glyphosate® (a.i)/10,000 m^2 or 0.369 g Glyphosate® (a.i.)/m^2. From the images of an empty fish pond in a video provided by Mr. Mestanza, it appears that the Mestanza fish ponds are between 1.0 and 1.5 m deep. To be conservative, I have assumed a depth of 1.0 m. I also assume that none of the Plan Colombia herbicide mixture was adsorbed to the sediment in the ponds and thus became unavailable for exposure to the fish (a highly unlikely if not impossible outcome).[2] Based on these extremely conservative assumptions, the concentration of Plan Colombia mixture in the Mestanza fish pond from a direct overspray would be 0.369 g Glyphosate®/m^3 (because the application rate of 3.69 g/m^2 was assumed to be diluted to a depth of 1 meter). Because one cubic meter is 10^6 ml or 10^3 L, this translates to a direct overspray concentration of Plan Colombia herbicide mixture in the fish ponds of 0.369 mg Glyphosate®/L.

To complete the hazard assessment one must compare this worst-case concentration of the herbicide in the fish ponds to the threshold for mortality in the Mestanza fish. I have done this for the two species of fish alleged to have been killed, the tilapia and the cachama.

2. Hazard Assessment

Based on the toxicity of Roundup® to cachama, the HQ for the scenario of a direct overspray would be 0.0038 (0.369 [concentration]/97.47 [LC_{50}]). The margin of safety, which is the inverse of the HQ, would be 264. That is, the LC_{50} concentration of Roundup® is 264 times greater than the worst-case concentration of Roundup® predicted to occur in the fish pond due to a direct over-spray, even assuming no dissipation, degradation or sequestration of any of the constituents of the Plan Colombia herbicidal formulation. This means that there would have to have been 264 direct over-sprays of the same pond during the same spray event to reach the threshold for lethality. If one uses instead the LC_{50} from the study of a Roundup® and Cosmoflux 411F® mixture by Ramirez (2009), the HQ for a direct overspray scenario is 0.0158 (0.369/23.42) with a margin of safety of 63. That is, a total of 63 over-sprays would have been required to cause acute lethality of half of the cachama. For a Plan Colombia spraying operation to have killed all of the cachama in the Mestanza fish ponds, as Mr. Mestanza alleges for the alleged October 2002 event, there would have needed to have been an even greater number of direct over-sprays.

The finding for tilapia is similar. Based upon the LC_{50}'s in the paper by Jiraangkoorskul et al (2003), the HQ for juvenile tilapia would be 0.022 (0.369/16.8) and the margin of safety would be 45.5 (45.5 direct over-sprays needed to reach the LC_{50} concentration) and the HQ for adult tilapia would be 0.01 (0.369/36.8) and the margin of safety would be 99.7 (roughly 100 direct over-sprays). Finally, using the least recorded LC_{50} for tilapia from the study by Liong (1998) still results in an HQ of 0.498 (0.369/7.4) and a margin of safety of more than 20 (20 direct over-sprays).

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[2] In fact, suspended soil is known to bind Glyphosate® and reduce the toxicity of Roundup® and the Plan Colombia herbicide mixture to aquatic organisms (Relyea 2005; Bernal 2009b). Based on the Mestanza video, the fish ponds appear to contain a significant amount of suspended sediments that would greatly reduce the concentration of the herbicide remaining in the water. Thus, by comparing the predicted concentrations of Glyphosate® in ponds with the threshold to cause toxicity without correcting for bioavailability of the herbicide in the water after binding to sediments, my calculated HQ values will be very conservative and overestimate the potential for effects.

It is worth noting here that the video evidence provided by Mr. Mestanza of images of the fish pond and surrounding areas one month after the alleged fish kill are inconsistent even with a single direct overspray of Plan Colombia herbicide, let alone the more than 20 direct over-sprays required to result in even 50% mortality of tilapia (and no mortality in cachama) under the most conservative scenario above. The video repeatedly shows green plant life surrounding the fish ponds. Had the area been directly over-sprayed even a single time, let alone more than 20 times, the plant life surrounding the fish pond would all be dead. This video evidence thus directly establishes the fact that there could not have been any lethal concentration of Plan Colombia herbicide applied to the fish ponds.[3]

Based on this analysis, I conclude that it would have been impossible for the Plan Colombia spraying operations to have killed cachama or tilapia even with a direct over-spray of the Mestanza ponds with Plan Colombia herbicide mixture. Based upon these findings, there is no need to continue to the next step in the hazard assessment which would have been to do a refined assessment of the potential concentration of Plan Colombia mixture that could have reached the Mestanza fish ponds or other farms under the prevalent climatological conditions in the region. Of course, any possible concentration of the herbicide in the fish ponds via drift would be much less than that in a direct over-spray scenario, making the fish kill allegations all the more untenable.

To put it bluntly, Mr. Mestanza's allegation that the Plan Colombia spraying operations caused fish kills at his farm is scientifically impossible.

V. Toxicity of the Plan Colombia Herbicide and Its Constituents to the Farm Animals at the Test Plaintiffs' Farms

In general, Glyphosate® is classified as essentially non-toxic to terrestrial (air-breathing, land-based) animals at any relevant concentrations in the environment (Giesy et al. 2000). Moreover, in contrast to aquatic life forms with more permeable skin, surfactants do not increase the toxicity of Roundup® of land-based animals because the surfactants do not have the same ability to penetrate through their skin.

A. Toxicity of Glyphosate for Farm Animals.

Glyphosate® has repeatedly been found to have low acute, oral or dermal toxicity to mammals (Giesy et al. 2000; US EPA 1993; WHO 1994). The acute oral dose to be lethal to 50% of the individuals in a population (LD_{50}) has been reported to be greater than 5000 mg Glyphosate® a.i per kilogram body weight ("a.i./kg bw"), and chronic effects during whole-life exposures in mice, rats and dogs are only observed at continuous exposures greater than 1000 mg Glyphosate® /kg (US EPA 1993). There was no dermal sensitization after repeated dermal

[3] The video also provides significant circumstantial evidence that the alleged fish kills did not in fact occur. Mr. Mestanza claimed that 80,000 adult tilapia died following the alleged October 2002 spraying event, but there is no evidence whatsoever of dead fish, or the remains of dead fish, shown in the video. Furthermore, in light of Mr. Mestanza's apparent intent to document his alleged damages and his financial resources both as a large scale farmer and the owner of a transportation business in Guayaquil, there is no reasonable explanation for his failure to have taken even a single picture to document the fish kill.

exposures and no long-term inhalation studies are indicated because there was no toxicity observed in sub-chronic exposures of rats. Although most acute toxicity studies of Glyphosate® have been conducted in laboratory animals, two studies in goats have demonstrated similarly low acute toxicity in large mammals. In one acute oral toxicity study, the LD_{50} of Glyphosate® in goats was calculated as 3,500 mg/kg bw, and in a second, the LD_{50} was calculated as 5,700 mg Glyphosate® /kg bw. (USDA, 1987b and c, as cited in WHO 1994). Two studies in mallard ducks (*Anas platyrhynchos*) demonstrated similarly low toxicity, with one study reporting an LD_{50} of 4,640 mg kg/bw and a second longer term study reporting a no-effect concentration level of 1,000 mg kg/bw for ducks fed Glyphosate® for a period of 6 months (Hazleton Lab. Inc. 1973, Wildlife Int. Ltd. 1978, as cited in WHO 1994).

B. Toxicity of Roundup® for Farm Animals.

There have been a number of toxicity studies of Roundup® in farm animals, and they have each demonstrated that Roundup® likewise has low toxicity to these animals.

An acute oral toxicity study of Roundup® in goats reported an LD_{50} of 4,860 mg/kg bw, indicating that Roundup® has the same low toxicity to goats as did Glyphosate® in the absence of POEA.

In a study of the effects of Roundup® on chickens, a concentration equivalent to 6080 mg Glyphosate® a.i./kg in the diet caused reductions in growth of chicks but did not cause any lethality (Kubena et al. 1981). A concentration of 608 mg Glyphosate® a.i./kg in the diet did not have any statistically significant effects on growth of chicks. Since, even a concentration in the diet of 6080 mg Glyphosate® a.i./kg for 21 days caused no lethality, exposures for a shorter period of time, would have required even greater doses to have caused any effects and would have been even less toxic.

An acute oral toxicity study of Roundup® in mallard ducks reported an LD_{50} of 5,620 mg/kg bw, again indicating that Roundup® has the same low toxicity (this time in ducks) as did Glyphosate® in the absence of POEA (Wildlife Int. Ltd. 1990, as cited in WHO 1994).

When the Roundup® formulation was fed for 7 days to Brahman-cross heifers weighing 160 to 272 kg at a rate of 400, 500, 630 or 790 mg Roundup®/kg body weight per day by naso-gastric tube, there was no effect on heifers fed 400 mg/kg bw in the diet, and there was no mortality seen until a dose of 790 mg/kg bw dose. The deaths were associated with labored breathing and pneumonia caused by aspiration of the rumen contents (WHO 1994). This finding was more likely caused by the physical volume of the Roundup® ingested than to any toxic effects of the herbicide.

The results of incident reports of accidental poisoning of domestic and farm animals provides useful collateral information in the assessment of the potential of Glyphosate-based herbicidal mixtures to cause lethality. A retrospective assessment of all phone calls received from 1991-1994 in four animal poison centers is instructive (Burgat et al. 1998). During this three year period, the poison centers received 482 calls about Glyphosate®, but only 31 of the calls were assessed as sure or probable cases of Glyphosate® intoxication. Of these, 25 exposures were in dogs that likely drank concentrated mixes of the herbicide formulation. There were only two reported cases of Glyphosate® intoxication in farm animals, one in a cow and one in a horse. None of the animals died. Rather, the predominant clinical finding in the exposed animals was spontaneous vomiting that occurred a few minutes or 1-2 hours after ingestion of a concentrated preparation of the herbicide (i.e. before it was mixed with water). This finding suggests that the initial response of animals exposed to potentially toxic concentrations of Glyphosate® is to vomit and thus minimize exposure. If the exposure is not sufficient to cause vomiting, it is also likely that it would not cause symptoms of toxicity and certainly not death. In fact, in 6 of the 31 cases of Glyphosate® intoxication there were no clinical signs of poisoning whatsoever which further confirms the low toxicity of Glyphosate® formulations to mammals. In a more recent, comprehensive review of reported poisoning in farm livestock and poultry in five European countries over the past decade, there is no mention whatsoever of any poisonings involving Glyphosate® (Guitart 2010).

C. Toxicity of Plan Colombia Herbicide for Farm Animals.

I am not aware of any studies of the toxicity of the Plan Colombia herbicide mix specifically in farm animals, but studies of the acute toxicity of the Plan Colombia mixture in laboratory animals indicate that it has the same low toxicity in terrestrial (land-based) animals as Glyphosate® and Roundup®.

D. Hazard Assessment for Farm Animals Allegedly Exposed to Plan Colombia Herbicide.

I have conducted a hazard assessment for ducks, goats and cows, the three farm animals at issue in this case for which we have specific LD_{50} data. As noted above, there is also acute toxicity data for chickens, but no mortality was seen at the highest dose tested. While it is thus impossible to conduct a hazard assessment for chickens, the hazard presented to chickens would be less than that for ducks, which have a lower (albeit still very high) LD_{50}.

1. Exposure Assessment.

Because no measurement were made of concentrations of Glyphosate® or associated adjuvants in air or on the soil, let alone in the tissue of any of the alleged deceased farm animals, estimates of potential exposure need to be generated. As with the exposure assessment for tilapia and cachama above, I have prepared a conservative Tier 1 assessment, assuming as a worst case scenario, that the farm animals were maximally exposed through a direct overspray and were further exposed through consumption of directly over-sprayed plant life.

For exposure via overspray, I have assumed that Glyphosate® penetrated through the animal skin with a maximum penetration of 2% (Solomon 2007; Williams 2000). While this is a reasonable assumption for pigs, it is a very conservative assumption for the other allegedly impacted farm animals (cows, horses, goats, chickens, ducks) because those animals have body hair or feathers that would have minimized penetration of the Glyphosate® through the skin.

For exposures via plant consumption, I assume that the Plan Colombia herbicide mix remains fully available in the leaves and edible portions of the plant, which is again an overly conservative assumption.

i. Ducks

If a duck is assumed to have $(0.25\ m)^2$ of dorsal surface area, and the application rate is assumed to be 0.369 g/m^2, the intercepted dose would be a total of 0.023 g. If an average absorption of 2% is applied, the absorbed dose would be 0.00046 g or 0.46 mg. Assuming an average weight of 1 kg, the absorbed dose would be 0.46 mg/kg bw.

ii. Goats

If a goat is assumed to have 1 m^2 of dorsal surface area, and the application rate is 0.369 g/m^2, the intercepted dose would be a total of 0.369 g. Applying an average absorption of 2%, the absorbed dose would be 0.0074 g or 7.4 mg. Assuming an average weight of 75 kg, the absorbed dose would be approximately 0.098 mg/kg bw.

iii. Cattle

Cattle have a body mass of between 500 and 800 kg. Assuming a dorsal surface area of $(2\ m)^2$ and a direct over-spray with an application rate of 0.369 g/m^2, a cow would receive a total intercepted dose of 1.476 g and a total absorbed dose (assuming 2% absorption) of 0.029 g or 29 mg, which for the smaller cow would be the equivalent of 0.058 mg/kg bw and for the larger cow would be 0.03625 mg/kg bw.

2. Hazard Assessment.

i. Ducks

Based upon an estimated dose of 0.46 mg/kg bw and a LD_{50} for Roundup® of 5,620 mg kg/bw, the HQ for a single overspray would be 8.2×10^{-5} (0.46/5,620) with a margin of safety of 12,217. Using instead the Glyphosate® LD_{50} of 4,640 mg/kg bw, the HQ for a single over-spray would be 9.9×10^{-5} (0.46/5,620) with a margin of safety of 10,086. In other words, ducks would have to be directly over-sprayed between 10,086 and 12,217 times before one would see 50% mortality.
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ii. Goats

Based on an estimated dose of 0.098 mg/kg bw and LD-50 of 4,860 mg/kg bw. The HQ for goats exposed to a single over-spray would be 2.0×10^{-5} (0.098/4,860) with a margin of safety of 49,592. Said another way for the Plan Colombia herbicide to be lethal to a goat (or more precisely 50% of goats), the goat would need to be sprayed with the equivalent of 49,592 over-sprays.

Because goats might also be exposed to Plan Colombia herbicide through dietary exposure to over-sprayed plant life, I have also considered the possibility of lethal exposures through that alternate route. As a worst case scenario, I have assumed that during an aerial application that all of the Roundup® was deposited on leaves of edible plants. To achieve a dose of 4,860 mg/kg a 75 kg goat would need to consume a total of 364,500 mg of a.i. Glyphosate®. At an application rate of 0.369 g/m^2 a goat would need to eat the equivalent of 987.8 m^2 of vegetation and or soil. To calculate the weight of vegetation in a square meter, I have used ratio between the weight-to-area for spinach leaves, which has been reported to be between 26.5 and 40.88 g/m^2 (McLaughlin 1929). Based on this relationship, a goat would need to eat a minimum of 26.17 kg in the period of a day to reach the LD_{50} amount. In fact goats eat about 5% of their body weight in food per day or about 3.75 kg of food per day and can easily survive on as little as 1.0 kg of food/day. Thus, goats would have needed to have eaten at least 7.0 times their maximum daily rate of food consumption to reach the LD_{50}. In this assessment I have assumed that all of the sprayed Plan Colombia mix was deposited directly on edible vegetation and that goats ate a 100% diet of maximally contaminated vegetations. This is an extremely conservative scenario, and still there is no chance that a goat would be killed from dietary exposure. From this analysis, I conclude that it would have been impossible for goats to have been killed by the worst case situation of a direct over-spray with Plan Columbia herbicidal mix.

iii. Cattle

For adult cattle in the size range of 500 to 800 kg, with an estimated dermal dose of 0.03625 and 0.058 mg/kg bw for the 500 and 800 kg cattle, respectively, the HQ based on an LD_{50} of 790 mg kg bw, would be 4.58 x10^{-5} and 7.34 x10^{-5}, for the smaller and larger cattle, respectively. The margin of exposures for the smaller and larger cattle would be 21,793 and 13,621 respectively. That is, to be killed (or for 50% to be killed) the smaller and larger cattle would have need to have been over-sprayed with the equivalent of 21,793 and 13,621 over-sprays using the standard Plan Colombia herbicidal mixture.

I have also conducted a hazard assessment for potential dietary exposure in cattle. Cattle eat between 2 and 5% of their body weight in food each day. Thus, if the maximum consumption rate of 5% is assumed, a cow would eat approximately 25 to 40 kg of food per day, depending on body mass. Assuming the larger cow (800 kg) and a LD_{50} of 790 mg/kg bw, a cow would need to consume 632,000 mg of Glyphosate® a.i. To accumulate this dose under the conservative assumption of direct overspray with 100% retention of Glyphosate® in the edible portion of the plants and a diet comprised of 100% Glyphosate® sprayed crops, a cow would need to eat the equivalent of 1,712 m^2 of vegetation. Assuming a conversion rate of 40.88 g/m^2, this would be a consumption rate of 69.98 kg, which would be between two and three times the cattle's daily consumption of food. As with the analysis for goats, even under this unrealistic consumption scenario, it would be impossible for cattle to die as a result of ingestion of plants sprayed with Plan Colombia herbicide.

As with the hazard assessment for tilapia and cachama above, the hazard assessment for farm animals should also be considered in light of the video evidence presented by Mr. Mestanza, which makes clear that there was not even a single overspray of Plan Colombia herbicide on his farm, let alone thousands. At an even more fundamental level, the Mestanza video directly contradicts Mr. Mestanza's claims that his farm animals were killed by Plan Colombia herbicide, as the video is replete with pictures of apparently healthy pigs, cattle, sheep and chickens, as well as three apparently healthy baby goats that were reportedly born just days before the video was taken.

VI. Conclusion

For the reasons stated herein, there is no scientific basis to opine that Plan Colombia herbicide sprayed in Colombia would have been transported via soil or water across the border into Ecuador. There is also no scientific basis to conclude that Plan Colombia herbicide could have caused the deaths of tilapia, cachama, and farm animals alleged by the plaintiffs. Indeed, as my analysis above makes clear, the plaintiffs' allegations are scientifically impossible.

Date: _January 11, 2011____

John P. Giesy

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John P. Giesy, Ph.D., FRSC

CR Note: Dr. Giesy's CV (Exhibit A), found in CD - Original Annexes

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Exhibit B

Dr. John Giesy Expert Report

Materials Considered

Exhibit B

John Giesy Expert Report

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Annex 13

Expert Report of Dr R.D. Smalligan, M.D., M.P.H., prepared for the Defendants in *Arias/Quinteros v. Dyncorp* (D.D.C.), 19 January 2011

(United States District Court for the District of Columbia,
Cases No. 1:01-cv01908 (RWR-DAR) and 1:07-cv01042 (RWR-DAR).
Cases consolidated for Case Management and Discovery)

EXHIBIT 12

EXPERT REPORT OF
DR. ROGER D. SMALLIGAN, M.D., M.P.H.
PREPARED FOR THE DEFENDANTS
IN ARIAS/QUINTEROS V. DYNCORP (D.D.C.)

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EXPERT CREDENTIALS & EXPERIENCE

My name is Roger D. Smalligan, and I submit this report on behalf of the DynCorp defendants in the Arias/Quinteros v. DynCorp (D.D.C.) litigation. I am a medical doctor, board certified in both Internal Medicine and Pediatrics and a Fellow of both the American College of Physicians and the American Academy of Pediatrics. I am the Regional Chair of the Department of Internal Medicine at Texas Tech University Health Sciences Center in Amarillo, Texas and have been in this position for the past year and a half. Prior to coming to this position, I spent five years in the Departments of Internal Medicine and Pediatrics at the East Tennessee State University School of Medicine in Johnson City, TN, having been promoted to the Division Chief of General Internal Medicine before taking my current position. I also serve as the Health Authority for the City of Amarillo, Texas.

My goal as a young person was to work in a developing country where my medical skills could help the poor. Therefore, I pursued my medical degree at Johns Hopkins University (1983-1987) followed by a broad residency in both Internal Medicine and Pediatrics at Vanderbilt University (1987-1991). After residency I felt the need to further prepare for my planned work in the developing world, and I then pursued a Masters in Public Health ("MPH") at the Johns Hopkins University School of Hygiene and Public Health with an emphasis in International Health and Epidemiology (1992-1993). This training was ideal for the type of medical care I would soon be called upon to deliver, as it introduced me to the diseases that are prevalent in developing countries around the world (such as Ecuador).

During the year that I worked toward my MPH, I learned of a rural Christian mission hospital in Ecuador that was in need of a physician and began to communicate with them about joining their efforts. Shortly after finishing my MPH, I (along with my wife and young baby) traveled to Ecuador and spent a month in the Amazon jungle region of Ecuador at the Hospital Vozandes del Oriente in Shell, Pastaza, Ecuador ("Shell Hospital"), a busy rural mission teaching hospital. In that visit I worked on call and covered the emergency room as a physician and teacher. This month-long experience confirmed my desire to work in that setting, where the need was so great. However, before beginning full time in Ecuador, further preparation was required, including raising funds from friends, family, churches and other organizations to allow intensive study of medical Spanish (for one year in Costa Rica). Following these additional preparations, I returned to Ecuador in 1996 and spent the next 8.5 years (1996-2004) as staff physician and then medical director of the Shell Hospital.

At the Shell Hospital, we typically cared for between 10,000-13,000 patients per year. Due to its location in the tropical rainforest, the extreme poverty of the population, lack of public health infrastructure and financing, and lack of general medical care, many patients come to the Shell Hospital for treatment for significant medical problems, many of which are tropical diseases. The Shell Hospital has the benefit of constantly receiving donations of medications and updated medical equipment from the U.S. and Europe and for this reason it was utilized as a referral hospital for the entire region. Patients most commonly came from provinces contiguous with Pastaza but it was not uncommon to have patients from further away (*e.g.*, Sucumbios and Esmeraldas), sometimes after having bypassed large cities with advanced medical care available at a significant cost.

My role at the Shell Hospital during my first years was as a staff physician, which involved interviewing, examining, and caring for the many patients – including children and adults – who came seeking care. These first months and years provided advanced, on-the-job training in the area of tropical medicine. I also spent a significant amount of time in the local communities including the small towns and villages. It was helpful to me to see the living conditions of my patients and I would occasionally fly deep into the jungle to evaluate an outbreak of disease or to help with a public health brigade. Living conditions varied from completely primitive in the jungle without water or electricity to simple poverty conditions in the nearby towns. It was not uncommon for me to be invited for a meal in a local person's home and these experiences helped me understand the risks of various diseases and more astutely diagnose their conditions when they came to the clinic or the hospital.

In my first years at the Shell Hospital, I also daily taught the medical students and residents on rotation with us about general medicine and tropical medicine. I would regularly participate in evaluations of these trainees and send letters of evaluation to U.S. universities as required by visiting students' and residents' programs. I was also actively involved in research projects throughout my years there, including a randomized study of various snakebite treatments (eventually published in the British Medical Journal) and an emerging infectious diseases research project sponsored by the US Navy (recently published in the American Journal of Tropical Medicine and Hygiene).

After approximately three years as staff physician I was asked to serve as the medical director of Shell Hospital. In this role I continued with my full clinical load but also began to participate in regional meetings of the Ministry of Public Health for the Ecuadorian government. These meetings involved joint planning between health outposts, facilities and hospitals regarding appropriate responses to emergencies and disasters. During my time there, for example, our town received a number of refugees fleeing a large eruption of the Tungurahua volcano located about 40 miles away. We also collaborated with the health department in coordinating and manning flights to the jungle to provide vaccinations and disease outbreak evaluations. Health systems planning was discussed at these meetings and there was interest in my input due to the reputation of the Johns Hopkins School of Hygiene and Public Health where I had studied public health.

Obtaining a medical license in Ecuador is complicated and time consuming for expatriate physicians. Fortunately, I was granted permission by the Ecuadorian government to practice medicine in rural Ecuador, due to the great need there, while working on the many legal and additional educational requirements necessary to have my medical degree recognized. After five years, I was ultimately granted a Doctor of Medicine degree from the Catholic University of Quito, Ecuador, and today I have an unrestricted license to practice medicine in Ecuador.

Based upon my training and experience, I consider myself an expert in tropical medicine, generally, and the practice of tropical medicine in Ecuador, specifically. At Shell Hospital I personally diagnosed and treated a variety of tropical diseases and conditions in thousands of patients who are very much like the plaintiffs involved in this case. I have been invited on various occasions to give lectures both in Ecuador and in the United States about my experiences including at Marshall University, Vanderbilt University, East Tennessee State University, Texas Tech University and the University of Chicago. In addition to the publications already mentioned, I have written or collaborated on a number of scientific articles related to the field of tropical medicine and continue to give lectures and speak at medical conferences on the topic. Further information regarding my credentials and a listing of my publications are set forth in my cv, attached hereto as **Exhibit A**.

The data and other information that I considered in preparing my expert report are cited herein and are listed in **Exhibit B**.

STATEMENT OF COMPENSATION

I am being compensated for my work in this matter at a rate of $300.00 per hour, including deposition and trial testimony.

PRIOR TESTIMONY

I have never previously testified as an expert witness in litigation.

SUMMARY OF EXPERT OPINIONS

1. There is a high background incidence of disease in the communities in which the test plaintiffs live, which is caused by the tropical environment in the border regions of Sucumbios and Esmeraldas and by the lack of many basic amenities, such as clean water, indoor plumbing, adequate housing, public sanitation, healthy diet, and availability of medical care.

2. The medical problems identified by the test plaintiffs are endemic to the region, without regard to any alleged effect of Plan Colombia herbicide spray.

3. Plaintiffs have not provided any evidence that would allow a medical expert to reliably opine that Plan Colombia herbicide spray was a cause of any of the test plaintiffs' alleged medical conditions or to exclude the endemic health risks in the region as the true cause of their alleged personal injuries.

THERE IS A HIGH BACKGROUND INCIDENCE OF DISEASE IN THE COMMUNITIES IN WHICH THE TEST PLAINTIFFS LIVE, WHICH IS CAUSED BY THE TROPICAL ENVIRONMENT IN THE BORDER REGIONS OF SUCUMBIOS AND ESMERALDAS AND BY THE LACK OF MANY BASIC AMENITIES, SUCH AS CLEAN WATER, INDOOR PLUMBING, ADEQUATE HOUSING, PUBLIC SANITATION, HEALTHY DIET, AND AVAILABILITY OF MEDICAL CARE.

Tropical medicine refers to the study and treatment of conditions or diseases that exist either exclusively or more commonly in tropical regions of the world. The word “tropical” refers to areas of high humidity, high rainfall, low elevation and usually with a high density of insects and fauna and flora native to such regions. These tropical characteristics themselves create an environment ideal for certain disease vectors such as mosquitos, sandflies and rodents which in turn propagate diseases among the local population. In addition, the overall health status of residents living in the tropics is further compromised by poor living conditions and a basic lack of resources.

Ecuador’s rural, tropical communities are quite unlike what one might encounter here in the U.S. Poverty is widespread in Ecuador and living conditions in rural areas are particularly poor. The province of Esmeraldas and the Amazon jungle region (which includes a number of Ecuadorian provinces including Pastaza and Sucumbios) are no exception. Living conditions throughout these regions can vary, but rural village dwellers usually inhabit homes consisting of a dirt floor, wood slat walls and a thatched or tin roof with no electricity or running water. These simple dwellings provide no protection at all from insects or rodents, which gives rise to many tropical diseases. In an effort to ward off the abundant insect population, many village dwellers maintain a constant fire inside their hut causing a constantly smoky environment which contributes to high rates of asthma and complicates other respiratory conditions. Many communities do not have an available source of clean water, indoor plumbing, or basic sewage removal and treatment systems. Public health studies have demonstrated that the availability of clean water is of utmost importance in reducing many of the infectious diseases and chronic diarrhea conditions that plague the poor (Esrey 1991; Mintz 1995). The largely unsanitary conditions predispose the population to many diseases including skin conditions like impetigo and scabies, as well as diseases like tuberculosis, scarlet fever, leptospirosis, and meningococcal disease.

The overall poor health status of inhabitants of this region is also compounded by the lack of variety in their diets due to expense and difficulty of obtaining adequate amounts of protein. Many poor families eat meat only from time to time when it is available or for special occasions. Dietary diversity has been shown in studies to promote good health and nutritional status. The lack of protein leads to protein malnutrition or kwashiorkor, which then makes people more susceptible to many different kinds of infections.[1]

The poor health status of rural Ecuadorians also results from a lack of access to basic medical care. While small health outposts are situated throughout Ecuador by the Department of

[1] It is well established that malnutrition can compromise the immune system (Beisel 2000; Chandra 1997).

Public Health, most do not have adequate staffing, medications or diagnostic capabilities. Because the pay of local physicians by the government is extremely low (approximately $300/month during my final years in Ecuador) it is very difficult to staff health posts and even government hospitals in the rural areas. Most importantly, there is no concept of routine medical care among young people and adults in these regions of Ecuador. Patients often do not seek medical care until their conditions are advanced and after they have already tried many local remedies. Despite a scientific explanation given for a health condition and a clear description of how to prevent it or cure it, other explanations and cures are often sought outside the western style of medicine, and this desire to circumvent or avoid modern medicine often compromises the health and treatment of individuals who need it the most.

While the living conditions are poor throughout much of Ecuador, conditions in the provinces of Sucumbios and Esmeraldas, where most of the test plaintiffs live, are particularly impoverished.[2] Statistics collected by the Ecuadorian government show that significant segments of the population lack access to basic sanitation services (INEC 2001). With regard to the risk of malaria, these two provinces were two of the top three provinces as measured by the annual parasite index (PAHO 2007). A government survey in 2005 found that 79% of people living in rural areas of Ecuador were living in poverty, compared with 39% of those in urban areas (PAHO 2007). Similarly, measurements of living conditions show that they are more primitive in rural areas compared with urban areas (Ministerio de Salud 2007).[3]

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[2] The Mestanza family live in Guayaquil, a large city 275 miles from the border region of Sucumbios where their farm is located. Several members of that family claim to have been injured while visiting their farm in 2000 to 2002, but it is noteworthy that this family is not poverty-stricken like many others in Sucumbios. Nonetheless, at their farm, they appear to live in primitive conditions typical of rural Ecuador.

[3] Based upon the evidence I have reviewed in this case, the test plaintiffs' living conditions are similar to what I would expect for rural inhabitants of Northern Ecuador.

THE MEDICAL PROBLEMS IDENTIFIED BY THE TEST PLAINTIFFS ARE ENDEMIC TO THE REGION, WITHOUT REGARD TO ANY ALLEGED EFFECT OF PLAN COLOMBIA HERBICIDE SPRAY.

The test plaintiffs have identified a variety of general and non-specific medical ailments that they allege were caused by or might have been caused by Plan Colombia spraying operations.[4] I will address the test plaintiffs' individual claims in the following section. To place the plaintiffs' allegations in their proper context, however, it is important to first understand the very high background incidence in rural Ecuador of the medical conditions they describe. There is nothing unusual or unexpected about the test plaintiffs' alleged medical conditions; indeed, they are typical of the patients I treated during my 8.5 years in the Amazon basin region of Ecuador.

- **Gastrointestinal problems**

A number of the test plaintiffs complained of gastrointestinal problems, including diarrhea, stomach upset, nausea and vomiting. These types of problems are exceedingly common throughout rural Ecuador and can be directly attributed to the lack of sanitation and clean drinking water, the close proximity of humans to livestock, and the heavy insect and rodent populations. Scientific studies have repeatedly reported that upwards of 80% of the people living in northern Ecuador have intestinal parasites, with some studies finding infection rates that approach 100% (Cooper 1993; Gatti 2002). A study of children in Esmeraldas by Gatti et al. (2002) reported that 98.9 % were infected with intestinal parasites. The authors noted that the "high detection rate is clearly related to poor sanitation, nutrition, use of contaminated water, and domestic animal promiscuity." Another study in Esmeraldas found that 75.9 % of those studied were infected with at least one species of intestinal helminth (Cooper 1993).

The differential diagnosis for gastrointestinal problems in rural Ecuador is broad and includes (in the approximate order of the frequency with which I would see the various conditions in my daily practice) such things as acute gastroenteritis (caused by parasites, bacteria, or viruses), gall bladder disease, gastroesophageal reflux with or without ulcers, appendicitis, pancreatitis (gall stone, viral or alcoholic), lactose intolerance, infectious colitis, hepatitis, malabsorption syndromes, Celiac disease and gastric cancer (the leading type of cancer in Ecuador).[5] Because parasitic disease is rampant in rural Ecuador, unless there are specific signs or symptoms pointing to another diagnosis, one often begins with a stool exam looking for parasites and, if present, treats them first to see if the symptoms resolve. Some sort of intestinal

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[4] From the array of alleged physical symptoms and health conditions that the test plaintiffs alleged were caused by the Plan Colombia spraying, plaintiffs' expert Dr. Wolfson identifies several general conditions in his report, and I accordingly address these general conditions in this section of my report.

[5] On a handful of occasions, I also treated patients who were suffering from gastrointestinal symptoms associated with intoxication with organophosphates or paraquat, generally following suicide attempts. The local people were quite aware of the toxic nature of these chemicals to humans and sought them out for these suicide attempts. In my 8.5 years in Ecuador, I do not recall ever treating a patient whose symptoms were associated with alleged exposure to glyphosate.

parasite was present in the majority of my patients who lived in impoverished regions like the test plaintiffs.

- **Skin problems**

Another common category of test plaintiff complaints was problems of the skin (*e.g.,* recurrent rashes, itching, irritation, infections). Again, these types of problems are widespread throughout rural Ecuador. Due to the lack of clean water, indoor plumbing and adequate sewage treatment and disposal, combined with the fact that many people live with dirt or wooden floors, the opportunity for skin infections is everpresent. There is also a lack of first aid materials and knowledge of how to clean and dress fresh wounds by the lay public. All of these factors contribute to the frequency with which we would see Staphylococcal and Streptococcal skin infections among our patients. Insect bites occur daily to most people due to the homes lacking glass windows or screens. Scratching of these insect bites with dirty fingernails and hands are a common method of contamination with these organisms which cause characteristic skin lesions, namely impetigo, pyodermatitis, furuncles and carbuncles (or small abscesses). These lesions are quite characteristic and are usually diagnosed and treated clinically. The next most common recurrent rash is scabies which is caused by a microscopic mite and causes intense itching which can then become secondarily infected with the Staph or Strep mentioned above. Due to the humid conditions one also frequently encounters chronic fungal infections in patients ranging from Candida in baby diaper regions to "ringworm" caused by Tinea species and Tinea versicolor which causes a hypopigmentation of the skin in many dark-skinned patients. Botfly myiasis is another common condition, characterized by an itchy, weeping wound that appears to be an infected insect bite from which one can extract the larvae (maggot) of a fly. I was unfortunate enough to have to extract nine of these larvae from my daughter's head at one time and three from my own body on various occasions. Certain parasites can also cause itchy skin lesions as well, such as Strongyloides. Contact dermatitis can also occur after exposure to certain tropical plants (equivalent to poison oak in the USA), and allergy to metals or other materials. However, in my experience in Ecuador, I never observed any skin conditions from exposure to glyphosate or other pesticides.

Less common skin conditions that are seen from time to time include cutaneous Leishmaniasis and the itchy bite caused by the reduvid bug that causes Chagas disease. A study in the subtropical rainforest of northwest Ecuador found that 14 % of those studied had evidence of active cutaneous leishmaniasis infection and 33 % had evidence of past infection (Armijos 1997). Calvopina et al. (2004) noted an increase of leishmaniasis over the four preceding years, with approximately 75 % of the cases occurring in the Pacific region of Ecuador. A study of the seroprevalence of the parasite that causes Chagas disease reported seroprevalence of 2.4 % in the Amazon region. The authors noted that their findings suggested that transmission of the disease is associated with poor housing conditions (Grijalva 2003).

- **Respiratory problems**

Respiratory problems were an extremely common complaint among patients coming to our hospital. Although the causes of these illnesses were often similar to the causes seen in the United States, a significant additional respiratory hazard in Ecuador is created by the use of fires within the home to ward off insects, as noted above. Rinne (2006) reported lower pulmonary function among children living in households in rural Ecuador that cook with biomass fuel (which exposes the children to biomass smoke).

Aside from indoor smoke pollution, the most common causes of respiratory ailments in my practice in rural Ecuador, in approximate order of frequency with which they were encountered, include viral upper respiratory infections (URI, or common cold and/or influenza), bronchitis, pneumonia, asthma, bronchiolitis, tuberculosis, Loeffler's syndrome (a condition that occurs with wheezing, eosinophils in the bloodstream and infiltrates on x-ray that appears as certain parasites migrate through the lungs), pertussis and paragonamiasis. The URIs could be diagnosed clinically and treated symptomatically. If there was concern for pneumonia versus bronchitis, then an x-ray was often performed to help clarify the situation. Sputum exams for acid fast bacilli (AFB) were done to detect tuberculosis and paragonamiasis and stool exams to look for potential acute parasitic infections contributing to Loeffler's syndrome in patients with new wheezing. Asthma and pertussis were largely diagnosed and treated clinically in our relatively low-technology situation.

- **Eye problems**

The primary unique risk factor for eye problems in tropical Ecuador is the sun. Because the equator crosses through Ecuador, it is in the closest proximity to the sun, and the intensity of the sunlight leads to a higher prevalence of general eye irritation. Thus, for example, one study found that 89.2 % of school aged children in the Northeastern province of Napo, Ecuador had pterygium (a fleshy growth on the inner aspect of the eye due to chronic ultraviolet light, wind and dust exposure) (San Sebastian 1999). In addition, in the 1990s there was a high background incidence of insect-born ocular disease in Esmeraldas province in particular. In one study, over 33% of the study population had ocular lesions associated with the insect born disease, onchocerca (Cooper 1995).

In my clinical practice in Ecuador, the the most common diagnoses reached in patients with eye problems were acute viral conjunctivitis, allergic conjunctivitis, bacterial conjunctivitis, uncorrected refractive errors due to the lack of optometrists and the cost of glasses, corneal abrasions due to welding or grinding that caused a foreign body to lodge in the eye, pterygium, hordeolum (stye), chalazion (chronic inflammatory ball-like lesion of the eyelid), or poor visual acuity due to the need of refractive correction (glasses).

PLAINTIFFS HAVE NOT PROVIDED ANY EVIDENCE THAT WOULD ALLOW A MEDICAL EXPERT TO RELIABLY OPINE THAT PLAN COLOMBIA HERBICIDE SPRAY WAS A CAUSE OF ANY OF THE TEST PLAINTIFFS' ALLEGED MEDICAL CONDITIONS OR TO EXCLUDE THE ENDEMIC HEALTH RISKS IN THE REGION AS THE TRUE CAUSE OF THEIR ALLEGED PERSONAL INJURIES.

Based upon my clinical practice and my general medical understanding of the potential health risks of herbicides, I am not aware of any evidence that exposure to a glyphosate-based herbicide through an aerial spraying operation could cause the types of medical conditions identified by the test plaintiffs in this case. I do not, however, hold myself out as an expert in herbicide toxicity, and I understand that there are other experts in this litigation who will speak more directly and informedly to this question, which I view as a question of general causation (i.e., is glyphosate capable of causing the medical ailments at issue).

My expertise is focused on the standard methodology used in addressing questions of specific causation in medicine, which is called development of a differential diagnosis for any given set of signs or symptoms presented by a patient. This methodology starts with a list of known potential causes of the patient's complaints, which is generated during the general causation analysis based on high-quality scientific studies and research. The specific causation step, or differential diagnosis, is the systematic consideration of each of the listed potential causes with unlikely or erroneous diagnoses being eliminated one by one until the most likely cause of the patient's condition is identified.

In order to develop a valid differential diagnosis, a physician must first take a careful history from the patient in an effort to determine the nature and cause of their symptoms. This includes inquiring about the date and time of onset of the symptoms, parts of the body affected, remedies that have been tried already and things that alleviate or aggravate the condition. It also includes obtaining information regarding the patient's recent travel and exposures as well as prior health status, personal and social habits and the family medical history. A thorough physical exam of the patient is the next crucial step and requires special attention to detail of the parts of the body to which the history has directed the physician. If this combination of careful history taking and detailed physical exam is followed, some diagnoses are clear while others require further investigation with laboratory tests, biopsies or radiographic studies. Each piece of information thus obtained serves to "rule out" one or several plausible conditions (and causes) that were in the differential diagnosis. Similarly and simultaneously, the correct diagnosis can often be "ruled in" and appropriate therapy chosen and instituted. A common and dangerous error in the practice of medicine is to prematurely reach a conclusion without considering the broad array of possible causes of a patient's condition.

In seeking to identify an accurate diagnosis for each of the test plaintiffs in this litigation, the first – and in my mind insurmountable – hurdle is that none of the test plaintiffs have provided the necessary components of the history, physical exam, and laboratory or radiographic studies. The nonspecific and vague nature of the complaints in general requires the generation of a long differential diagnosis without the hope of ruling in or ruling out many of the conditions with any degree of certainty. As detailed below, the test plaintiffs' descriptions of their alleged medical ailments are varied and in many instances inconsistent and contradictory.[6] The varied nature of the test plaintiffs' medical claims (and the inconsistent alleged timing of these ailments with respect to the alleged spraying), are contrary to the allegation that the illnesses were all caused by exposure to Plan Colombia herbicide (or indeed to any single alleged toxin), but these facts do not otherwise assist in the effort to identify the actual causes of their conditions. Many of the medical ailments that are alleged to develop and often persist over varying time periods are, as noted above, endemic to the region or commonly found in a general medical practice. Plaintiffs do provide somewhat consistent facts as to their unhealthy living conditions (poor housing, lack of clean drinking water and indoor plumbing, etc.). However, they do not provide any reliable history of other conditions to which they were exposed at the time of their alleged illnesses. To the extent that the test plaintiffs state that they received medical care for their conditions, they have not provided any medical records regarding that treatment, nor have they provided the results of any medical testing. Indeed, except for one case, none of the test plaintiffs have provided any contemporaneous evidence upon which an expert could reach a reliable opinion to a reasonable degree of medical certainty as to either the nature of the medical conditions or the cause of those conditions. For this one test plaintiff where such evidence is available (Edith Quevedo), the evidence clearly demonstrates that her condition was caused by a bacterial infection rather than the alleged exposure to glyphosate. Moreover, a number of the test plaintiffs testified as to treatments that they received for their medical conditions, but in each case, those treatments were not what would have been provided if the physicians believed that the conditions were caused by exposure to a herbicide or any other alleged topical toxin.

My assessment of the medical claims of each of the individual test plaintiffs is set forth below:

A. Quevedo Family

In their depositions, the Quevedo test-plaintiff family members allege that they suffered various physical injuries caused by the Plan Colombia sprayings. They do not, however, give specific dates for their exposures. Rosa Altimirano testified that she was exposed in "2002, towards 2003" (Dep. 37), while her husband Luciano Quevedo did not provide any date of exposure at his deposition. (His questionnaire response listed his dates of exposure as "2002-2006" (Questionnaire V.C.).) With one exception, their claims of physical injury are based on self-reporting. For that exception, a skin condition of daughter Edith Quevedo, which was documented by photography and video, the condition was diagnosed as a bacterial infection, a diagnosis with which I agree (discussed in more detail below). The Quevedo family's personal injury claims have changed over time and they are often inconsistent in nature, timing, and duration. For example, though Luciano reports vision problems, no other family member complains of eye injury from exposure to the spray. These inconsistencies make it impossible to conclude that one disease or exposure could have caused all of the family's maladies. All of the alleged symptoms, however, are consistent with diseases and health conditions that are prevalent in the tropics and that I saw regularly during my practice in Ecuador. It is highly likely that these

[6] In light of the test plaintiffs' varying allegations, I have chosen to rely primarily upon their sworn deposition testimony.

diseases and health conditions, as opposed to the alleged exposure to the Plan Colombia spray, are responsible for the plaintiffs' alleged symptoms.

The Quevedo family reports living in a wooden home approximately 5x6 meters in size with well water piped into the home (Luciano Questionnaire IV.A.1; Rosa Dep. 26). This is reportedly potable water, and they do not boil or filter it (Luciano Dep. 111). Both Luciano and Rosa report an indoor bathroom though Luciano also says it is 10 meters from the house (Rosa Dep. 26; Luciano Dep. 14). The family lives in very close proximity to some of their farm animals (Rosa Dep. 51, 52, 54; Robinson Dep. 32), which puts the family members at increased risk for a number of animal-borne diseases.

1. Luciano Quevedo

Luciano is a 50-year-old male who reports various injuries he allegedly experienced following exposure to the Plan Colombia spraying. He has not produced any medical records to support his alleged sympoms, and his allegations in his deposition are inconsistent with the symptoms he was reported to be experiencing in a "toxicology report" prepared for the Quevedo family during a June 14, 2001 nongovernmental organization's investigation of alleged health effects from Plan Colombia spraying.

At his deposition, Mr. Quevedo first complained of itching all over his body and an inability to read small print as a result of exposure to the Plan Colombia herbicide (Dep. 36, 37). As explained above, itching of the skin could be caused by any number of conditions that are common in the region, and Mr. Quevedo's visual problem is very likely related to age-related presbyopia. Only after being shown his written questionnaire response, which listed other alleged physical injuries, Luciano stated that he also experienced headaches, aching bones, kidney problems, and fever following the spraying (Dep. 47-48, 55). Again, each of these symptoms could be caused by many different diseases and health conditions that I treated regularly in the Ecuadorian Amazon. Mr. Quevedo also complains of ongoing bone aches, kidney problems, and occasional headaches (Dep. 48, 50, 55). One potential cause of these symptoms is a kidney infection, which can make one feel extremely sick and cause fever. The lack of a thorough medical exam and laboratory confirmation, however, makes this mere speculation. Based upon the information Mr. Quevedo submitted, no physician could even determine what medical conditions he suffered from, much less identify exposure to the Plan Colombia spray as a cause of those conditions.

2. Rosa Altamirano

Rosa Altamirano is the 51-year-old wife of Luciano. She alleged in her deposition testimony that following exposure to glyphosate she experienced itching, a rash, headaches, kidney problems, and bone pain (Dep. 34, 44-45). She still experiences bone pain, kidney problems, and occasional headaches (Dep. 45). As set forth above, there are any number of common conditions endemic to the Ecuadorian Amazon basin that could have caused these conditions. Mrs. Altamirano submitted some medical records, most of which relate to her last pregnancy in 2000 followed by a tubal ligation. The next entry is from a visit in November of 2004 where she presented with dizziness (mareos), headache (cefalea) and muscle aches (mialgias) and pains and is diagnosed with acute anemia (anemia aguda). Though Mrs.

Altamirano contends that her headaches and bone pains were caused by the spraying, this is very unlikely in light of the fact that this visit occurs approximately one year following the alleged spraying. Moreover, the symptoms are much more consistent with an acute viral illness or malaria or dengue fever than any brief topical exposure to glyphosate. None of the medical records makes any mention of the Plan Colombia spraying.

Moreover, Mrs. Altamirano's inconsistency in reporting her alleged symptoms makes it difficult to even determine what conditions she suffered from, let alone identify a cause. Her questionnaire response states that she experienced fever and diarrhea, among other symptoms (Questionnaire V.E.1 and V.E.7). But she did not complain of these symptoms in her deposition, and they were not identified on the "toxicology report" produced by the plaintiffs. (It is also notable that Mrs. Altamirano claims to have been exposed to the Plan Colombia spray in "2002, towards 2003" (Dep. 37), but the "toxicology report" listing the Quevedo family's alleged injuries is dated June 14, 2001.) Because of these inconsistencies and the lack of any relevant medical records or other information, no physician could reliably diagnose Mrs. Altamirano's symptoms. Any attempt to do so would be pure speculation, and there is no evidence that would allow a physician to reach a reliable conclusion as to the cause of her health conditions.

3. Edith Quevedo

Edith is the 15-year-old daughter of Luciano and Rosa. Her parents variously testified that she was affected by itching, a rash, and headaches (Luciano Dep. 39; Rosa Dep. 34-35). Edith herself testified that she also experienced burning of the nose, stomachache, diarrhea, and fever (Dep. 49, 60, 95-96). According to Rosa, Edith no longer has any physical effects from the spray (Rosa Dep. 46). As with their other symptoms, the Quevedo family alleges that Edith's rash was caused by exposure to the Plan Colombia herbicide. But this claim is contradicted by contemporaneous video and photographic evidence, along with a physician's diagnosis following direct examination of Edith's skin condition. Her skin condition was filmed and photographed by an Ecuadorian physician named Adolfo Maldonado, during a visit to northern Ecuador to document the alleged effects of the Plan Colombia sprayings. Based upon my review of the video and photographs, the lesions look typical of impetigo, a type of bacterial infection. This impression is supported by Dr. Maldonado, who testified that Edith had a bacterial infection (Maldonado Dep. 55). The lesions were treated with a combination antifungal, antibiotic and anti-inflammatory cream (Trigentax) along with unspecified "medicine" and they improved (Dep. 57-60). This identification and successful treatment rules out glyphosate or any other toxic exposure as the cause of her rash. Edith also complains of itching that occurred several days after her exposure (Dep. 52), and her mother notes that the family started itching "after weeks and months that went by" (Rosa Dep. 34). This delayed timing is inconsistent with dermal exposure to a chemical irritant, where symptoms should be contemporaneous with exposure.

Edith's other claimed medical conditions are non-specific and do not suggest any toxic exposure. Headache, fever, stomachache, and diarrhea are common symptoms among children in rural Ecuador for which there are many potential causes, and without more information it would be speculation to try to identify the specific cause. The combination of stomachache, fever, and diarrhea is entirely consistent with an acute gastroenteritis or parasitic infection. Absent medical records, a physical examination, and laboratory tests, it is impossible to determine the cause of any of Edith's symptoms. There is no reliable basis to opine that they were caused by exposure to Plan Colombia herbicide.

4. Robinson Quevedo

Robinson is the 10-year-old son of Luciano and Rosa. He was approximately 2 or 3 years old at the time his mother Rosa alleges that the family was exposed. His mother Rosa testified that he experienced skin infections, headaches, and diarrhea which made him very skinny (Rosa Dep. 35).[7] Rosa testified that Robinson was completely healthy at the time of her deposition in 2009 (Rosa Dep. 45-46). The plaintiffs have provided no medical records for Robinson. Skin infections are prevalent in Ecuador, however, and are not typically caused by exposure to a toxic substance. Diarrhea is also common, in large part due to the unsanitary living conditions in the area where the plaintiffs live. Similarly, there are any number of conditions I treated regularly in Ecuador that cause headaches. With the information available here, no reliable diagnosis of Robinson's symptoms can be made.

With respect to Rosa's complaint that Robinson was underweight, by far the most common complaint in my clinic over the years at the Shell hospital from parents was that their children were too skinny and that they had no appetite. It was difficult to convince parents that their child's weight was appropriate in spite of showing them where their child was on the growth chart. As with the other alleged symptoms, the Quevedos have provided no data that would allow me to determine whether Robinson was in fact underweight or not. But as mentioned previously, malnutrition is known to be extremely common in rural areas of Ecuador, and certainly repeated bouts of diarrhea from any of the known common causes endemic to the region could contribute to being underweight. Any attempt to diagnose Robinson's alleged symptoms, let alone ascribe them to an alleged toxic exposure, would be purely speculative.

B. Calero Family

During their depositions, the Calero test-plaintiff family members claim that they experienced various medical problems caused by an alleged exposure to the Plan Colombia spray on a single occasion in August 2003. This testimony regarding the circumstances of alleged exposure differs from the information set forth in their earlier questionnaire responses, which claimed alleged exposures on a varying array of other dates. The family's allegations regarding medical problems are based on self-reporting. They have not produced any medical records, laboratory tests, or any other contemporaneous evidence that support their claims, and to the extent they provide testimony as to medical diagnoses they have received, the diagnoses are directly contrary to the causal claims. The health problems alleged by each family member are inconsistent in nature, timing and duration, and they have changed over time. No single disease or exposure could account for all of the family's wide array of alleged medical problems, but each of the individually alleged medical problems is common, if not endemic, to the region and is consistent with the types of medical problems that I treated in my clinical practice in Ecuador.

[7] Rosa testified that Robinson experienced only skin infections and diarrhea, but she also testified that all of her children had headaches (Dep. 35).

The Caleros live in primitive conditions typical of rural Ecuador. Their house is reportedly made of wood walls and a zinc roof (Calixta Questionnaire IV.A.1), and they have no running water in the house. They collect rain water and filter it with a cloth (Santos Dep. 68), which only removes large debris without providing any reduction in microbes. They do not report that they boil their drinking water. They have no indoor toilet facility and do not use an outhouse (Santos Dep. 68; Questionnaire IV.B.3, 4), so sewage is likely present in the environment surrounding the house. As discussed above, these living conditions significantly increase the risk of medical problems. Given the family's living conditions, the medical ailments they identify are not surprising or unexpected.

1. Santos Calero

Santos Calero is a 66-year old male who alleged at deposition that his exposure to Plan Colombia herbicide spray had caused burning on his skin, pain in his bones and kidneys, and a burning sensation in his bladder (Dep. 23, 32-33, 84). Mr. Calero has produced some medical records, and the relevant records establish causes completely unrelated to the spraying for certain of his alleged symptoms. The testimony that Mr. Calero has provided, while non-specific, strongly suggests alternative causes for his alleged medical conditions and clearly does not provide the type of medical evidence that would be needed to reach a reliable opinion that Mr. Calero suffered any adverse medical effect from his claimed exposure to Plan Colombia herbicide.

Mr. Calero testified that he felt a burning on his skin a few days after allegedly being exposed to Plan Colombia herbicide spray, though he denies having felt the spray on his skin (Dep. 23). This purported timing is not consistent with an acute reaction to a topical irritant, and is thus contrary to the claim that his alleged exposure to glyphosate was the cause. As noted above, rashes and other skin problems are endemic in Ecuador, and there is nothing unusual about the symptoms that Mr. Calero reports. Moreover, Mr. Calero testified that he was given a cream to put on his arms for burning and itching skin and that his condition resolved within a few days (Dep. 88). The first medical record entry after 2003 is for May 12, 2004 when he is diagnosed with a right shoulder abnormality (ankylosis) due to an "old" (antigua) injury and a severe kidney infection (pielonefritis) and is treated with antibiotics. The kidney infection would explain Mr. Calero's complaints of kidney pain and a burning sensation in his bladder. Then in September 9, 2004 it appears he presented for a disability evaluation regarding some weakness in his right shoulder due to the previous injury. These diagnoses make his symptoms unlikely to have been related to the alleged glyphosate exposure as a cause of these symptoms.

Any attempt to reach a reliable medical opinion that Mr. Calero's alleged ailments were caused by exposure to Plan Colombia herbicide is further undermined by the fact that Mr. Calero has not been a consistent historian regarding his medical condition. Mr. Calero's deposition testimony as to his alleged medical ailments following his claimed exposure is notably different from the allegations contained in his earlier questionnaire response, which identified only headaches, dizziness, vomiting, itching, and skin infections/poisoning (Questionnaire V.D.15, E.1, E.15). Both his testimony and questionnaire responses differ from information contained in an NGO "toxicology report," dated September 12, 2002 and produced by plaintiffs, in which it was recorded that Mr. Calero was alleging that the herbicide spray caused pain in one lung, eye irritation, and numbness in his arms. (It is also noteworthy that this "toxicology report" was prepared almost a year prior to the date that Mr. Calero now alleges he was exposed to Plan Colombia herbicide.) In light of this information, it is impossible to reach any reliable conclusion even as to the nature of Mr. Calero's medical conditions, let alone that his conditions were caused by exposure to glyphosate.

2. Calixta Pineda

Calixta Pineda is the 66-year old wife of Santos Calero. At her deposition, Mrs. Pineda alleged that exposure to Plan Colombia herbicide had caused a rash with itching, a uterine infection, and headaches (Dep. 16, 50-51). Mrs. Pineda did not provide any medical records or contemporaneous evidence regarding her alleged medical ailments, and her testimony does not provide any reliable basis for an opinion that her alleged exposure to Plan Colombia herbicide caused her any medical impairment.

Mrs. Pineda testified that she experienced a rash with itching approximately one month after her alleged exposure to Plan Colombia herbicide spray (Dep. 16), a time frame that is clearly inconsistent with any opinion that the rash could be attributed to her claimed exposure. Mrs. Pineda testified that she was diagnosed with a skin infection (Dep. 18), which would not be caused by a cutaneous exposure to a toxic substance. As with her husband, Mrs. Pineda testified that her rash was transient and successfully treated by a cream (Dep. 18). Mrs. Pineda's alleged rash is typical of rashes that are endemic in the region, and there is no basis to look for any cause for the rash beyond the unsanitary living conditions in which Mrs. Pineda lives. Mrs. Pineda's uterine infection likewise cannot be reasonably attributed to glyphosate exposure; indeed, there is no logical way to medically connect a uterine infection to a brief cutaneous exposure to a substance. Finally, headaches are a non-specific medical symptom that can be caused by a wide variety of systemic infections and conditions including a uterine infection. Without more historical and physical exam information, any attempt to identify a cause for a headache that reportedly occurred over seven years ago would be purely speculative.

3. Betty Calero

Betty Calero is the 36-year-old daughter of Santos Calero and Calixta Pineda. Betty Calero alleged in her deposition that she believed that exposure to Plan Colombia caused her to suffer various health conditions. Betty Calero produced some medical records, most of which relate to her pregnancies and deliveries. On February 14, 2002, she was seen for a prenatal visit at 20 weeks of pregnancy and complained of moderate headache along with a vaginal secretion and she was treated with acetaminophen and a vaginal antifungal suppository. No reference to fumigation is made. In May 2003, the visit documentation is illegible. In June 2004, a visit is documented for another pregnancy at 35 weeks when she is having some cramps and is given anti-inflammatory medication but is stated to be in good condition. In January 2004, she has an intrauterine device placed for contraception. She was later seen on September 3, 2004, where she complains of recurrent headaches for over one year and is diagnosed with sinus headaches. There is no reference to fumigation or spray exposure in the medical record.

Betty Calero testified that her claimed exposure to Plan Colombia spraying caused a rash, itching, and eye irritation (Dep. 25, 74). As explained above, these conditions are endemic in the region for reasons entirely unrelated to any potential exposure to herbicide. There is no reliable medical basis to opine that these conditions were caused by exposure to Plan Colombia spraying. She also testified that she experienced a strong cold and burning in her nose, throat, and eyes (Dep. 74). The burning sensation stopped, but she has had itching of her nose, throat, and eyes since 2003 (Dep. 93-94), making it highly unlikely to be related to any brief alleged toxic exposure and much more likely to be an allergic condition. She also complained of kidney problems (Dep. 74) that cannot be explained by a possible brief cutaneous exposure to glyphosate, but which are much more likely to be related to recurrent urinary tract infections which are common in women in Ecuador. She also testified that she experienced pain all over her body and beginnings of a stroke (Dep. 63), as well as mental problems and pain in her kidneys and legs (Dep. 56-57, 95). All of these conditions could have a number of different causes. Finally, Ms. Calero complained of headaches (Dep. 63, 74) which, as noted above, cannot be reliably associated with any specific cause without a far more extensive and reliable medical record than has been provided here. Without more information, it is impossible to reach a reliable diagnosis for any of Ms. Calero's alleged health conditions.

4. Yuli Calero

Yuli Calero is the 12-year-old daughter of Betty Calero and the granddaughter of Santos Calero and Calixta Pineda. Yuli was four years old at the time of the alleged Plan Colombia exposure. Betty Calero testified that the Plan Colombia spraying caused Yuli to experience a rash and a respiratory problem (Betty Dep. 84, 88). Calixta Pineda testified that Yuli has asthma, cough, and back pain (Calixta Dep. 116). As explained previously, skin conditions such as rashes are extremely common in rural Ecuador. Yuli's respiratory problem reportedly was diagnosed and treated as bronchitis by a doctor (Betty Dep. 86). She continued to have ongoing respiratory symptoms in the months and years following the alleged spray episode and still has them (Betty Dep. 88). As noted above, recurrent viral upper respiratory infections are common in tropical Ecuador, as are bronchitis, pneumonia, asthma, tuberculosis and Loeffler's syndrome. Without more information it is impossible to know which of these common conditions might be the cause of Yuli's ongoing respiratory problems. There is no basis to link any of Yuli's alleged conditions to an alleged single exposure to Plan Colombia herbicide.

It is also noteworthy that in the Calero family's September 12, 2002 "toxicology report" there was no mention of Yuli suffering from any rash or respiratory problems following the then-claimed exposure to Plan Colombia herbicide. Rather, in that report, it was claimed that Yuli suffered from stomach pains and loss of appetite. Yuli and her family do not allege any such ailments in their deposition testimony.

C. Edgar Balcazar

Mr. Edgar Balcazar is a 40-year-old man who reported seeing spray planes at a distance of approximately 4 or 5 km from his home (he lives 4 or 5 km from the border) but was unable to testify as to when this occurred. He reportedly lives in primitive conditions in a house that is 6x8 meters in size and made of cement and wood (Questionnaire IV.A.1). He has no running water and brings his water to the house from a stream about 100 meters from the house (Dep. 26-27). He does not filter the water (Questionnaire IV.A.5) and did not report boiling the water. There is no indoor toilet facility, but the family does use a nearby outhouse (Dep. 26).

Mr. Balcazar alleges in his deposition testimony that he experienced burning of the skin and eyes, headaches, rash, dizziness, diarrhea, respiratory problems, and a bowel infection (Dep. 40-41, 55-56, 104, 107). He also alleges that he suffered from stomach problems and stomachache (Dep. 97; Questionnaire V.E.1). All of these started after the spraying was observed, although he does not provide a date for these alleged symptoms. He testified that the skin and eye irritation began 1-1.5 hours after the alleged herbicide exposure but his diarrhea (and potentially some other symptoms) began several days later (Dep. 42). Mr. Balcazar testified that he has had a bowel infection requiring treatment since the time of the sprayings several years before (Dep. 55-57). He could not recall the name of the medicine but states that he continues to take capsules and a syrup for the condition (Dep. 56-57). He testified that medical records should be available at the "international clinic" where he saw a Japanese stomach specialist and at Hospital Vozandes in Quito where he was also evaluated along with his son, but no such records have been provided (Dep. 97-98). Moreover, Mr. Balcazar has not been a consistent historian. For example, his questionnaire does not mention a bowel infection, and his questionnaire alleges pain all over his body (Questionnaire V.E.1), which he did not mention in his testimony.

Mr. Balcazar's testimony as to the distance of the witnessed Plan Colombia spraying operations and the time lapse between the spraying and the diarrhea is directly contrary to his allegation that the symptoms were caused by exposure to the herbicide. Mr. Balcazar's medical complaints are most likely due to his unsanitary living conditions and the known diseases endemic to the region. Diarrhea and stomachache are two of the most common conditions seen in a primary care setting in rural Ecuador. The plaintiff is very likely infested with parasites of various types and may also suffer from bouts of bacterial gastroenteritis due to common organisms found in unsanitary environments, such as Salmonella, Shigella, E. coli, Campylobacter and other species. In addition, an obvious diagnosis for plaintiff's ongoing chronic abdominal pain is chronic gastroesophageal reflux disease (GERD) or chronic gastritis associated with highly endemic H. pylori infection, although it could be due to an inflammatory bowel disease such as Crohn's disease or ulcerative colitis. Gastric cancer is the most common cancer diagnosed in Ecuador and would need to be ruled out with esophagogastroduodenoscopy (EGD), though the patient does not report weight loss which is a common symptom if cancer is present. A bowel infection would not be caused by exposure to a toxic substance.

Mr. Balcazar reports eye irritation beginning 1-1.5 hours after his alleged herbicide exposure (Dep. 42). Complaints of eye irritation are common and could be caused by numerous conditions that I saw regularly during my practice in rural Ecuador. The complaint of burning of the eyes in general is not uncommon in rural Ecuador given its location on the equator and consequent high levels of UVA and UVB light exposure which is damaging to the eyes. Also, Mr. Balcazar makes a vague reference to respiratory symptoms occurring after the spraying episodes, but these symptoms are not characterized to any degree with regard to timing following alleged spray exposure, exact nature of the respiratory symptoms, relieving or exacerbating factors, medications used, or other important information that might help one determine the true cause of his respiratory symptoms. Mr. Balcazar's alleged dizziness also could have been caused by a number of diseases and health conditions common in rural Ecuador.

There is no reliable basis to opine that any of Mr. Balcazar's alleged symptoms are related to glyphosate exposure.

D. Witness 37 Family[8]

In their depositions, the Witness 37 family test plaintiffs allege exposure to aerial spraying on three days in 2003 (Wit. 37 Dep. 34-35, 64-65, 72). Only one member of the family (Wit. 33 Witness 33) submitted any medical records, and these fail to support or even relate to any of his allegations of physical injuries. The specific medical complaints vary between family members and there are inconsistencies within the various reports of the individual family members as well. However, each of their reported symptoms is consistent with many conditions that I diagnosed and treated regularly during my practice in rural Ecuador. This vast number of potential causes combined with no physical examination, relevant medical history, or confirmatory laboratory tests makes it impossible to reach a reliable conclusion as to the cause of the family's symptoms, but there is no basis to opine that they were or could have been caused by a common exposure to Plan Colombia herbicide.

The Witness 37 family of 10 or more people reportedly lives in a wooden home with unfiltered water piped in by a water company (Witness 37 Dep. 22; Questionnaire IV.A.1-4). The water is reportedly potable, but it is not filtered (Witness 37 Dep. 22; Questionnaire IV.A.5). The family has no indoor bathroom. Instead, they use an outhouse located near the house with a septic tank (Witness 37 Dep. 22; Questionnaire IV.B.3-5).

1. Witness 37

Witness 37 is a 61-year-old male who alleges in his deposition that he suffered from loss of vision, headaches, dizziness, diarrhea, vomiting, and skin rash (Dep. 44-45, 115). His claims are unsupported by contemporaneous evidence; he has not submitted any medical records or laboratory tests. Witness 37 also has not been a consistent historian regarding his medical conditions. At his deposition, for example, he did not mention the allergy, fever, or itching symptoms that were stated in his questionnaire, but he added new claims that were unidentified in his questionnaire. In any event, the symptoms he alleged are commonly seen in rural Ecuador and have many potential causes. There is nothing unusual about his claimed ailments, and his testimony provides no basis to support a causal link between his alleged symptoms and a chemical exposure.

While Witness 37 Questionnaire did not mention vision problems, at his deposition he claimed that his vision began to deteriorate approximately 4 months after being exposed to the Plan Colombia herbicide (Dep. 116). At his deposition, he initially stated that he was unable to see well enough to read (Dep. 11-12). After defendants' counsel provided him with a pair of reading glasses, however, he stated that his vision improved and he was apparently able to see well enough to read (Dep. 11-12). It is thus highly likely that he suffers from typical, age-related presbyopia that is easily corrected with reading glasses. Any suggestion that this condition was caused by exposure to a herbicide is without basis.

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[8] The Witness 37 family members are the only test plaintiffs who live in the Esmeraldas province of Ecuador, which is not in the Amazon region but whose residents suffer the same kind of (or worse) health problems described throughout this report for poor, rural residents of Northern Ecuador.

In his deposition testimony, Witness 37 claims that he also suffered from dizziness, headaches, diarrhea, vomiting, and a rash (Dep. 44-45). As discussed above, each of Witness 37 alleged symptoms are consistent with many diseases and health conditions endemic to rural Ecuador, making it impossible with the sparse information available here to render a diagnosis or reach a reliable conclusion as to a potential cause. There is no medical basis to opine that any of Witness 37's conditions were caused by exposure to Plan Colombia herbicide.

2. Witness 33

Wit. 33 is the 26-year-old son of Witness 37 who alleged at deposition that he suffered from vomiting, diarrhea, headaches, and a rash following his exposure to the Plan Colombia spraying in 2003 (Dep. 25, 46-47) (notably though, his questionnaire did not identify vomiting or diarrhea). Wit. 33 testified that he experienced these symptoms intermittently for at least six months (Dep. 28). He reports having gone to see a nurse and having received medication that helped alleviate his symptoms (Dep. 28). Wit. 33 has submitted medical records from a single visit that appears to be dated July 15, 2008 (15-07-08). The writing is largely illegible but it appears he presented with "strong diarrhea and vomiting" and was prescribed oral rehydration, diclofenac, and ampicillin or amoxillin. There is no reference to fumigation or spray exposure and this is a visit 5 years distant to the alleged exposure. It is highly unlikely that a brief exposure to a toxin would cause recurrent symptoms, and they are much more likely due to parasitic or bacterial infections given the poor living conditions and lack of clean drinking water. Due to the absence of a complete medical history, medical records, and laboratory tests, however, a reliable diagnosis cannot be determined. Witness 33 claimed medical condition or conditions could be due to many causes endemic to rural Ecuador, and there is no medical basis to opine that they were caused by exposure to Plan Colombia herbicide.

3. Witness 37's son

Wit. 37's son is the 15-year-old son of Witness 37 who testified that he saw spray planes three times when he was approximately 8 years old (Dep. 24), which would be around 2003 or 2004. Wit. 37's son testified that he suffered from itching, headaches, diarrhea and dizziness after each time he saw the spray planes, and that after the second exposure he also experienced a skin rash (Dep. 27, 37, 44). His father Witness 37 testified that the entire family suffered from dizziness, headaches, diarrhea, vomiting, and skin rash (Witness 37 Dep. 44-45, 49). After the first exposure Wit. 37's son testified that his symptoms lasted 1-2 days, after the second exposure they lasted approximately 2 days, and after the third exposure they lasted about 3 days (Dep. 27-28, 37, 44). Wit. 37's son reports that he has intermittently experienced headaches, dizziness, and itching skin since his exposure (Dep. 78). All of these symptoms are commonly caused by diseases and conditions regularly seen in Northern Ecuador, and there is no medical basis of which I am aware that the transient exposure to a chemical could cause intermittent symptoms of the types alleged. Rather, Wit. 37's son medical history suggests that his recurring symptoms arise from his continued exposure to the unhealthy, unsanitary conditions where he lives. Given the lack of any distinct symptoms, medical records or diagnostic tests, it is impossible to reach any reliable conclusion even as to the specific nature of his medical ailments, and there certainly is no basis to reach a medical conclusion that his symptoms were caused by exposure to Plan Colombia herbicide.

E. Salas Family

In their depositions, the Salas family test plaintiffs allege that they suffered various physical injuries from exposure to the Plan Columbia spray on various inconsistent dates.[9] The family's allegations of personal injuries from exposure to the herbicide spray are based on self-reporting. While the plaintiffs submitted medical records for Laura and John, none of these records even relate to the test plaintiffs' alleged injuries, much less support their claims. There are also inconsistencies in the family members' reports of their alleged injuries.

The Salas family reportedly lives in a house made of cement and wood and they have a toilet 8 meters from their house (Santos Questionnaire IV.A.1; Laura Dep. 154-55). There is an oil well approximately 500 meters from their house that pollutes the area (Laura Dep. 138; John Dep. 74-76).[10] The family filed a complaint about an oil spill from that site, claiming that it affected the family's living conditions (Santos Dep. 116-17).

1. Jorge Salas

Jorge Salas is a 56-year-old male who alleges that he received various physical injuries from exposure to glyphosate on three occasions. Mr. Salas has presented inconsistent accounts of his alleged medical ailments, testifying that he suffered eye irritation during each herbicide exposure, but failing to include this alleged injury in his questionnaire. Mr. Salas has submitted no medical records, and there are no laboratory tests or other evidence to support his claims.

At his deposition, Mr. Salas testified that during his first alleged exposure, he experienced itching, nose and eye irritation, and a skin infection (Dep. 27, 33), that during the second alleged exposure, he experienced itching and inflammation of the throat, eyes, and skin (Dep. 40, 50), and that during the third alleged exposure, he suffered from the same burning and itching in his throat and eyes (Dep. 60-61). As noted previously, all of these symptoms are common in rural Ecuador. Mr. Salas testified that he was given antibiotics for a skin infection after the first alleged spray exposure (Dep. 33). A skin infection would have been caused by one of many infectious agents which are widespread in Ecuador, and could not have been caused by a cutaneous exposure to a chemical. Moreover, Mr. Salas's testimony that he continues to have itching of his skin (Dep. 127-28) is inconsistent with transient exposures to a chemical irritant, and may be indicative of impetigo, eczema, scabies, or a parasitic infection, to name just a few of the possibilities. Mr. Salas's deterioration of vision (Dep. 127) is likely due to age-related presbyopia. Without a more detailed history, medical records, or laboratory tests, it would be speculation to identify a diagnosis for Mr. Salas's alleged ailments, or to ascribe them to any specific cause.

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[9] Jorge's Questionnaire reported exposure on October 4, 2002, and Laura's Questionnaire claimed that she had been exposed "since 2002" (Questionnaire V.C.). At the depositions, Jorge testified that he was exposed in December 2000, May 2001, and October 2003 (Dep. 23-25, 35, 53), while Laura testified that she was exposed in June 2002, January 2003, and October 2003 (Dep. 33, 60, 71).

[10] Laura's Questionnaire stated that the oil well was about 200 meters from the family's home (Questionnaire IV.C.1).

2. Laura Sanchez

Laura Sanchez is a school teacher and the 47-year-old wife of Jorge and mother of John, who reports several medical problems following three alleged exposures to herbicide spray in 2002 and 2003. Her allegations are inconsistent across her alleged exposures and have changed over time. Unlike her husband, Mrs. Sanchez has submitted some medical records, most of which pertain to her pregnancy and gynecological concerns but none are relevant to her claims here. The plaintiffs have not presented evidence to support a reliable diagnosis of Mrs. Sanchez's symptoms, let alone a causal link between her symptoms and herbicide exposure.

Though her symptoms vary across exposures, Mrs. Sanchez generally testified that she experienced itching skin, burning of the nose, itching and burning of the eyes, headache, burning in her stomach, and throat problems (Dep. 38, 43, 64, 67). As discussed above, irritation of the skin and eyes is very common in the tropics because of endemic diseases, environmental factors, and unsanitary living conditions. Without a more detailed history, medical records, or laboratory tests, no reliable diagnosis of these symptoms can be rendered. The burning in her stomach could be due to several diseases and health conditions endemic to the region. The nose and throat irritation could be caused by an upper respiratory infection, allergies, or sinus problems, as well as many other common conditions. A headache likewise could be caused by a number of conditions, and indeed for most headaches there is no known cause.

Any attempt to diagnose Mrs. Sanchez's conditions or identify a causal connection to a chemical exposure is further undermined by the fact that we must rely solely upon Mrs. Sanchez's self-reporting of her symptoms, but that self-reporting has changed over time. Mrs. Sanchez's Questionnaire stated that she experienced, among other symptoms, dizziness and body weakness (Questionnaire V.E.1, 7). At her deposition, she did not allege that she experienced either of these symptoms. Moreover, the "toxicology report" submitted by the plaintiffs for Mrs. Sanchez does not include these symptoms either. (It is also notable that the "toxicology report" is dated June 28, 2001, approximately a year prior to Mrs. Sanchez's first claimed exposure.)

3. John Salas

John is the 17-year-old son of Jorge and Laura who is alleged to have experienced markedly different symptoms compared to his parents following exposure to the herbicide spray. The plaintiffs have submitted some medical records for John, but they do not relate to his alleged symptoms and provide no support for the claim that glyphosate caused his physical injuries. All of the medical records presented are for events between 1993 and 1996 except for a single entry from 2002 related to a dental visit. The claims of physical injury have changed over time. John's questionnaire alleged that the spraying caused only respiratory problems and respiratory disease (Questionnaire V.E.1, 7). At deposition, he and his parents added a number of previously-unidentified symptoms. Particularly given the lack of any relevant medical records, this inconsistent reporting of John's medical history makes it impossible to render a reliable diagnosis or establish any cause of his varyingly alleged ailments. Nothing in the Salas's testimony or the materials they have submitted could support a reliable conclusion either as to the identity of John's diseases or conditions, or what might have caused them.

John testified that exposure to the herbicide spray caused body pain, bone pain, sore throat, headache, and an inability to get out of bed (Dep. 49). His mother Laura testified that he also experienced burning eyes, itching, vomiting, dizziness, throat problems, and a lack of appetite (Laura Dep. 44, 65, 71). All of these symptoms are non-specific and quite common in rural Ecuador, and there are many potential diseases and conditions that could have caused each of them. Jorge testified that John also had the flu (Dep. 109-10), which would explain many of his alleged symptoms. They are, however, consistent as well with a number of other common diseases, none of which are related to a chemical exposure. At his deposition, John complained of ongoing headaches, sore throat, and bone pains which he has experienced since the herbicide exposure (Dep. 51-52). He testified that these conditions require occasional treatment with medications by the school principal (Dep. 55). All of these are common complaints and have many potential causes. Recurrent sore throat in a young person is most commonly due to bouts of Streptococcal pharyngitis or viral pharyngitis, which are caused by infectious agents and neither of which would be caused by a chemical exposure. Bone pain in young children who are going through growth spurts is quite common and can be due to what is termed “growing pains.” Beyond this most obvious cause, there are other more serious illnesses endemic to the region that could be considered, such as Dengue fever and malaria. Given the lack of more specific information, including more in depth history, physical exam, and laboratory tests, it is impossible to determine a distinct cause of any of his symptoms. There is no medical basis upon which one could opine that any of his alleged ailments were caused by exposure to Plan Colombia herbicide.

F. Mestanza Family

In their depositions, the test-plaintiff members of the Mestanza family allege that they suffered various symptoms as a result of alleged spraying on five occasions between 2000 and 2002. Their exposure allegations are inconsistent with the answers in their questionnaire responses, which alleged exposures on varying other dates. The family members’ claims are all based on self-reporting; there are no relevant medical records, medical history, or laboratory tests that could support a reliable diagnosis. The need to rely on the family’s self-reporting is particularly problematic because the family has admitted that some of the ailments that they had at one time attributed to the spraying did not in fact occur. For example, 42-year-old son Edy Mestanza’s Questionnaire claimed that he saw spray planes, described the spray operations in detail, and alleged that he experienced various symptoms from the spraying. He admitted at his deposition, however, that he was never at the farm during the spraying and suffered no physical injuries because of it. The Mestanza family likewise had previously alleged that the Plan Colombia herbicide had caused various injuries to three other family members who they subsequently conceded also were hundreds of miles away from the location of the alleged spraying (at the family’s principal home in Guayaquil) and who suffered none of the alleged symptoms (Pls.’ Motion to Dismiss Three Individual Pls. at 1-2; Defs.’ Response at 3-8). For those family members who still allege that they were physically injured, the allegations of physical injury are inconsistent and have changed over time.

Moreover, as discussed below, there are a number of other conditions common in rural Ecuador that could have caused each of the family members’ now-alleged symptoms. Because of all of these factors, it would be pure speculation to diagnose their conditions or identify a causal connection between the symptoms and a chemical exposure.

According to their questionnaires, at their farm in Sucumbios,[11] the Mestanzas live in a home made of wood with no running water (Victor Questionnaire IV.A.1, 4). There were inconsistent questionnaire answers regarding where the family obtains drinking water, but it is obtained from some natural body of water (Victor & Ercilia Questionnaires IV.A.2-3). Ercilia's Questionnaire response stated that they did not filter their water, while Victor's Questionnaire stated that they filtered it by boiling it (Victor & Ercilia Questionnaire IV.A.5). If they indeed failed to filter or boil their water, it would increase the family's susceptibility to a number of potential infectious disease agents. Victor and Ercilia's Questionnaires both stated that the family uses an outhouse, but their answers were not consistent as to whether there was a toilet inside the home (Victor & Ercilia Questionnaires IV.B.3, 4). After reviewing a video of the family's living conditions with standing water, goats, pigs, and cows nearby, the unsanitary living conditions are vividly confirmed. Mr. Mestanza also makes a long speech about the lack of a school in the community which has caused a number of families to move away seeking an education for their children.

1. Victor Mestanza

Victor Mestanza is a 60-year-old male who reports exposure to spraying in late 2000, January 2002, September 2002, and October 7 and 10, 2002. Mr. Mestanza testified that the spraying caused him to experience itching skin, irritation of his eyes and throat, and bacterial or fungal infections, and he testified that the spraying may have caused symptoms including headaches and problems with his stomach, throat, and vision (Dep.46-47, 56, 68, 74, 82-83, 137, 140). Like the rest of the family, Mr. Mestanza has submitted no medical records to document his alleged conditions. There is similarly no detailed history or confirmatory laboratory results. Moreover, Mr. Mestanza has not been a consistent historian with respect to his alleged symptoms. At his deposition he failed to mention several of the symptoms claimed in his questionnaire, and stated that many of the rest "may be a coincidence" (Dep. 83). He also did not make any mention of personal injuries from the spraying in a video he made shortly after the October 2002 spraying, and no such injuries are apparent in the video. In any event, each of Mr. Mestanza's varyingly alleged symptoms is common in rural Ecuador, and his testimony does not provide any reliable basis upon which to opine that they were caused by exposure to Plan Colombia herbicide.

Mr. Mestanza testified that he experienced some combination of itching of his skin and irritation (burning and/or itching) of his eyes and throat after each exposure. He reports having seen Dr. Erwin Gonzabay for these conditions and having received treatment. As mentioned above, eye and skin conditions are extremely common in rural Ecuador and could be explained by many diseases that I saw regularly in my practice there. In addition, a number of potential diseases or health conditions could be responsible for Mr. Mestanza's complaints of throat irritation.

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[11] As made clear in their depositions, the Mestanza family's principal place of residence, currently and at the time of the alleged spraying events, is in Guayaquil, 275 miles from the Ecuador-Colombia border.

Mr. Mestanza also reports other symptoms that he concedes “may have been coincidence” after the spraying including stomach problems, gastritis, headaches, throat problems, and loss of eyesight (Dep. 82-83). He appears to have claimed that he had bacterial or fungal infections and an inability to eat as a result of the spraying (Dep. 137, 140). Mr. Mestanza has produced a certification signed by Dr. Gonzabay stating that as of October 2002 Mr. Mestanza had chronic contact dermatitis from polluted water, about a 35% diminution in vision forcing him to wear glasses, and chronic gastroenteritis, all of which Mr. Mestanza attributes to the spraying. Though this certification is signed by Dr. Gonzabay, Dr. Gonzabay has testified that he has not reached any opinion that these symptoms were caused by the spraying and that he did not prepare the certification, which was provided to him by Mr. Mestanza some ten months after he had seen him. Dr. Gonzabay explained that in signing the certificate, Dr. Gonzabay was simply acknowledging that Mr. Mestanza had made these health complaints.[12]

All of the symptoms varyingly alleged by Mr. Mestanza are commonly seen in Northern Ecuador as a result of endemic health problems that have nothing to do with any alleged toxic exposure. Indeed, many of his health complaints could not occur as a result of a chemical exposure. Bacterial or fungal infections would be caused by one or more of the many infectious agents prevalent in rural Ecuador, and could not be caused by a chemical exposure. Chronic dermatitis also is unlikely to be caused by infrequent and isolated chemical exposures, and in any event can be caused by numerous conditions endemic to the Ecuadorian Amazon. The decreased vision was most likely due to age-related presbyopia, especially because Victor used eyeglasses to correct it (according to the Gonzabay certification). Among a myriad of other causes, headaches can be caused by patients who need glasses not having them or having an incorrect prescription. As mentioned earlier, chronic gastritis is extremely common in Ecuador and is highly associated with H. pylori infection, though there are many other potential causes. There is no reliable basis to conclude that any of Mr. Mestanza’s symptoms were caused by herbicide exposure.

2. Ercilia Bosquez

Ercilia Bosquez is the 58-year-old wife of Victor. While her health complaints are somewhat unclear, she appears to be alleging that she experienced different symptoms following the different alleged spraying events, and her reporting of her symptoms has changed over time. As with her husband, Mrs. Bosquez’s claims are based on self-reporting; there are no medical records or contemporaneous evidence to support her medical complaints. Mrs. Bosquez’s testimony does not provide a reliable basis to conclude that her claimed symptoms were caused by exposure to Plan Colombia herbicide.

During her deposition, Mrs. Bosquez testified that she: (1) experienced itching of the nose and burning of the throat after her first exposure (Dep. 38-39), (2) experienced throat and stomach problems after her second exposure (Dep. 56), (3) experienced no symptoms after her

[12] Dr. Gonazabay testified that the certifications reflected what the patient reported, and he did not conclude that the spraying caused the reported symptoms (Dep. 61). At his deposition, Victor acknowledged that his certification only repeated what he told Dr. Gonzabay (Dep. 143).

third exposure (Dep. 60), and (4) experienced nose and throat irritation, stomach problems, and after two days or so itching and a rash, after her fourth and fifth exposure (Dep. 70). She reported a skin problem due to contaminated water (Dep. 102-03). After being shown her questionnaire responses, Mrs. Bosquez testified that she experienced respiratory problems and diarrhea (Dep. 89-90). She also testified that she has suffered the following symptoms since the first sprayings: a sore throat, stomachache, a rash, and an itch (Dep. 46-47). She alleges that her ongoing rash is intermittent, getting better with cream given her by the doctor and then tending to recur (Dep. 97-99). Mrs. Bosquez has submitted a certification from Dr. Gonzabay stating that as of October 2002 she had chronic contact dermatitis due to polluted water, chronic pharyngotonsillitis, and chronic gastroenteritis. As explained during the discussion of Victor Mestanza's claims, this certification merely recounts Mrs. Bosquez's allegations and does not represent an opinion by Dr. Gonzabay regarding what may have been responsible for her complaints.

All of Mrs. Bosquez's alleged symptoms are non-specific and are symptoms that I treated quite often during my practice in Ecuador. Mrs. Bosquez's ongoing rash and itching are far more likely to be caused by a parasite or bacterial infection than alleged isolated chemical exposure 8 or 9 years ago. In the Gonzabay certification, Mrs. Bosquez complains of three chronic illnesses. However, chemical exposures that are not ongoing are unlikely to cause chronic conditions, and there are a number of explanations for each of the claimed symptoms. Chronic contact dermatitis could be caused by repeated and ongoing cutaneous exposure to numerous substances that are everpresent in Ecuador. Chronic pharyngotonsillitis is most commonly due to recurrent viral or bacterial infections, among many other potential causes. As mentioned, chronic gastritis is extremely common in Ecuador and is highly associated with H. pylori infection, though again there are other potential causes. It would be impossible to arrive at a reliable diagnosis for any of Mrs. Bosquez's symptoms. The various symptoms Mrs. Bosquez reported following different exposures makes it significantly less likely that her symptoms would have been due to any single cause, let alone transient exposures to the Plan Colombia herbicide.

3. Edy Mestanza

Edy Mestanza is the 42-year-old son of Victor and Ercilia. As noted above, despite his questionnaire responses indicating that he had seen the spray aircraft and suffered various symptoms from exposure to the spraying, he admitted at his deposition that he experienced no physical injuries and had not even been at the farm when he was allegedly exposed to the herbicide (Dep. 66, 81). He identified, however, new claims of emotional and psychological damages as a result of his alleged property losses from the spraying and his family members' alleged physical injuries (Dep. 82, 158-59). These claims are unsupported by any medical records or contemporaneous evidence.

4. Jennifer Mestanza

Jennifer Mestanza is the 14-year-old daughter of Edy and granddaughter of Victor and Ercilia. Her testimony and that of her family members reveals a wide range of conflicting symptoms. The symptoms alleged are inconsistent across exposures and the family members have dramatically different recollections of her symptoms. As with the rest of the family, no medical records or laboratory tests are available. Neither Jennifer's nor her family members' testimony can provide a sufficient basis to diagnose her symptoms or link them to herbicide exposure.

Jennifer remembers very little about her first alleged exposure (in 2000), but testified that after the later exposures (in 2002), she suffered itching skin, burning eyes, and a sore throat (Dep. 49-50). Victor (her grandfather) testified that during the first exposure she experienced burning in her eyes and throat (Victor Dep. 47), while Ercilia (her grandmother) testified that Jennifer had the same symptoms as she did (Ercilia Dep. 44), i.e. itching in her nose burning in her throat (Ercilia Dep. 38) (and potentially sore throat, stomachache, a rash, and an itch, which Ercilia stated she had experienced since the first exposure (Ercilia Dep. 46-47)). Like Ercilia, Jennifer also apparently had no symptoms following the third exposure (Ercilia Dep. 61). Jennifer testified that she still suffers from itching skin, sore throat, and burning eyes (Dep. 50). Edy (her father) testified that she still has skin and throat problems (Edy Dep. 92), and that she previously experienced and may still be experiencing respiratory problems (Edy Dep. 93). Ercilia testifed that Jennifer still experiences only throat problems (Ercilia Dep. 104). The plaintiffs submitted a certification signed by Dr. Gonzabay stating that as of October 2002 Jennifer suffered from chronic contact dermatitis due to polluted water, approximately 35% diminution of vision forcing her to wear eyeglasses, and chronic gastroenteritis, allegations that are identical to those set forth in the certificate the family had prepared for Victor Mestanza.[13] In her deposition, however, Jennifer testified that she could not remember any stomach problems, that her eyesight is fine, and that she has never worn eyeglasses. (Jennifer Dep. 57-58, 104-106). It is also notable that Dr. Gonzabay's treatment of Jennifer suggests that he did not attribute her condition to any toxic exposure. Dr. Gonzabay testified that he treated Jennifer with corticoids, antimycotics, and antibiotics, which are standard remedies for bacterial or fungal infections, and that this treatment was successful (Gonzabay Dep. 62-63).

As with the rest of the family, Jennifer's alleged symptoms are common in the Ecuadorian Amazon. It is difficult to postulate how any alleged transient exposure to a herbicide could cause the ongoing skin problems from which Jennifer is alleged to suffer. It is much more likely that Jennifer suffers from eczema, scabies, a fungal infection, or contact dermatitis due to ongoing exposure to some other substance, among many other potential causes. As mentioned previously, recurrent throat irritation in this age group is common and is usually due to recurrent viral or Streptococcal infection. Likewise, eye irritation is quite common in the tropics and could be due to the intense sunlight or numerous other diseases or factors. Nothing in any of the family's testimony or any other materials provides a reliable basis to diagnose Jennifer's medical conditions or opine to a causal relationship to herbicide exposure.

[13] As explained earlier, in signing this certificate, Dr. Gonzabay was simply acknowledging the family's allegations; he testified that he did not make any determination himself as to whether the Plan Colombia spraying caused the alleged symptoms.

G. Elvia Alvarez

The last test plaintiff, Elvia Alvarez is a 54-year-old woman who testified at her deposition that she she saw spray planes near her farm in April 2001, and then approximately six months later she heard planes but apparently did not see them (Dep. 30, 78-79). She lives in a wood plank house (Dep. 22; Questionnaire IV.A.1), and she testified that she gets her water from a stream that flows from a swamp and from rainfall (Dep. 22, 60-61). She does not filter the water (Dep. 22), which increases the risk that microbes and other organisms could cause infections and other health problems. She has an outhouse about 30 meters from the house (Dep. 22).

Ms. Alvarez alleged in her deposition testimony that she experienced a headache, dizziness, body pain, stomachache, diarrhea, and she was spitting up blood (Dep. 34). She testified that these symptoms began slowly about one or two days after her exposure, and while it is unclear, it appears that she experienced most of them for about three months (Dep. 34, 63-64). She apparently experienced fever and cough for three to six months, and she still has bloody sputum, but it is unclear and she may still experience all of these symptoms (Dep. 63-64). Ms. Alvarez did not provide any medical records documenting these symptoms. She testified that she has been told that she has tuberculosis, but she has been afraid to visit a doctor and instead uses traditional remedies (Dep. 64-65). I agree that her symptoms indeed sound like a typical case of pulmonary tuberculosis but could also represent a case of bronchiectasis or paragonamiasis. None of these conditions would be caused by a brief chemical exposure.

Ms. Alvarez also testified that she had a rash that lasted for approximately a month (Dep. 135). As explained earlier, skin conditions are extremely common in rural Ecuador, and her rash could have been caused by bacterial skin infections or parasitic infestation. Likewise, there is nothing unusual about Ms. Alvarez's other claimed symptoms; they are symptoms that I treated regularly in Ecuador. It is unlikely that a brief chemical exposure would cause either delayed or chronic symptoms, both of which Ms. Alvarez reports. Indeed, it is unlikely that any single cause could be responsible for a wide variety of symptoms with varying lengths of time elapsed from exposure to onset of symptoms. In any event, with the information available no physician could reliably diagnose Ms. Alvarez's symptoms.

Any possibility of reaching a reliable opinion as to a potential cause of Ms. Alvarez's medical conditions is foreclosed by the fact that she has been an inconsistent historian regarding her symptoms. Her questionnaire alleges only body aches and cough productive of bloody sputum (Questionnaire V.E.1 and V.E.7). In her deposition testimony, she adds previously-unidentified headache, dizziness, stomachache, diarrhea, and rash (Dep. 34, 135). Her questionnaire states that her symptoms started one year after she saw the spray planes (Questionnaire V.E.1), but she later testified that the symptoms began "little by little" one or two days after she saw the spray planes (Dep. 34). These inconsistencies, combined with the numerous alternative causes for her symptoms and the lack of confirmatory medical records or laboratory tests, precludes reaching any reliable conclusion even as to a diagnosis of Ms. Alvarez's symptoms, let alone opining to a causal connection between those symptoms and exposure to Plan Colombia herbicide.

RESPONSE TO EXPERT REPORT PREPARED BY PLAINTIFFS' EXPERT, DR. WOLFSON

Plaintiffs' expert, Dr. Wolfson, does not opine that any of the plaintiffs' alleged medical conditions were caused by exposure to Plan Colombia herbicide. Instead, Dr. Wolfson has offered the opinion that "most, if not all, of the health complaints experienced by these [test] plaintiffs" (Wolfson Rpt. 3) – i.e., "itchiness to the skin, nose, and eyes; skin irritation; burning sensation to the skin and eyes; rash; vomiting; respiratory problems; headaches; dizziness; stomach aches; diarrhea; and burning throat" (Wolfson Rpt. 3, emphasis omitted) – "are consistent with exposure to glyphosate-based herbicide spray" (Wolfson Rpt. 3, emphasis added).[14]

Dr. Wolfson does not provide any medical basis for this opinion, and for the reasons set forth in my report, I disagree with his conclusion. Putting to one side the question of whether any type of exposure to a glyphosate-based herbicide could cause any of the symptoms he identifies to any degree – a question that I understand is being addressed by other experts in this case – it is impossible, without significantly more medical evidence (and more reliable medical evidence) regarding the nature of each of the plaintiffs' alleged injuries and exposures, to reach Dr. Wolfson's tentative "consistent with" opinion. Moreover, Dr. Wolfson makes no mention of the many other common potential causes in the differential diagnosis of each plaintiff's alleged maladies, which are regularly seen in the tropical and impoverished rural communities in Ecuador where the test plaintiffs live. From a physical and medical standpoint, the twenty test plaintiffs appear no different than the thousands of similarly situated individuals that I treated during my 8.5 years of medical practice in rural Ecuador, and there is insufficient evidence to look to an alleged toxic exposure as a cause of their common medical complaints.

Dated: 1/19/2011

Roger D. Smalligan, MD, MPH

CR Note: Dr. Smalligan's CV (Exhibit A), found in CD - Original Annexes

[14] The "causation" reports prepared earlier for each plaintiff by Dr. Campana in 2009 similarly concluded that each plaintiff's alleged health complaints (whatever they were for each plaintiff) were "consistent" with exposure to glyphosate spray.

EXHIBIT B

Roger D. Smalligan, M.D. Materials Considered

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Other Materials Considered

1) Binder of Full Deposition Testimony for all Test Plaintiffs.

2) Defendants' Response to Plaintiffs' Motion to Dismiss Three Individual Plaintiffs, No. 1:01-cv-01908-RWR-DAR, ECF Doc. No. 172, January 6, 2010.

3) Expert Report by Plaintiffs' Expert Witness, Dr. Michael Wolfson.

4) Excerpts of Test Plaintiff Victor Mestanza Deposition Transcript, November 9, 2009.

5) Excerpts of Dr. Edwin Gonzabay Deposition Transcript, July 8, 2009.

6) Response from Stephen Johnson, Assistant Administrator, U.S. EPA, to Colin Powell, Secretary of State, re Consultation Review of the Use of Pesticide for Coca Eradication in Colombia. August 19, 2002.

7) Plaintiffs' Motion to Dismiss Three Individual Plaintiffs, No. 1:01-cv-01908-RWR-DAR, ECF Doc. No. 171, December 23, 2009.

8) Plaintiffs' Reply in Support of Their Motion to Dismiss Three Individual Plaintiffs, No. 1:01-cv-01908-RWR-DAR, ECF Doc. No. 175, January 13, 2010.

9) Order by Judge Richard W. Roberts, No. 1:01-cv-01908-RWR-DAR, ECF Doc. No. 178, January 29, 2010.

10) Video featuring Victor Mestanza and the Mestanza farm. November 2002. PLS-00005881.

11) Video featuring Victor Mestanza and the Mestanza farm. August 2009. PLS-00005882.

12) a binder for each test plaintiff family containing:

A) a table with citations to claims of physical injuries in certain evidentiary submissions of the test plaintiffs (initial disclosures, questionnaire responses, declaration of Marco Campana, deposition testimony excerpts, Accion Ecologica toxicology sheet and survey)

B) the following information for each test plaintiff (if applicable to the test plaintiff and/or family):

i) initial disclosure

ii) questionnaire responses

iii) excerpt from the Marco Campana declaration specific to each plaintiff

iv) all deposition testimony excerpts re alleged personal injuries/illnesses and related issues

v) other test plaintiff-specific information relating to their alleged physical injuries (e.g., medical records, photographs and/or video, excerpts from prior lawsuits, prior certifications, Accion Ecologica toxicology sheet and survey)

vi) excerpts of certain non-governmental organization and other third party reports that mention the test plaintiffs or the areas in which they live with respect to diseases or public health conditions

C) a map showing the approximate location of the test plaintiffs' farm and spray lines (if any) for the dates of spray exposure alleged by any of the family members in their depositions

Annex 14

Expert Report of Dr R.C. Ploetz, Ph.D. on Behalf of the Defendants in *Arias/Quinteros v. Dyncorp*, 19 January 2011

(United States District Court for the District of Columbia, Cases No. 1:01-cv01908 (RWR-DAR) and 1:07-cv01042 (RWR-DAR). Cases consolidated for Case Management and Discovery)

EXHIBIT 11

Expert Report of Randy C. Ploetz on Behalf of the Defendants in *Arias/Quinteros v. DynCorp*

I. Introduction

A. Expert Credentials

My name is Randy C. Ploetz. I am a tenured Professor of Plant Pathology with the University of Florida, where I have served on the faculty since 1986. I received a B.S. in Forestry and an M.S. in Plant Pathology from Purdue University, and a Ph.D. in Plant Pathology from the University of Florida. My areas of specialization are the etiology, epidemiology and control of diseases in subtropical and tropical agroecosystems. My current research activities include investigations of: (a) the epidemiology and management of laurel wilt disease on avocado; (b) the population biology of *Colletotrichum gloeosporioides* and the diseases it causes on mango; (c) the *Botryosphaeria* pathogens of diverse hosts in South Florida; (d) the phylogeny and geographic origins of the pathogens that cause mango malformation and the management this disease; and (e) the biology and management of various diseases of tropical fruit, vegetable and ornamental crops. My current extension and outreach activities include addressing the threat posed to banana production in the Western Hemisphere by the pathogen Tropical Race 4 of Panama disease (TR4 below).

I have a research appointment at the University of Florida (95%) with secondary teaching responsibilities (5%) as a student advisor (currently seven Ph.D. and one M.Sc.) and an instructor in HOS 5555 (Tropical Fruit Production and Research in Florida). I am a member of several professional societies, and have held, and currently hold, leadership positions in the International Society of Plant Pathology, the American Phytopathological Society, the Florida State Horticultural Society and the Florida Phytopathogical Society. I received the University of Florida's Research Professor Award in 2004 and the American Phytopathological Society's International Service Award in 2008.

I am an authority on diseases of tropical crops, with emphasis on those that occur on tropical fruits. I have written over 300 publications, including papers in refereed journals (90), books (4), book chapters (54), abstracts (135) and numerous technical bulletins and popular articles. A list of my publications is included with my CV, which is attached hereto as Exhibit A. I edited and wrote chapters in *Fusarium Wilt of Banana* and *Compendium of Tropical Fruit Diseases* for APS Press and another book, *Diseases of Tropical Fruit Crops*, for CAB International; each of which are standard references for research and teaching. I am interviewed often on tropical plant disease problems, most recently concerning the perceived threat of extinction of banana and the serious impact that cacao diseases have on global chocolate production (television: NPR Canada; radio: Discovery Channel and Ira Flatow's Science Friday; magazines: *Popular Science*, *Scientific American* and *New Yorker*; and books: *Banana: The Fate of the Fruit that Changed the World*).

Much of my work is conducted in other countries, with on-going collaborations in several countries and work in 36 since 1990 (Australia, Austria, Bahamas, Benin, Bolivia, Brazil, Burundi, Canada, China, Colombia, Costa Rica, Dominican Republic, Ecuador, Egypt, France, Honduras, Indonesia, Israel, Jamaica, Malawi, Malaysia, Mexico, Nicaragua, Nigeria, Oman, Peru, Rwanda, South Africa, South Korea, Spain, Swaziland, Taiwan, Thailand, Uganda, United Arab Emirates, and the United Kingdom).

I have been to Ecuador four times. In 2004, I was an invited participant at a meeting in Quevedo on cacao diseases and their biological control. While there, I reviewed cacao research programs at Ecuador's Autonomous National Institute of Farming Research (INIAP) facility in Pichilingue and visited cacao production and research sites in the region. Most recently, I spoke at banana conferences on the threat posed by the pathogen TR4 (outreach activity mentioned above). I was an invited speaker at the Association of Ecuadorian Banana Exporters (AEBE) (a national association of banana producers and exporters) conferences in 2007 and 2009, and an invited speaker at the ACORBAT (biennial hemispheric meeting of banana producers and researchers) meeting in 2008, all of which were held in Ecuador in the city of Guayaquil. In 2007, I visited traditional and organic banana production sites in the country, and in 2008 visited agricultural production and research sites. I was also an invited plenary speaker at the ACORBAT 2010 meeting in Medellin, Colombia, in November 2010.

In general, I am a consultant for international agencies and producers; I assess new disease outbreaks and the status of other, important problems on tropical crops; and I advise research projects. I served two consecutive terms as Chair of the Fusarium Wilt Working Group of the Consultive Group on International Agricultural Research's (CGIAR's) International Network for the Improvement of Banana and Plantain.

B. Compensation and Prior Expert Witness Experience

I am being compensated at a rate of $450 per hour. I have never previously served as a testifying expert in litigation.

C. Materials Considered

The materials that I have considered in my report are referenced herein and set forth in Exhibit B, attached hereto.

II. <u>Summary of Expert Opinions</u>

I have been advised that the Ecuadorian plaintiffs in the above referenced litigation are alleging that their crops were damaged by herbicide spray used in the Republic of Colombia for the aerial eradication of coca for Plan Colombia. Based upon my review of the videographic and photographic evidence, lab tests, and other investigation reports provided by the plaintiffs relevant to these allegations, along with my general background and expertise in tropical diseases in crops, I have reached the following opinions:

A. Plant diseases are prevalent in tropical environments (see Ploetz, 2007b, attached as Exhibit C), and are commonplace in the region in which the plaintiffs reside.

B. The videographic, photographic and laboratory data evidence provided by the test plaintiffs does not provide any reliable scientific basis for their allegations of glyphosate based damages. To the contrary, the evidence presented indicates that the alleged crop damage was likely caused by plant diseases that are endemic to the region.

III. Basic tutorial on plant diseases

Disease background. Disease is defined as a disruption of the normal growth or function of a plant that is caused by the continuous insult of a pathogen, *i.e.*, a disease-causing agent (Agrios, 2005). Disease results from the interaction of a susceptible plant (="host") and a pathogen. Pathogens in two of three Domains of living organisms, the Eukaryota and Eubacteria, cause plant diseases (Figure 1) (no pathogens are known in the third Domain, the Archaea, and viruses and viroids, which are not living organisms, have unclear affinities with these life forms). Those in the Eukaryota have cells with complex structures called organelles (e.g. nuclei) that are surrounded by membranes, whereas the Eubacteria are similar organisms that do not possess organelles. The most common pathogens are fungi, which cause 70% of all plant diseases, followed by bacteria, oomycetes, viruses, nematodes, phytoplasmas, parasitic plants, viroids and protozoa (Agrios, 2005; Ploetz, 2008). Each host plant species is affected by a specific suite of diseases, some of which are unique to that plant and others that are caused by generalist pathogens and also occur on other host plants.

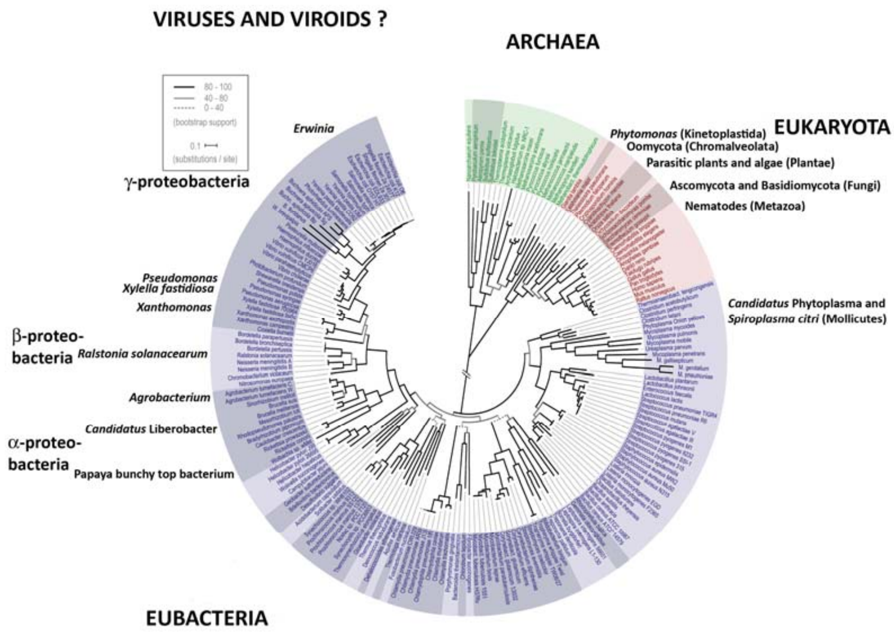

Figure 1. Phylogenetic relationships among plant pathogens (adapted from Ciccarelli et al. 2006)

Disease etiology and diagnosis. In general, pathogens must infect their hosts before they can cause disease (noninfectious diseases are uncommon; see Woltz, 1978). Infectious diseases cause a wide variety of symptoms, including blights, fruit and leaf spots, post-harvest decays, vascular wilts, cankers, rots and tumors (Agrios, 2005).

To prove that a given microbe can cause the disease symptoms that are observed on a plant, a series of criteria must be met (Agrios, 2005). Koch's postulates indicate that: i) a microbe must be associated with and isolated from diseased tissue, ii) that the isolated microbe will infect and cause the same symptoms when used to inoculate healthy plants of that species, and iii) that the microbe can be reisolated from the inoculated, symptomatic plants. With these criteria, proof has been met that the suspect microbe can cause the indicated disease (*i.e.*, it is a pathogen).

Fulfilling Koch's postulates are important when it is necessary to establish the cause of a new disease (new pathogen:host combination). However, they need not be met in investigating the cause of specific plant damage when a disease is well known and understood. For some common diseases, fairly reliable identification can be obtained by observing characteristic symptoms that the disease causes on its host plant and the host species or host tissue on which the disease occurs. Frosty pod of cacao (aka *monilia* pod rot or *moniliasis*) and the Sigatoka leafspots of banana and plantain are examples of diseases that can be diagnosed based on the symptoms that they cause (Renard, 2001; Thurston, 1998). In contrast, symptoms caused by some common diseases have a less distinctive appearance and can be confused with those caused by other diseases or plant damage (Riley et al., 2002). For example, the damage that root diseases cause in the above-ground portions of plants is often ambiguous in that the specific disease can usually not be identified based on above-ground symptoms. When symptoms are ambiguous, isolation and identification of the causal agent is necessary. If no pathogen is recovered, unculturable pathogens should then be considered (e.g. viruses, viroids, and some Eubacteria). And if no evidence is found for the latter pathogens, non-disease possibilities (injuries and disorders; see below) would then be considered.

In summary, many common diseases produce characteristic symptoms on their hosts that are diagnostic. However, diagnosing the cause of common diseases that have ambiguous symptoms requires additional work to identify the causal agent and, thus, the disease. If in the latter cases, no causal agent can be isolated or identified following appropriate testing of the plant for potential causative pathogens, other non-pathological causes may be responsible.

How pathogens cause disease. Pathogens cause disease on plants via different mechanisms (Agrios, 2005). Some pathogens produce toxins that directly kill host plant cells and organs. Others directly or indirectly affect the host's vascular system making it unable to conduct water, nutrients or photosynthates. Some diseases kill and/or macerate host tissue thereby degrading fruits, seeds or storage organs, connective or other tissues responsible for mechanical support, or photosynthetic organs. And some perturb normal hormonal balances resulting in abnormal vegetative or reproductive structures.

Disease impacts. Plant diseases can be incredibly destructive. The most infamous example, potato late blight, caused the Irish potato famine, and other plant disease epidemics have caused hardship and fiscal losses (e.g. coffee rust and Panama disease of banana). In the tropics, plant diseases are among the most significant constraints to crop production (Holliday, 1980; Ploetz, 2007b; Renard, 2001; Thurston, 1998; Wellman, 1972).

Disease development. Unless measures are taken by producers to manage diseases, they will develop wherever susceptible crop plants, their pathogens, and disease-conducive environments exist (Robinson, 1976; Zadoks and Schein, 1978). These relationships can be conceptualized in Figure 2, in which pathogen and host interaction are needed for disease development but each of which, in turn, are influenced by the environment and man. In the humid tropics, plant diseases are commonplace and can be quite difficult to control (Holliday, 1980; Ploetz, 2007b; Thurston, 1998; Wellman, 1972). Without control measures, diseases would be expected to develop on virtually all plants in such areas.

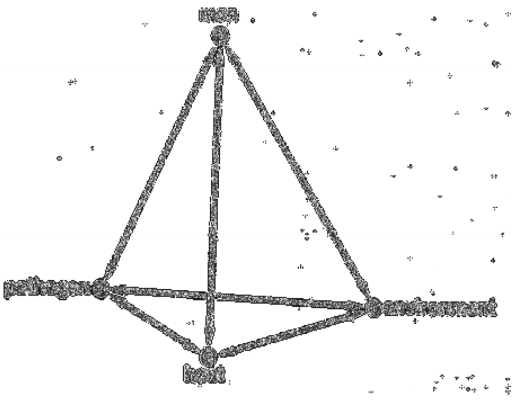

Figure 2. Disease tetrahedron (Zadoks & Schein, 1978)

Disease diagnosis, part 2. Of significance to this report, many plant pathogenic fungi cannot be distinguished microscopically (with morphological features) from related but nonpathogenic species. The large genus *Fusarium* is especially problematic in that it contains pathogens, nonpathogenic parasites and saprobes (Leslie and Summerall, 2006; Ploetz, 2006a). *Fusarium oxysporum* alone contains at least 120 distinct vascular wilt pathogens, each of which affect a specific, limited and related set of hosts (usually a single species) (Michielse and Rep, 2009); however, it is also an extremely common soil saprobe (Leslie and Summerell, 2006). Under the microscope, all members of the *Fusarium oxysporum* species complex appear the same; pathogenic and nonpathogenic parasites and saprobic members of the species cannot be distinguished. To identify the numerous and diverse pathogenic and nonpathogenic members of this species, more discriminating attributes are needed (Michielse and Rep, 2009; O'Donnell et al., 2009). Traditionally, time-consuming pathogenicity tests have been used to identify the pathogens, but various genetic approaches, which enable quicker diagnoses, are becoming available.

Two different types of plant damage may superficially resemble, but are distinct from, diseases. Physical damages are not considered diseases. These include abiotic injuries, such as those caused by chemical toxicity, lightening damage or mechanical insult, and biotic damage, such as that caused by insects. Likewise, disorders are not considered diseases. For example, imbalances or extreme levels of environmental factors, such as flooding and drought, and nutrient toxicities and deficiencies are considered disorders, not diseases. Although these types of damage are usually easily distinguished from diseases, they can interact with diseases (Datnoff et al., 2007; Schoeneweiss, 1975).

Disease interactions. The occurrence and extent to which plant diseases can interact with injuries and disorders depends upon the specific disease (i.e., unique host: pathogen interactions). Interactions that affect a given host: pathogen interaction may or may not affect a different disease on the same host plant or a similar disease on a different plant.

The identification of such interactions can be difficult, and when they do occur it is seldom, if ever, possible to demonstrate their occurrence in the past without data from the time of the proposed interaction. In general, it would not be possible to prove that an interacting factor occurred in the past with only a photographic record.

Disease management. The following general tactics can be used to manage plant diseases (Agrios, 2005; Palti, 1981; Ploetz, 2007b):

- Avoidance. Avoiding disease-conducive planting sites or situations can reduce the incidence and severity of some diseases. For example, low-lying or water-logged soils exacerbate diseases that are caused by the so-called "water molds" (oomycetes) and should, thus, be avoided. Likewise, most diseases of foliage and fruit can be reduced if air flow in plantations is maximized to ensure that these organs dry as soon as possible.

- Exclusion and eradication of causal agents. Without a pathogen there is no disease. Thus, when specific pathogens are not found in an area, their exclusion is important. And once they are first found in an area, eradication may be possible. However, both situations are not applicable to the described situation in Ecuador, because the diseases and pathogens that are indicated were present in these areas well before 2000.

- Protection and treatment of host plants. Host plants can be protected from disease development via cultural and chemical measures. For example, Sigatoka leafspots of banana and plantain can be managed culturally by removing affected leaves and improving air circulation in plantations, as well as chemically with fungicides.

- Use of disease-resistant plants. When they are available, disease-resistant plants are cost-effective means by which diseases can be managed. For example, the Cavendish cultivars of banana are very susceptible to black Sigatoka, but cooking bananas, such as Bluggoe, are not.

IV. Diseases are highly prevalent in tropical crops

Plant diseases can be particularly severe in tropical environments where high rainfall and uniform, warm temperatures are the norm (Holliday, 1980; Renard, 2001; Thurston, 1998; Wellman, 1972) (for details, see Ploetz, 2007b, which is attached as Exhibit III). These conditions are highly favorable for the development of most diseases, and respites from disease pressure in tropical environments are usually infrequent. Moreover, consistent with the fact that biological diversity increases with decreasing latitude – a trend that is called the Latitudinal Diversity Gradient (Hillebrand, 2004; Jablonski et al., 2006; Willig et al., 2003) – Wellman (1967; 1968; 1972) estimated that there are 10 diseases on a given crop plant in the tropics for every disease that occurs on it in temperate regions. Thus, plants in tropical environments are faced with a more prevalent and diverse population of pathogens than in any other environment. As a consequence, crop losses due to plant diseases are thought to be 50% to 100% higher in tropical, than in temperate, regions (Hill and Waller, 1982; Thurston, 1998). In total, the proportion of all plant losses in the tropics that are caused by disease has been estimated at **between 30%** (Harlan, 1971) **and 50%** (Wellman, 1972).

For several reasons, diseases in the tropics are most pronounced, and pose serious management problems on, perennial crops (e.g. banana, cacao, citrus, coffee, sugarcane and cassava) (Ploetz, 2007b). Perennials are long-lived and, thus, are more prone to inoculum buildup and epidemic disease development. Perennials also have longer exposures to disease-promoting or predisposing factors, such as excess water, poor soil nutrition, and insects. Further, in perennial systems, there are increased opportunities for pathogen dissemination within and among crops.

Crop diseases are most prevalent in the lowland, humid tropics (i.e., regions in which the test plaintiffs' farms are located) (Holliday, 1980; Thurston, 1998; Wellman, 1972). In these areas, high rainfall and uniform warm weather provide optimum conditions for the development of most plant diseases, especially those that are caused by fungi, oomycetes and bacteria (Renard, 2001). There are no annual freezes that would reduce the occurrence and prevalence of pathogens (as occurs in temperate regions) (Thurston, 1998). Plants at different stages of growth are frequently intermixed in the tropics; thus, pathogen inoculum and susceptible host tissues are often coincident. And there are a great number and diversity of plant species in these regions; as host numbers increase, so too do the numbers of pathogens (see Exhibit C).

V. Test Plaintiffs' Claims

It is my understanding that the plaintiffs in this litigation are alleging that certain damage to their crops was caused by herbicide spray that was being applied aerially to eradicated coca crops in Colombia. I have reviewed the videographic, photographic, and laboratory data provided by the test plaintiffs and it does not provide reliable evidence supporting their allegations of glyphosate-based damages. To the contrary, the evidence presented demonstrates that the alleged crop damage is likely due to plant diseases that are endemic to the tropical environment in which the plaintiffs live.

Plaintiffs Do Not Employ Best Farming Practices. As set forth above, the risk of plant disease is particularly pronounced in the tropics and, as a result, the importance of proper disease management tactics is heightened. Based upon the videographic evidence that I have reviewed from two of the test plaintiff farms (Balcazar and Mestanza), there is no indication that the individual plaintiffs employed cultural or other management practices for plant diseases. For example, practices are not evident that would have lowered plantation humidity, facilitated drying of host plant surfaces, and increased drainage. Leaf removal and mat management in banana production, raised beds or drainage canals, and weed management would all help reduce disease pressure in these plantations. And where disease damage was present, as is evident, *e.g.*, in the isolated banana, cacao and citrus crops in the videos presented by plaintiffs, there is no evidence for the use of fungicides or the removal of diseased plant host organs (sanitation). Moreover, the test plaintiffs' deposition testimony makes clear that they did not fertilize these crops nor employ herbicides, insecticides or other tools that are used commonly during crop production. Unhealthy crops, such as those observed in video and photographic evidence, are not uncommon under these conditions. And in low-input production systems such as these, it is probable that propagation materials for these crops were not from pathogen-free stocks; citrus is especially prone to diseases that are caused by pathogens that are found in non-certified propagation materials (Timmer et al., 2000).

Laboratory Findings Indicate the Presence of Potential Pathogens in Test Plants on or near the Plaintiffs' Farms. As discussed more fully below with respect to the individual plaintiffs' claims, in various labs, assays were conducted to investigate factors that were associated with crop health on the different farms (see Laboratory Tests of Plants). Microbial isolations were made from symptomatic crop plants to identify plant pathogens. In most cases, microbe genera, but not species, are reported in the provided summaries. However, despite the lack of detail (e.g., see discussion in Disease Diagnosis, part 2), the data generally support the occurrence of plant pathogens on the tested plants.

In general, there was tendency in some of these reports to propose, without supporting evidence, that "fumigation " with glyphosate caused observed events or lab results. These conclusions are usually laced with waffle terminology such as "may be", "could well be", or "due to a possible external influence" all of which indicate the absence of conclusive evidence for their fumigation hypothesis. There is no evidence to indicate that diseases that were observed were abnormal or accentuated during the indicated time frames, nor is there corroborating evidence from neighboring production areas to indicate that healthy crops could be grown in these areas under these rather poor conditions.

Video Imagery From Test Plaintiff Farms Demonstrates The Presence of Plant Diseases. Two of the test plaintiffs have provided contemporaneous videographic evidence of the crop damage that they allege was caused by glyphosate. In fact, the video imagery repeatedly provides evidence that the crops at issue were in fact suffering from identifiable diseases, and in many cases, the laboratory findings corroborate the disease symptom imagery (i.e. the expected pathogen genera were recovered from plants with the observed disease symptoms).

The diseases that were identified, based on the lab and video evidence, are common in the region and would be expected on the indicated crops. Poor crop health would be expected on these farms, given the susceptibility of the produced crops, the nutrient-poor soils on which they were grown, and their deficient management. As outlined above, there is no evidence for good husbandry in any of the provided evidence (e.g. fertilization, plantation and/or canopy management, and disease, insect or weed control).

In my opinion, the plaintiffs' allegations that the crop damages on their farms are due to Plan Colombia herbicide spraying events confuse correlation and causality. Correlation is not the same as causality, and it cannot be used to prove these claims. For example, if a disease develops in one of my experiments in June it does not automatically mean that high rainfall that occurs during that month in Florida has had an impact on the development of that disease. Therefore, when floral malformation in mango is observed in the summer, it is not due to high rainfall [the disease is actually most severe in dry environments (Ploetz, 2003)], but because that is when flower development and fruit set are most pronounced and disease symptoms are, consequently, most apparent. Likewise, because crops were in poor health and developed diseases on the plaintiffs' farms does not mean that these events were caused by glyphosate spraying across the border.

My analysis of the evidence relevant to specific individual test plaintiffs is set forth below:

A. <u>The Mestanza Farm</u>

I have been provided three key pieces of evidence in connection with the alleged crop damage at Mr. Mestanza's farm in Puerto Mestanza: (1) a 47.5-minute video taken on Mr. Mestanza's farm reportedly one month after a Plan Colombia spraying event at the border adjacent to his farm in late 2002, (2) a 24-minute video taken on Mr. Mestanza's farm in 2009, and (3) a laboratory analysis in February 2004 of the soil on Mr. Mestanza's farm and of plants that were allegedly impacted by Plan Colombia spraying. This evidence does not provide any scientifically reliable support for Mr. Mestanza's allegations that his crops were damaged by Plan Colombia spraying. To the contrary, this evidence demonstrates that the crop damage that Mr. Mestanza identifies is in fact due to pathogenic plant disease.

1. Evidence of Pathogenic Plant Disease in the November 2002 Mestanza Video (PLS00005881)

The Mestanza video is of poor quality with a general absence of good, diagnostic close-ups of the crops at issue in Mr. Mestanza's complaint. However, the video does provide some useful information regarding the causes or potential causes of plant injuries at Mr. Mestanza's farm. This information is set forth below, with time stamps for where the imagery appears in the video.

:09:00. At this point in the video, Mr. Mestanza is displaying Orito, a diploid dessert banana. Orito is susceptible to yellow Sigatoka (*Sigatoka amarillo*) (Jones, 2000), symptoms of which are evident here (as Mr. Mestanza states, "everything is burned"). This disease is first evident as pale green flecks, <1 mm long, that become chlorotic streaks, 3-4 x 1 mm. They broaden, lengthen, turn brown to rusty, and become surrounded by chlorotic haloes. As they mature they enlarge to 12-15 (up to 50) x 2-5 mm, darken and then become grey with a dark brown or black border. Spots can coalescence to kill large areas of the leaf. In general, these symptoms resemble those of black Sigatoka (which is a more important cause of such symptoms on other banana and plantain cultivars in the area) and Eumusae leaf spot (a disease that does not occur in the Western Hemisphere) (Ploetz, 2003).

:11:33. The camera focuses on a damaged Orito plant and someone is heard stating "This is the product of spraying" Actually, the Orito plant displays classic Sigatoka damage.

:**12:47 and :59.** More Sigatoka damage is evident here.

:13:14-40, The husbandry in banana production areas is very poor. For example, there is no mat management or weed control evident here.

:15:35. At this point in the video, the camera focuses on bunches of Orito in which "black tips" finger rot is evident. Several different diseases result in this symptomology, including cigar end, Lasiodiplodia tip rot, Deightoniella swamp spot and anthracnose. Corroborating evidence is provided for two of these diseases in subsequent lab results; they indicated that *Colletotrichum* (*musae*), cause of anthracnose, and *Verticillium* (*theobromae*), cause of cigar-end rot, peduncle rot, tip rot, cigar-end rot, crown and pedicel rot, were recovered from Orito fruit in the vicinity of Mr. Mestanza's farm (*see* Puerto Mestanza. Technical report, Gustavo Bernal, 27-29 Feb 2004)

:16:53. Mr. Mestanza states that "30 hectares of Orito are destroyed." Actually considering the way in which these plants are being managed, his Orito crop appears to be in pretty good shape.

:18:47. Mr. Mestanza is displaying a developing bunch of Orito with small fingers. Mr. Mestanza alleges that this is evidence of damage caused by glyphosate spray. The visual evidence, however, is consistent with premature harvest (indeed, Mr. Mestanza cut the bunch from the tree to show it to the cameraman) or the impact of nematodes or bacteria (possibly Moko disease or *Erwinia* sp.).

:19:12. Mestanza indicates that he feeds Orito to his fish and pigs, which is odd. This is a dessert banana that produces small fingers/fruit; it is usually produced for human consumption. If animal feed was desired, other, more productive cultivars would/should have been used.

:20:34. The bunch of Orito displayed here displays the same type of finger rot seen at :15:35:06, and is consistent with the same diseases mentioned above.

:20:52. The fruit displayed here shows symptoms of anthracnose, cigar-end rot and, possibly banana streak.

:21:15. This Orito plant has been damaged by yellow Sigatoka.

:31:25. There is a very brief glimpse of papaya. Mr. Mestanza states that the plants "are all dying already." Actually, the one shown plant does not show "dying" symptoms.

:31:37. The video focuses here on some defoliated bay trees. However, as with the previous video display of dragon's blood trees, no conclusion can be reached other than that the trees appear to be dead. No cause can be determined based upon this video evidence. However, the presence of living vegetation surrounding the trees is inconsistent with to the claim that the problems could have been caused by herbicide drift.

:32:26 – 46. The crops shown at this point in the video also display Sigatoka damage.

:33:00. Mr. Mestanza is removing fruit from a plantain bunch that looks as if it had been on the ground for at least a week. If the fruit has in fact been lying on the ground for this period of time, the blackening inside the fruit and on the outside is meaningless (and consistent with what one would see, for example, if one left a bunch of bananas on a shelf for a week). Based on its appearance, it is doubtful that the bunch had just been removed from the plant.

:36:30. There is some apparently damaged grass show in the video, but it is interspersed with or adjacent to healthy grass and other healthy plants. The video does not provide sufficient information to reach a conclusion as to the cause of the damage, but the fact that other plants in the area are not damaged again is inconsistent with any claim that the damage was due to drifting or aerially applied glyphosate.

:43:40. The citrus trees at this point in the video appear to be diseased (e.g. sparsely foliated), but the poor video quality and absence of close-ups make it difficult to say much with assurance. It is noteworthy that healthy papaya is visible in the same vicinity as the citrus trees, which is again inconsistent with the allegations of herbicide damage. There are a number of diseases of citrus that are common in the tropics that could have caused the observed damage, including greening, gummosis, and tristeza (Timmer et al., 2000).

2. Evidence of Pathogenic Plant Disease in the 2009 Mestanza Video (PLS00005882)

:00:41 – :02:00, :03:44, etc. Dead coconut trees are visible amongst healthy coconut trees. Without better photos and cross-sections of dead and dying trees, it is impossible to determine cause of damage. However, based on the symptoms on dying trees, red ring disease (caused by the coconut palm nematode, *Bursaphelenchus cocophilus*) is possible. Red ring is endemic to the region and kills coconut and several other species of palm in the region. Again, the evidence of a nonuniform distribution of dead and healthy trees is not consistent with the hypothesis that the damage was caused by drifting or aerially applied glyphosate. However, such nonuniform distribution is typical of a plant disease with an insect vector, such as red ring.

:13:05. At this point in the video, we can see mummified cacao pod, possibly caused by black pod, frosty pod or witches' broom diseases (see discussion below under Balcazar). As is evident in the video (and consistent with Mr. Mestanza's deposition testimony regarding his general farming practices), no care is being given to these plants (fertilizer, weeding, etc.) and they are grown in full sun (cacao is typically grown in shaded production). Thus, it is not surprising that the cacao do not look healthy.

No other new plant symptoms/damage is seen in this video that is not already seen and discussed in Mr. Mestanza's November 2002 video (PLS00005881).

3. February 2004 Laboratory Analysis of Soil and Crops on or About the Mestanza Farm and Corroboration of Video Diagnoses

I have also reviewed a February 2004 laboratory report by Gustavo Bernal entitled "Technical report on visit to the Province of Sucumbios (border with Colombia)." This report provides information on soil from Puerto Mestanza and fruit crops from neighboring communities in Corazón Orense and Santa Marianita. It is assumed that disease noted on these plants was caused by pathogens that are endemic in the affected area, as there are no contrary data presented here or elsewhere in these reports. Note should be made of report's finding also regarding the poor soil here, as indicated on page 2 of the report: "<u>Crops in these conditions fail to grow normally and do not produce fruits in their normal shapes and sizes</u>…" Clearly, diseases are not the only natural factors that would impact crop health and productivity in this area.

At page 4 of the report, it is stated that "[t]he symptoms observed [in the samples of fruit] are the result of the damage caused by pathogenic fungi." The laboratory results from the fruit phytosanitary analysis are set forth on page 3. As set forth below, the fungal genera that were identified are noteworthy in that they contain pathogens that cause disease on plantain and cacao. Separate laboratory findings are reported in a separate table on a page numbered 21 (the document is not sequentially numbered). Noteworthy here is the finding of fungi in the plantain and pasture grass samples that are possible pathogens on those plant species.

The specific findings for the crops analyzed are set forth below:

<u>Banana/plantain</u>. The analysis of plantain as reported at page 3 identified the presence of two genera: *Colletotrichum* and *Verticillium* (Ploetz, 2003). *Colletotrichum* (*musae*) causes anthracnose, which is primarily a post-harvest disease that affects the peel and crown surface areas (crown rot) but can also develop when green fruit are injured; *Colletotrichum* (*musae*) also causes fungal scald and stem-end rot. The finding of this pathogen in the tested plantains corroborates the visual diagnosis from the video at **:15:35.** *Verticillium* (*theobromae*) causes peduncle rot, tip rot, cigar-end rot, crown and pedicel rot, and can transform black tip into cigar-end rot. The finding of this pathogen corroborates the visual diagnosis from the video at **:15:35.** The separate analysis of plantain reported at page 21 identified *Mycospherella* (sic). Black Sigatoka would be expected on plantain in this region (Ploetz, 2003); it is caused by *Mycosphaerella fijiensis*. Yellow Sigatoka, which was evident on Orito in the video, is caused by a related fungus, *M. musicola*. Orito is unusual; it is susceptible to yellow Sigatoka, but tolerates black Sigatoka (most banana and plantain cultivars are more susceptible to black Sigatoka).

Yuca (cassava). *Cladosporium* spp. are usually saprobes (not pathogens), and there are no diseases of this crop caused by fungi in this genus (Lozano and Nolt, 1993). There was no cassava shown in the Mestanza video and the written description of damage to the cassava tested in February 2004 is ambiguous.

Oranges. The phytosanitary analysis of the orange detected "Phitomyces" and "endophragmia". These are not pathogens. Based on the video, the citrus trees on Mr. Mestanza's farm have other more serious disease problems, only one of which, gummosis, would show up in routine lab isolations (it is caused by *Phytophthora* spp., but the pathogens that cause greening and tristeza, two other possible diseases here, are not culturable). Dark spots that were mentioned on both sides of the leaf in the lab analyses may have been symptoms of greasy spot. However, its causal agent, *Mycosphaerella citri*, is difficult to isolate in a routine laboratory analysis. All of these pathogens would be easily moved to new production areas on infected planting materials (Timmer et al., 2000).

Lemon (lime). The phytosanitary analysis of the lemon identified *Cladosporium*. Species in this genus are commonly saprobes. Lichens mentioned in lab analysis are not plant pathogens.

Cacao. The analysis of cacao detected *Phytophthora*. Several different species of *Phytophthora* cause black pod, a serious and widespread disease on this host (Dollet, 2001; Evans, 2007).

B. The Balcazar Farm

I have been provided two key pieces of evidence that are relevant to my opinions regarding the allegations of crop damage made by Mr. Balcazar: (1) a short video dated June 21, 2001 and (2) a laboratory analysis of crops from Mr. Balcazar's farm dated July 12, 2001. This evidence does not provide any scientifically reliable basis to opine that the crop damages alleged by Mr. Balcazar were caused by herbicide spray from Plan Colombia eradication operations. To the contrary, as with Mr. Mestanza, the Balcazar video and lab test results indicate that the crop damage on the Balcazar farm was caused by pathogens that are endemic to the region.

1. Evidence of Pathogenic Crop Disease in the Balcazar Video

:02:09. At this point in the video, we can see cacao pod to Mr. Balcazar's right that display symptoms of the disease frosty pod, which is caused by *Moniliophthora rorei*,.

:02:25. Mr. Balcazar asserts that the symptoms seen in his cacao are a new problem. Actually, frosty pod has been in this region for decades. Black pod, caused by *Phytophthora* spp., and witches' broom, caused by *Moniliophthora perniciosa*, also mummify cacao pods, but without covering the pod surface with white spores. Frosty pod, black pod, and witches' broom are the most important and damaging diseases of cacao (Evans, 2007; Ploetz, 2007a); all of these diseases are common in Ecuador.

:03:04. Mummified cacao pods are displayed here. The picture quality is poor, but the cacao pod on the left appears to be affected by frosty pod.

:03:17. The cacao pods above Mr. Balcazar's head and to his left display symptoms of frosty pod. It is also evident in the video (consistent with Mr. Balcazar's testimony concerning his farming practices) that proper farming practices are not being followed. There is no evidence of proper care of the cacao (fertilizer, weeding etc.) and they are being grown in full sun rather than in shaded areas. The generally unhealthy appearance of the cacao is thus not surprising.

:03:45. The citrus trees shown at this point in the video are in bad shape and appear to be heavily diseased; however, the quality of the video is so poor that it is difficult to say much with assurance. Based on the general appearance of these trees, the following diseases are possible (Timmer et al., 2000): postbloom fruit drop and lime anthracnose, caused by *Colletotrichum acutatum*; greasy spot, caused by *Mycosphaerella citri*; gummosis, caused by *Phytophthora* spp.; tristeza, caused by *Citrus tristeza virus*; and greening, caused by *Candidatus* Liberibacter species.

:5:10. The pasture grass shown here displays symptoms of blight. The poor video quality makes it difficult to reach any definite conclusion, but the symptoms could have been caused by the fungi that were recovered in lab analyses of the grass on Mr. Balcazar's farm (see below).

:7:55. Mr. Balcazar states that he lives 5 km from Colombian border. This is an incredible distance for herbicide drift.

:8:18. The cacao pod at the right in this point in the video displays symptoms of black pod disease.

:8:46. The banana plant shown here has severe symptoms of black Sigatoka.

:8:50. More symptoms of black Sigatoka are evident here.

:8:59. Once more, the plants displayed show symptoms of black Sigatoka. It is also noteworthy that the coffee is being grown in the full sun, rather than in the shade where coffee does best.

2. July 2001 Laboratory Analysis of Crops on the Balcazar Farm and Corroboration of Video Diagnoses

I have reviewed the results of laboratory analyses of crops on the Balcazar farm that were conducted by the Ecuadorian Ministry of Agriculture and Livestock on July 12, 2001. These analyses reported the findings of pathogens in three tested crops on the Balcazar farm as follows:

Cacao. Two fungi were recovered, "*Fusarium moniliforme*" and "*Monilia rorei*." The former name refers to a corn pathogen (*Fusarium verticilloides*). "*Fusarium moniliforme"* is very confused in the literature and is no longer used (Leslie and Summerall, 2006). *Fusarium decemcellulare* causes cushion gall on cacao, but it is distinct from *Fusarium verticilloides* (Ploetz, 2007a). Thus, the significance of "*Fusarium moniliforme*" is not clear. "*Monilia rorei*" refers to *Moniliophthora rorei*, cause of frosty pod (aka moniliasis, helado, etc.) (Evans, 2007; Thurston, 1998). Frosty pod, which is the most serious disease of cacao, occurs naturally throughout Ecuador. Frosty pod could have caused the mummified cacao fruit seen in the Balcazar video (see above comments).

Platano. Three fungal genera were recovered from roots, *Fusarium* sp., *Rhizoctonia* sp. and *Trichodema* sp. All three genera are common on roots of this crop, and the former two genera contain plant pathogens. A specific subpopulation of *Fusarium oxysporum*, f. sp. *cubense*, is an important pathogen of some banana cultivars; it causes Panama disease (Ploetz, 2006b).

Marundu. Five fungal genera were recovered from base (root collar) of this grass, *Fusarium* sp., *Rhizoctonia* sp., *Cladosporium* sp., *Theilaviopsis* sp. and *Curvularia* sp. All contain plant pathogenic species. Rhizoctonia blight is a serious disease on this crop and the dead grass shown in the Balcazar video may have been suffering from this disease.

C. <u>Salas and Calero Farms</u>

It is my understanding that the Salas and Calero test plaintiff families live in the area near Chone 1 and Chone 2. I do not have any video imagery from either of these plaintiff families' farms [and the photographs that I have been provided purportedly showing plant damages at the Salas farm is of a very poor quality and does not provide any evidence of crop damage let alone information that would provide a basis for a scientific conclusion as to the cause of alleged crop damage. I have reviewed a document entitled "Report on Verification Mission, Impacts of fumigations in Putumayo as part of Plan Colombia (October 2002)", which reports on the results of testing of certain crops in Chone 2. This report contains various opinions/accusations regarding alleged impacts of glyphosate from Plan Colombia which are beyond the scope of this expert report, but which I understand are being addressed by other experts. My analysis focuses on the plant laboratory findings and the interpretations of those findings in the October 2002 verification report.

Two crops from Chone 2 were mentioned on page 17 of the verification report, peanut and rice. *Fusarium* sp., *Rhizoctonia* sp., *Alternaria* sp. and *Cylindrocarpon* sp. were recovered from peanut roots, leaves and/or soil. Each of these genera contains peanut pathogens (Porter, 1993). *Fusarium* sp., *Rhizoctonia* sp., and *Rhizopus* sp. were recovered from rice roots and leaves.

The findings of these pathogens in crops from Chone 2 is consistent with what would be expected in this tropical environment and, in combination with the general problems of pathogenic plant disease in the area, suggests that any crop damages at the Salas and Calero farms was likely caused by endemic plant disease. There is nothing in the 2002 verification report or any other evidence of which I am aware that would provide a scientifically reliable basis to opine that any crop damage at the Salas or Calero farms was caused by Plan Colombia glyphosate spray.

The 2002 Verification report contains a number of false statements in connection with the finding of *Fusarium* sp. on tested crops. First, the report states that the finding of *Fusarium* sp on leaves of tested plants was "noteworthy." This is incorrect. As noted on page 5 of this report, *Fusarium* species are very common worldwide, including tropical environments. The presence of this genus in northern Ecuador would be expected on many plants, as well as in/on animals, soil and water; they are ubiquitous fungi (Leslie and Summerell, 2006). The report also makes a number of allegations about the potential use of *Fusarium oxysporum* to eradicate coca. I have been advised by counsel for the defendants that *Fusarium oxysporum* has never been used in Plan Colombia eradication operations and that plaintiffs are not alleging such use in this case. I would note, in any event, that the forma specialis of *Fusarium oxysporum* that affects coca, *F. oxysporum* f. sp. *erythroxyli*, is a typical wilt strain of this species, in that it is host-specific and would not affect the indicated crop plants. Accordingly, even if *Fusarium oxysporum* had been used, it would not have had any adverse impacts on lawful crops or, indeed, on any plant life other than coca.

D. <u>The Alvarez, Quevedo, and Witness 37 Farms</u>

The remaining test plaintiff families have not provided any useful videographic, photographic or laboratory data regarding their alleged crop damage.

I have been provided with a couple of photographs that purportedly show damage to crops at the farm of Ms. Elvira Alvarez. However, these photos are of very poor quality and do not provide any evidence of crop damage, let alone information that would provide a basis for a scientific conclusion as to the cause of alleged crop damage.

There are no useful photographs or any other data regarding the damage alleged by the Quevedo and Witness 37 test plaintiff families. The Quevedo farm is in the same vicinity as the Balcazar farm, and the evidence of plant disease on the Balcazar farm is accordingly of some relevance in considering the Quevedo family's alleged crop damage.

Dated: 19 Jan 2011

Randy C. Ploetz

Randy C. Ploetz

CR Note: Dr. Ploetz's CV (Exhibit A), found in CD - Original Annexes

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Exhibit B

Dr. Randy Ploetz Expert Report

Materials Considered

Exhibit B

Randy Ploetz Expert Report

Additional Publication Considered

Powell J.R. & Swanton C.J. (2008) A critique of studies evaluating glyphosate effects on diseases associated with Fusarium spp., Weed Research 48: 307-318

Other Materials Considered

1) Bernal G., Technical Report on Visit to the Province of Sucumbíos (border with Colombia), (unpublished Technical Report, Colombia: CCTE.) (February 29, 2004)
2) Binder of 20 Test Plaintiff Deposition Testimonies
3) Campaña A. & Nato O.F., Investigation: Pesticide Impacts in Ecosystems, Analysis Report by UBC/CEAS Laboratory (University of British Columbia, Canada and Center for Health Studies and Consultancy, Quito, Ecuador) (September 26, 2007) English summary and Spanish report.
4) Ecuadorian Ministry of Agriculture and LiveStock laboratory test of Edgar Balcazar's farm, Test Plaintiff No. 1109, July 12, 2001 (English summary and Spanish report)
5) English Transcription of Test Plaintiff Victor Mestanza's 2002 Video
6) Excerpts of Lab Tests from Annex 2 of Preliminary Economic Valuation and Impact Assessment of the Environmental Assets and Services Affected by the Fumigations in the Northern Ecuadorian Border along the Province of Sucumbios, Prepared by Suarez S., Aguirre D.B., Lozano P., Cabrera R. & Reyes F., Revised and updated version of January 2008 with English summary and Spanish report.
7) Maldonado, Adolfo et al., Verification Mission Report: Impacts in Ecuador of the Fumigations in Putumayo as part of Plan Colombia, Accion Ecologica, October 2002.
8) Original and Translation of Plant Lab Report for Chone 2, Ecuador and Vereda Nueva Granada, Colombia and translation of soil lab report for Chone 2, Playera Oriental, Ecuador, and Vereda Nueva Granada, Colombia, Accion Ecologica website, October 9, 2002
9) PLS00005881 Disk with Victor Mestanza's 2002 Video
10) PLS00005882 Disk with Victor Mestanza's 2009 Video
11) Video footage of Edgar Balcazar
12) Photographs excerpts taken from Victor Mestanza's 2002 Video
13) Photographs produced by Plaintiffs' Counsel of Salas's Family farm labeled PLS00005971
14) Photographs produced by Plaintiffs' Counsel of Elvia Alvarez's farm labeled PLS00005966
15) Summary of Letter by Montenegro G.S. of Test Results from Center of Integral Analytical Solutions Centrocesal Co. Ltd. Attachment to Annex 2 of Preliminary Economic Valuation and Impact Assessment of the Environmental Assets and Services Affected by the Fumigations in the Northern Ecuadorian Border along the Province of Sucumbios, Prepared by Suarez S., Aguirre D.B., Lozano P., Cabrera R. & Reyes F., Revised and updated version of January 2008.

16) A binder for each test plaintiff family containing:

A) a table with citations to claims of crop damages in certain evidentiary submissions of the test plaintiffs (initial disclosures, questionnaire responses, declaration of Marco Campaña, deposition testimony excerpts, Accion Ecologica toxicology sheet and survey).

B) the following information for each test plaintiff (if applicable to the test plaintiff and/or family):

i) initial disclosure

ii) questionnaire responses

iii) excerpt from the Marco Campaña declaration specific to each plaintiff

iv) all deposition testimony excerpts re alleged crop damages and related issues

v) other test plaintiff-specific information relating to their alleged physical injuries (e.g., photographs and/or video, excerpts from prior lawsuits, prior certifications, Accion Ecologica toxicology sheet and survey lab tests taken from their region and related government announcements.)

vi) excerpts of certain non-governmental organization and other third party reports that mention the test plaintiffs or the areas in which they live with respect to diseases or crop damages

C) a map showing the approximate location of the test plaintiffs' farm and spray lines (if any) for the dates of spray exposure alleged by any of the family members in their depositions.

Exhibit C

Dr. Randy Ploetz Expert Report

2007 Referenced Article

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Diseases of Tropical Perennial Crops: Challenging Problems in Diverse Environments

The world's oldest ecosystems are found in the tropics. They are diverse, highly evolved, but barely understood. Diseases that impact crops in these regions can be significant contraints to production, especially when they occur in lowland environments with high rainfall and uniform, warm temperatures; respites from disease pressure there are often infrequent. Difficulties in managing diseases in the humid tropics are multiplied when the affected crops are perennial. The favorable conditions for disease development and the presence of susceptible host tissue over long periods make diseases of tropical perennial crops serious management challenges.

This topic is introduced with a few concepts on the occurrence and development of these pathosystems. Peculiar aspects and scenarios that influence the types of and extent to which different diseases develop are summarized. Measures that are useful on annual or short-term crops may be ineffective against these diseases. They are scientifically interesting problems. New vectors, as for mango malformation, or pathogens, as for bunchy top of papaya, are associated with some of the diseases. And some of the diseases are caused by two or more distinct taxa; for example, citrus greening, mango malformation, Panama disease, and tracheomycosis of coffee. Some of the most important diseases are host-specific and are caused by either coevolved or new-encounter pathogens. Resistance, the most effective tool with which many of these diseases are managed, is usually available in coevolved pathosystems but may be uncommon in new-encounter situations. Inadequate host resistance can be a significant barrier in the management of both coevolved and new encounter diseases.

General tactics are described that are useful against diseases of tropical perennials. The successful management of plant disease utilizes several principles and practices, regardless of the host and environment in which it is grown. These include the avoidance, exclusion, and eradication of the causal agents. Host protection is of great importance, as is the identification and incorporation of resistance in the host plant. All of these approaches are discussed with tropical perennial examples.

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Agriculture Begins

Agriculture began after the Pleistocene (last ice age) and started independently in several different regions (Table 1). It developed first in the Near East (sites in the Fertile Crescent and in present-day Israel and Turkey) due to a fortuitous combination of suitable climate and useful plants and animals that could be domesticated (33,76,144). These first farmers appeared at least 11,000 years ago, and were followed in quick succession by others in Northern and Southern China, Mesoamerica, New Guinea, the Andes, and the Eastern United States (32–34). Additional areas of independent development may also include Amazonia, Ethiopia, the Sahel, Southeast Asia, and Western Africa.

During agriculture's brief history, humans have utilized numerous plants (12,21,91,135,148). At least 3,000 taxa have been used for food and several hundred more have been used for other purposes. In Table 2, the following categories have been considered: beverage, drug, elastomer, fiber, food, insecticide, oil, spice, and timber and pulp.

Despite the large numbers of useful species, only a subset is very significant and few are of major importance (114,128,136, 143,148). Scarcely more than a hundred species enter world commerce, and among the food crops, few are staples: About 0.5% of the food species supply more than 90% of the world's food (42,148).

Biological Diversity in the Tropics

Biological diversity increases with decreasing latitude (61,67,162). This trend, called the Latitudinal Diversity Gradient (LDG), has been observed for a wide range of trophic levels and life forms. In general, species numbers increase dramatically as one moves from the poles to the equator.

The LDG is one of the oldest recognized patterns in the biological sciences. Humboldt (63) discussed the relationship two centuries ago, and Darwin (26) wrote about it in his famous book. This increase in diversity is most pronounced in tropical rain forests, which are thought to host 50% of all species but occupy only 7% of the world's landmass (162). And it appears to be a general rule on our planet since it is found in the fossil record and re-establishes after mass extinctions (67).

Plants are among the most prominent organisms that conform to the LDG. Thus, it is not surprising that most of the early agricultural hubs (nine of the above 12) and first crop domestications occurred in the tropics, i.e., between the Tropics of Cancer and Capricorn (Table 1). More than half the crops in Table 2, 69 of 126 (55%), originated in the tropics. Some tropical annuals, e.g., rice, potato, and maize, are now also grown in temperate zones during the summer. But essentially all tropical perennials are restricted to the tropics due to their cold sensitivity.

A wide range of habitats is found in the tropics, including humid lowlands, deserts, seasonally dry forests, grasslands, savannahs, montane environments, and swamps (148,161). Further diversity in each of these habitats results from variable edaphic, meterologic, and biotic conditions. This vast array of environments enables an equally wide range of plants to be grown; almost every crop in Table 2 can be grown somewhere in the tropical world. For example, important temperate domesticates are grown in the lowland tropics (members of the Brassicaceae and Fabaceae are especially common) and at high elevations where moderate temperatures exist (members of the Fabaceae, Poaceae, and Rosaceae are most notable) (114). Thurston's (148) estimate that twice as many crops are grown in the tropics as in the temperate zones of the world is probably accurate.

Studies that compare tropical and temperate ecosystems are uncommon, and a disproportionate amount of the research on microorganisms has been conducted in temperate zones. For example, in reviewing the literature on fungi and bacteria in forest ecosystems since 1963, Lodge et al. (87) found only 96 references for tropical forests, but 2,411 for temperate forests. Despite this disparity, the LDG is also evident among microbes.

Three groups of nonpathogenic fungi, decomposers (86), endophytes (6), and arbuscular mycorrhizae (64), are very diverse in the tropics, as are fungi in general (156,157). Plant pathogens also appear to be more numerous and diverse in the tropics. One group, the flagellated protozoa (*Phytomonas* spp.), is rare outside the tropics (2), and 60% of the described viroid species have tropical, natural hosts (55).

If one considers diseases of crop plants, there may be an even greater difference between temperate and tropical areas. Wellman (161) found a pronounced temperate/tropical bias among the crops that were well represented in both zones: pumpkin and squash, 19 temperate diseases and 111 tropical; sweet potato, 15/187; tomato, 32/278; common bean, 52/253+; and potato, 91/175. Wellman (159–161) concluded that for every disease that occurred on a given crop in temperate areas there were 10 in the tropics.

Disease problems can be severe in the tropics, especially where high rainfall and uniform, warm temperatures are the norm. These conditions are highly favorable for the development of most diseases, and respites from disease pressure are usually infrequent in these areas. Overall, losses are thought to be 50 to 100% higher in tropical than in temperate regions (60,148). Estimates of the proportion of all losses in the tropics that are caused by diseases range from 30% (56) to 50% (161).

Plant pathology began in, and generally continues to be a discipline focused on, temperate climates; comparatively little plant pathological research has been conducted in the developing tropical world (143). Work in the tropics has made significant contributions to the discipline of plant pathology (100,132), but much more would be revealed if resources that approached those used in temperate zones were devoted to research in the tropics.

Perennial crops: Challenging hosts for disease managers. When one considers the total areas planted and annual yields, the most important food crops are annuals. Other than sugarcane (its total represents harvested cane, not a final product), only production figures for maize, rice, and wheat exceed 500 million metric tons per year (Table 2). Although they are minor components of most natural floras, annuals predominate in agriculture for the following reasons: they produce quick results after planting; when stored, they enable escape from unfavorable climatic conditions (particularly the grains and pulses); and when incorporated in fallow or rotation cultures, they facilitate the avoidance of pests and pathogens (128).

Despite the importance of annual crops, Table 2 indicates that perennial crop plants (those that live longer than 2 years [4]) are more numerous (73 of the 126 [58%]). There are several reasons why these most common hosts are often serious disease management challenges.

Rather than being protected for a few weeks or months, perennial hosts require long-term measures. Since they are long-lived and there are no seasonal breaks in production, perennials are more prone to inoculum buildup and epidemic disease development.

Managing the large reservoirs of inoculum and high disease pressures that develop in perennial monocultures can be difficult and costly. For example, management of black Sigatoka leaf spot of banana (black leaf streak), caused by *Mycosphaerella fijiensis*, contributes as much as 25% of the final retail cost of export bananas and can fail during periods of high rainfall or less than adequate fungicide applications (105). In India, 10% of the total costs of coffee production went toward the control of rust (130). And eradication efforts can be very expensive. Cacao swollen shoot, caused by *Cacao swollen shoot virus*, in West Africa and citrus canker, caused by *Xanthomonas axonopodis* pv. *citri,* in Florida are worst-case examples of where large sums of money were invested in ultimately unsuccessful campaigns.

Due to long-term selection pressure, there are increased opportunities in perennial systems for the development of pesticide-resistant pathogens. Despite an increased awareness of pesticide resistance and the establishment of strategies to avoid the build-up of resistant strains (11), a rapid erosion of the efficacy of new chemicals is still common (68,120).

Long-term exposure to disease-promoting or predisposing factors can increase disease development in perennial hosts (7). Host nutritional status is an important abiotic factor that can be related to increased disease (27,101). Likewise, an excess of water can encourage the development of diseases induced by stramenopiles

Table 1. Crop plants that were domesticated in early agricultural centers[z]

Area	First dates (years B.P.)	Crops: Grasses and grains	Pulses	Fiber	Root and tubers	Melons and squash	Fruit and vegetables
Fertile Crescent	11,500	Emmer and einkorn wheat, barley	Pea, lentil, chickpea	Flax	None	Muskmelon	Date, fig
China	10,000	Rice, foxtail and broomcorn millet	Soybean, adzuki bean, mung bean	Hemp	None	None	None
MesoAmerica	10,000	Maize	Common bean, tepary bean, scarlet runner bean	Cotton (*G. hirsutum*), *Yucca* spp. *Agave* spp.	Jicama	Squashes (*C. pepo*, etc.)	Pepper (*Capsicum* spp.), avocado
Andes, Amazonia	3,500-1,000	Quinoa	Lima bean, common bean, peanut	Cotton (*G. barbadense*)	Cassava, sweet potato, potato, oca	Squashes (*C. maxima*, etc.)	Pineapple
West Africa and Sahel	3,000 and 5,000	Sorghum, pearl millet, African rice	Cowpea, groundnut	Cotton (*G. herbaceum*)	Yams	White-flowered (bottle) gourd	Watermelon
India	5,000	None	Hyacinth bean, black gram, green gram	Cotton (*G. arboreum*), flax		Cucumber	Mango
Ethiopia	3,000	Teff, finger millet	None	None	None	None	None
Eastern USA	2,500-1,000	Maygrass little barley, knotweed, goosefoot			Jerusalem artichoke	Squash (*C. pepo*)	
New Guinea	7,000	Sugarcane	None	None	None	None	Banana

[z] Adapted from refs. 33 and 136; additional data are from 32, 34, 76, and 128.

Table 2. Taxonomy, origins, and production zones of the major crop plants[u]

	Order	Family (subfamily)	Crop(s), taxa	Category/ usage	Center of origin[v]	Major production areas	Production, 2005 (t)
Gymnosperms							
	Coniferales	Pinaceae	Pines, *Pinus* spp.	Timber, pulp	Diverse	Temperate to tropical	N.A.
			Spruces, *Picea* spp.	Timber, pulp	Northern Hemisphere	Temperate	N.A.
			Larches, *Larix* spp.	Timber, pulp	Northern Hemisphere	Temperate	N.A.
			Douglas firs, *Pseudotsuga* spp.	Timber, pulp	Northern Hemisphere	Temperate	N.A.
Angiosperms			Spruces, *Picea* spp.	Timber, pulp	Northern Hemisphere	Temperate	N.A.
Magnoliid complex	Laurales	Myristicaceae	Nutmeg, mace, *Myristica fragrans*	Spice	Moluccas	Indonesia, Grenada, Sri Lanka, India Malaysia	81,292
		Lauraceae	Avocado, *Persea americana*	Fruit	Tropical America	Mexico, USA, Indonesia, South Africa, Chile	3,229,134
			Cinnamon, *Cinnamomum verum*[w]	Spice	Sri Lanka	Indonesia, Sri Lanka, India, Seychelles, Madagascar	134,410
	Piperales	Piperaceae	Black pepper, *Piper nigrum*	Spice	Southwest India	India, Indonesia, Brazil	411,359
Monocots	Alistamatales	Araceae	Taro, *Colocasia esculenta*	Root and tuber	Indo-Malaya	West Africa, Pacific	10,586,651
			Yautia (tanier), *Xanthosoma sagittifolium*	Root and tuber	Tropical America	Caribbean, West Africa, Pacific	421,966
	Asparagales	Orchidaceae	Vanilla, *Vanilla planifolia*	Spice	SE Mexico, C. America	Madagascar, Indonesia, China	10,539
		Alliaceae	Garlic, onion, *Allium* spp.	Spice	Near East	USA, Japan, Spain	14,548,669 57,400,277
		Agavaceae	Agave fibers, *Agave* spp. (mainly sisal, *A. sisalana*)	Fiber	MesoAmerica, Caribbean	Brazil, East Africa	385,463
		Asparagaceae	Asparagus	Vegetable			6,658,007
	Dioscoreales	Dioscoreaceae	Yams, *Dioscorea* spp.	Root and tuber	Asia, Africa, Tropical America	West Africa, Southeast Asia, Oceania, Caribbean	39,856,954
	Arecales	Arecaceae (Palmae)	Betel nut, *Areca catechu*	Drug-medicinal	Southeast Asia	Southeast Asia	727,425
			Coconut, *Cocos nucifera*	Fruit, oil, fiber (coir)	Southeast Asia	Philippines, Indonesia, India, Sri Lanka	55,234,124 (fruit), 954,290 (coir)
			Oil palm, *Elaeis guineensis*[x]	Oil	West Africa	Indonesia, Malaysia	173,391,199 (fruit)
			Date, *Phoenix dactylifera*	Fruit	N. Africa, Middle East	Iraq, Iran, Egypt	6,921,950
	Poales	Bromilaceae	Pineapple, *Ananas comosus*	Fruit	South America	Thailand, Philippines, Brazil	16,769,660
		Poaceae (Bambusoideae)	Bamboos, many genera	Timber, fiber	Mostly tropical	Mostly tropical	N.A.
		Poaceae (Ehrhartoideae)	Rice, *Oryza sativa*	Grain	IndoChina	Global	618,440,644
		Poaceae (Pooideae)	Oats, *Avena* spp.	Grain	Europe	Temperate world	23,953,749
			Barley, *Hordeum vulgare*	Grain	Southwest Asia	Europe, N. Africa, Near East, Russia, China, India, Canada, USA	139,043,947
			Rye, *Secale cereale*	Grain	Southwestern Asia	Europe, Russia	15,515,206
			Wheats, mainly *Triticum aestivum*	Grain	Fertile Crescent	Global	629,566,0417

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[u] Listed taxa chosen based on importance described elsewhere (42,135,136). Taxa are listed based on their phylogenetic relatedness (adapted from Stevens [139]).
[v] Center of origin based on best available evidence. Questionable or unclear centers are denoted with a ?.
[w] At least 10 species of *Cinnamomun* are sold in the spice trade, notably the cassias, but only *C. verum* is considered true cinnamon (158).
[x] An American species, *E. oliefera*, has been used to produce disease-resistant interspecifc hybrids.
[y] Includes plantains, as well as dessert and cooking bananas.
[z] Due to its transcontinental spread via floating seed, kapok has long been a pantropical crop.

Table 2. (*Continued from previous page*)

	Order	Family (subfamily)	Crop(s), taxa	Category/ usage	Center of origin[v]	Major production areas	Production, 2005 (t)
		Poaceae (Panicoideae)	Sugarcane, *Saccharum* spp.	Sugar	New Guinea	India, Cuba, Brazil	1,291,685,924
			Millets, *Eleusine coracana, Pennisetum americanum*	Grain	Africa		28,559,553
			Sorghum, *Sorghum bicolor*	Grain	Africa	Global	58,668,212
			Maize, *Zea mays*	Grain	Mexico, C. America	Global	710,675,149 (dry + green)
	Zingiberales	Musaceae	Banana[y], *Musa* spp.	Fruit	Southeast Asia	Tropical America, Africa	105,815,354
			Abacá (Manila hemp), *Musa textilis*	Fiber	Philippines	Philippines, Central America	100,987
			Ginger, *Zingiber officinale*	Spice	Southeast Asia	India, Southeast Asia	1,004,546
Eudicots (tricolpates)	Caryophyllales	Amaranthaceae	Amaranths, *Amaranthus* spp.	Grain	Subtrop., trop. America	Asia	N.A.
			Quinoa, *Chenopodium quinoa*	Grain	Andes	Andes	57,765
			Sugar beet, *Chenopodium vulgaris*	Sugar	Europe	Europe, Russia, USA	240,984,299
			Spinach, *Spinacia oleracea*	Vegetable	SW Asia	Europe, Americas	12,980,944
	Polygonales	Polygonaceae	Buckwheat, *Fagopyrum* spp.	grain	Temperate E. Asia	Russia, France, USA, Canada	2,649,524
	Saxifragales	Grossulariaceae	Gooseberry, *Ribes* spp.	Fruit	Europe, N. America		134,452
			Currant, *Ribes* spp.	Fruit	Europe		862,232
	Vitales	Vitaceae	Grapes, mainly *Vitus vinifera*	Fruit	C. Asia	Mediterranean Europe, USA	65,584,122
	Malpighiales	Euphorbiaceae	Tung, *Aleurites* spp.	Oil	East Asia	China, Argentina, USA, Brazil	517,480
			(Para) rubber, *Hevea brasiliensis*	Elastomer	Amazon	Indonesia, Malaysia	9,123,590
			Cassava, *Manihot esculenta*	Root and tuber	South America	South America, Africa	203,061,895
			Castor (bean), *Ricinus communis*	Oil	Africa?	Brazil, India, Russia, China	1,393,812
		Linaceae	Flax, linseed, *Linum usitatissimum*	Fiber, oil	Eurasia	Temperate world	887,227 (fiber), 693,000 (seed)
		Passifloraceae	Passionfruit, *Passiflora* spp.	Fruit	Tropical America	Tropical America	1,000,000
		Salicaceae	Aspens and poplars, *Populus* spp.,	Timber, pulp	Temperate to arctic north	Temperate to arctic north	N.A.
	Fabales	Fabaceae (Papilionoideae)	Peanut (groundnut), *Arachis hypogaea*	Pulse, oil	Argentina, Bolivia		35,865,389
			Pigeon pea, *Cajanus cajan*	Pulse	India	India	3,476,995
			Chickpea, *Cicer arietinum*	Pulse	Western Asia	India, Mediterranean	8,694,192
			Soybean, *Glycine max*	Oil, pulse, forage	Northeast Asia	USA, South America	214,347,289
			Lentil, *Lens culinaris*	Pulse	Near East	India, Pakistan, Ethiopia, Near East, Mediterranean	4,059,587
			Alfalfa (lucerne), *Medicago sativa*	Forage	Iran	N. America, Europe, S. America	N.A.
			Lima bean, *Phaseolus lunatus*	Pulse	Middle, S. America	Subtropics, tropics	N.A.
			Common bean, *Phaseolus vulgaris*	Pulse	Middle, S. America	Global	25,160,509 (dry + green)
			Pea, *Pisum sativum*	Pulse	Near East?	N. Europe, Russia, China, NW USA	20,283,678 (dry + green)
			Clovers, *Trifolium* spp.	Forage	Eastern Mediterranean	Temperate world	N.A.
			Broad (field) bean, *Vicia faba*	Pulse	Europe, Near East	N. temperate world	5,778,600 (dry + green)

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Table 2. (*Continued from previous page*)

Order	Family (subfamily)	Crop(s), taxa	Category/ usage	Center of origin[v]	Major production areas	Production, 2005 (t)
		Cowpea, *Vigna unguiculata*	Pulse	Ethiopia?	India, W. Africa.	3,766,540 (dry)
		Bambara groundnut, *Voandzeia subterranea*	Pulse	Tropical Africa		61,500
Rosales	Rosaceae	Strawberry, *Fragaria ananassa*	Fruit	Europe	Europe, Russia, USA	3,616,865
		Apples, *Malus* spp.	Fruit	Asia Minor, Caucasus, C. Asia	Temperate world	59,444,377
		Almond, *Prunus amygdalus*	Nut	Central - Western Asia	Temperate world	1,648,916
		Apricot, *Prunus armeniaca*	Fruit	W. China	Temperate world	2,820,659
		Cherry, *Prunus*	Fruit	C. Asia	Temperate world	3,008,390 (sweet + sour)
		Peach and nectarine, *Prunus*	Fruit	W. China	Temperate world	15,782,002
		Plum, *Prunus* spp.	Fruit	N. America, Europe	Temperate world	9,458,503
		Pears, *Pyrus* spp.	Fruit	E. Asia	Temperate world	19,539,311
		Quinces, *Cydonia*	Fruit			387,540
		Raspberries, blackberries, *Rubus* spp.	Fruit	Europe, USA	Europe, USA	498,102
	Cannabidaceae	Hemp, *Cannabis sativa*	Fiber, drug-medicinal, oil	Temperate Asia	Russia, India	67,460 (fiber), 32,160 (seed)
	Moraceae	Breadfruit, *Artocarpus* spp.	vegetable	Polynesia	Polynesia	N.A.
		Fig, *Ficus carica*	Fruit	Southern Arabia	Turkey, Egypt, Greece, Iran, Morocco	1,075,174
		Hops, *Humulus lupulus*		Europe	Europe, temperate world	100,976
	Urticaceae	Ramie, *Boehmeria nivea*	Fiber	Malaysia, China, Japan	China	249,500
Cucurbitales	Cucurbitaceae	Watermelon, *Citrullus lanatus*	Fruit	Southern Africa		96,455,182
		Cucumber, *Cucumis sativus*	Vegetable	India		41,836,847
		Cantaloupe (muskmelon), *Cucumis melo*	Fruit	Africa		28,349,422
		Squashes, pumpkins, gourds, *Cucurbita* spp.	Vegetable	Tropical America		19,816,731
		White-flowered (bottle) gourd *Lagenaria siceraria*	Vegetable	Southern Africa		N.A.
Fagales	Fagaceae	Chestnut, *Castanea* spp.	Nut	Northern temperate		1,124,999
	Juglandaceae	Walnuts, *Juglans* spp.	Nut	Europe, N. America	China, Europe, N. America	1,526,816
	Betulaceae	Hazulnuts (filberts), *Corylus* spp.	Nut	Europe, SW Asia		705,219
Myrtales	Myrtaceae	Allspice, *Pimenta dioica*	Spice	Caribbean basin		2,481,241
		Clove, *Syzygium caryophyllus*	Spice	Moluccas	Zanzibar, Pemba, Madagascar, Indonesia	145,370 (whole + stems)
		Eucalyptus, *Eucalyptus* spp.	Timber	Australia		N.A.
Brassicales	Caricaceae	Papaya, *Carica papaya*	Fruit	Central America	Brazil, Nigeria, India, Mexico, Indonesia	6,810,727
	Brassicaceae	Turnip, *Brassica campestris*	Vegetable	Mediterranean, Afganistan, Pakistan		N.A.

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Table 2. (*Continued from previous page*)

Order	Family (subfamily)	Crop(s), taxa	Category/ usage	Center of origin[v]	Major production areas	Production, 2005 (t)
		Cabbages, kales, cauliflower, broccoli, *Brassica oleracea*	Vegetable	Mediterranean, Asia Minor		86,200,900
		Swedes, rapes, *Brassica napus*	Vegetable	Europe-Mediterranea		N.A.
		Mustards, *Brassica* spp., *Sinapis alba*	Vegetable			623,253 (seed)
		Radish, *Raphanus sativus*	Vegetable	Mideast-Mediterranean?		N.A.
Malvales	Malvaceae (Malvoideae)	Okra, *Abelmoschus esculentus*	Vegetable	W. Africa (Ethiopia?)	Subtropics, tropics	5,041,694
		Cottons, *Gossypium* spp.	Fiber, oil	Mostly tropics	Global	18,586,467 (lint), 33,442,393 (cottonseed)
	Malvaceae (Bombacoideae)	Kapok, *Ceiba pentandra*	Fiber	Tropical America[z]	Southeast Asia	122,000 (fiber), 392,967 (fruit), 331,296 (seed in shell)
	Malvaceae (Sterculoidiae)	Kola(nut), *Cola nitida*	Drug-medicinal	W. Africa	W. Africa	221,000
	Malvaceae (Tilioideae)	Jute, *Corchorus* spp.	Fiber	India	India	3,250,322
	Malvaceae (Byttnerioideae)	Cacao, *Theobroma cacao*	Confectionary, beverage	South America	West Africa	3,822,009 (beans)
	Dipterocarpaceae	Dipterocarps, *Shorea* spp., *Hopea* spp., *Dipterocarpus* spp., *Vatica* spp.	Timber	Southeast Asia	Southeast Asia	N.A.
Sapindales	Rutaceae	Citrus, *Citrus* spp.	Fruit	Southeast Asia	USA, Brazil	105,440,168
	Meliaceae	Mahoganies, *Swietenia* spp., *Khaya* spp.	Timber	Tropics	Tropics	N.A.
	Anacardiaceae	Cashew, *Anacardium occidentale*	Fruit, nut	Tropical America	Tropical America	1,718,010 (cashewapple) 2,337,358 (cashew nut)
		Mango, *Mangifera indica*	Fruit	India, Southeast Asia	India, China, Mexico, Thailand, Pakistan	28,221,510
		Pistachio, *Pistacia vera*	Nut	C. Asia	Near East	489,209
Ericales	Sapotaceae	Karite (shea) nut, *Butyrospermum paradoxum*	Oil	W. Africa	W. Africa	693,000
	Actinidiaceae	Kiwifruit (Chinese gooseberry), *Actinidia deliciosa*	Fruit	S. China	New Zealand, Chile	1,120,938
	Ebenaceae	Persimmon, *Diospyros kaki*	Fruit	Asia	Asia, N. America, S. Europe	2,561,732
	Theaceae	Tea, *Camellia sinensis*	Beverage	China	China, India	3,436,180
	Lecythidaceae	Brazilnut, *Bertholletia excelsa*	Nut	Northern S. America	Bolivia, Brazil	73,960
	Ericaceae	Blueberry, cranberry, *Vaccinum* spp.	Fruit	N., S. America, Europe		242,610 386,160
Solanales	Convolvulaceae	Sweet potato, *Ipomea batatas*	Root and tuber	Tropical America	Subtropics, tropics	129,392,309
	Solanaceae	Pepper, chile, *Capsicum* spp.	Vegetable, spice	Tropical America	Temperate, tropical world	24,941,587
		Tomato, *Lycospersicon esculentum*	Vegetable	Tropical America	Global	122,659,873
		Tobacco, *Nicotiana tabacum*	Drug-medicial	Tropical America	Global	6,564,017
		Eggplant (aubergine), *Solanum melongena*	Vegetable	India?	Subtropics, tropics	30,477,775
		Potato, *Solanum tuberosum*	Root and tuber	Tropical America	Global	323,102,918

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Table 2. (*Continued from previous page*)

Order	Family (subfamily)	Crop(s), taxa	Category/ usage	Center of origin[v]	Major production areas	Production, 2005 (t)
Gentianales	Rubiaceae	Cinchona (quinine), *Cinchona* spp.	Drug-medicinal	Andes	Indonesia	N.A.
		Coffees, *Coffea arabica*, *C. canephora*	Beverage	Ethiopia, W. Africa	Tropical America	7,779,495 (green beans)
Lamiales	Oleaceae	Olive, *Olea europaea*	Oil	Mediterranean	Spain, Italy, Greece	14,442,435
	Lamiaceae	Teak, *Tectona grandis*	Timber			N.A.
	Pedaliaceae	Sesame, *Sesamum indicum*	Oil	Africa?	India, China, Sudan, Mexico, Venezuela, Burma	3,325,679
Apiales	Apiaceae	Carrot, *Daucus carota*	Vegetable	Afganistan	Temperate world	24,481,021
Asterales	Asteraceae	Safflower, *Carthamus tinctorius*	Oil	Near East	India, USA, Mexico	805,667
		Pyrethrum, *Chrysanthemum* spp.	Insecticidal	Caucasus, NW Persia		13,405 (dry flowers)
		Sunflower, *Helianthus annuus*	Oil	Midwestern USA	Russia, Argentina, Balkans	30,944,162
		(Globe) artichoke, *Cynara cardunculus*	Vegetable	Mediterranean, Canary Islands	Europe, USA	1,203,775
		Lettuce, *Lactuca* spp.	Vegetable	Eastern Mediterranean	N. America, Australia, Europe, S. America	22,204,280

and bacteria, whereas water deficits can predispose crops to other diseases (39,101,107). Insect damage and other diseases are among the biotic factors that affect host susceptibility (101,131,147). For example, canker and Phytophthora root rot, caused by *Phytophthora palmivora*, are diseases of citrus whose severities are increased by, respectively, the citrus leaf miner, *Phyllocnistis citrella*, and the Diaprepes root weevil, *Diaprepes abbreviatus* (150), whereas the development of anthracnose of avocado, caused by *Colletotrichum gloeosporioides*, is increased by scab damage, caused by *Sphaceloma perseae* (95).

In perennial systems, there are increased opportunities for pathogen movement within and among plantations. This occurs with all contagious diseases, but can be especially important with slow-moving diseases that might retain a restricted distribution in a short-season crop (107,140,166). Given sufficient time, even sedentary soilborne problems can spread significantly.

When explosive aboveground diseases are involved, new strains (47) or taxa (151) that are more fit or virulent than pre-existing populations can rapidly increase to dominate a field or region. This process is most rapid when there is no seasonal opportunity to change to resistant genotypes and hosts are grown in monocultures. Diseases are usually far less damaging in intercropped production (147) and in natural ecosystems (15,17) than they are in uniform plantings. Yellow rust of coffee, *Coffea arabica*, caused by *Hemileia vastatrix*, and South American leaf blight of Para rubber, *Hevea brasiliensis*, caused by *Microcyclis ulei*, are two examples of diseases that are innocuous in mixed or natural systems but become enormous problems in monocultures (40,92).

Multilines and cultivar mixtures have been used to discourage epidemic disease development in annual crops, and rusts and powdery mildews of cereals are common targets (49,98). This approach is relatively uncommon with perennials, especially when cultivar identity is required in the marketplace. There is also evidence to suggest that when hosts are large, autoinfection may negate the beneficial impact of heterogeneous host mixes (17,49,116). In a recent review, Mundt (98) mentioned only one perennial crop in the tropics, coffee, in which mixes of resistant cultivars were used to combat rust.

Replacing susceptible perennial hosts is costly, and it often takes several years before widespread changes can be made. Schieber (130) indicated that it took about 10 years for rust-susceptible coffee cultivars to be replaced; and the transition to Cavendish cultivars that resisted Panama disease, caused by *Fusarium oxysporum* f. sp. *cubense*, in the American banana trades took a decade or longer (140).

Finally, perennial crops are more apt to be affected by variable production or economic factors than annual crops. The impact of coffee rust provides examples. Avelino et al. (7) demonstrated that seasonal and site-specific variation affected the development of coffee rust and resultant yield; fungicidal management of this disease was justified only in some years and some locations. In marginal production areas where low yield potentials resulted in narrow profit margins, the use of fungicides was never justified (130). In these areas, rust-resistant cultivars were most important (118,133). Given the dramatic fluctuations that occur in global coffee prices (1), it is reasonable to assume that fungicide applications for rust control would be reduced if market returns were low.

Diseases of Tropical Perennial Crops

The disease challenges that face producers of tropical perennial crops are outlined in the following sections. As discussed above, the overall picture is one of diverse pathogens and host plants in what are often disease-conducive environments (148,161). These are difficult problems. Due to their polycyclic nature, measures that are useful on annual or short-term crops may be ineffective. In general, more effective and durable management options are needed in perennial situations, especially when there is no winter or off-season during which inoculum and disease pressure would be reduced (see Buddenhagen [14] for a contrasting view). It is not surprising that diseases can be serious constraints in the production of tropical perennials, and that special strategies may be needed to effect their management.

Below, some basic concepts are presented on the occurrence and development of these pathosystems. Peculiar aspects of these diseases and scenarios that influence the types and the extent to which they develop are summarized. They are scientifically interesting problems. New vectors (mango malformation) or pathogens (bunchy top of papaya) are associated with some of these diseases, and several are caused by two or more taxa, for example, bud rot of betel nut and coconut, citrus greening, mango malformation, Panama disease, phytoplasma diseases of coconut, and tracheomycosis of coffee (29,58,89, 107, 109,117,123,150; C. S. Lima, L. H. Pfenning, S. S. Costa, M. A. Campos, and J. F. Leslie, *unpublished*). Some of the most important diseases are host-specific or have restricted host ranges; they are caused by either coevolved or new-encounter pathogens. Resistance, the most effective tool with which many of these diseases are managed, is usually available in coevolved pathosystems but is uncommon in some new-encounter situations. Inadequate host resistance represents a significant barrier to managing many new-encounter diseases.

This review concludes with general tactics that are useful against diseases of tropical perennials. The successful management of plant disease utilizes several principles and practices, regardless of the host and the environment in which it is grown (101,143,154,165). These include the avoidance, exclusion, and eradication of the causal agents. Host protection is of great importance, as is the identification and incorporation of resistance in the host plant. All of these approaches are discussed with tropical perennial examples.

Coevolved pathosystems. Although the term "coevolution" was first coined in 1964 to describe butterfly:plant interactions (38), the idea that tandem evolution occurs between species was discussed by Darwin (26) and described in the 1950s in a plant-pathological context (20). In describing results from his classic research on flax rust, Flor (46) suggested that "…obligate parasites, such as the rust fungi, must have evolved in association with their hosts" and that "…during their parallel evolution, host and parasite developed complementary genic systems." Gene-for-gene systems have now been identified in many other pathosystems, and the specific adaptation of pathogens to host taxa, such as those described as formae speciales, is generally accepted as "the outcome of coevolution" (25).

These relationships can be conceived of as arms races in which increased disease resistance develops in a host in response to increased virulence in a pathogen (10,74). The flux of resistant, rare host genotypes and susceptible, common genotypes has been studied most closely for obligate pathogens that have specific host ranges and possess the complementary gene-for-gene relationships described first by Flor (46), but it also occurs in nonobligate situations (25).

Coevolutionary interactions are spatially and temporally complex and thus can be difficult to study and document (10,16, 146). And there are reasons why coevolution might not develop between co-occurring hosts and pathogens, even when these are obligate relationships (122). For example, insufficient genetic variation may exist in the host or pathogen for coevolution to occur, or the pathogen may not speciate at the same time as the host (122). Nonetheless, coevolution appears to be an important factor in the development of many pathosystems (17). Several criteria can be used to identify possible coevolved pathosystems (10,16,19,25,46, 53,57,62,129,136,146). These include:

- a limited, often specific host range for the pathogen;
- an original geographic distribution of the pathogen that overlaps with that of the host;
- the occurrence of significant disease resistance in the host's primary center of origin;
- regional overlap of resistance and pathogenicity factors and phenotypes in the respective host and pathogen populations (i.e., geographic evidence for reciprocal selection);
- gene-for-gene relationships; and
- tandem speciation (aka parallel cladogenesis).

Most examples of supposed coevolved pathosystems possess some, but not all, of these attributes (25,40,92,112), and there are relatively few examples of unequivocal host–pathogen coevolution where unambiguous molecular data underpin the relationship (62,129). However, the numbers of unequivocal coevolved pathosystems will surely increase as greater sophistication is used in the identification of these relationships and the coevolution process is better understood. In the meantime, coevolution will remain a useful concept for the study of host–pathogen interactions.

Centers of origin, the enemy release hypothesis, and new-encounter diseases. The great plant explorer Vavilov (155) recognized different geographic regions in which important sets of crops plants were domesticated and utilized by primitive societies, and where, subsequently, ancient civilizations began. The concept of agricultural centers of origin has been criticized, refined, and more fully developed in recent years (33,56).

Although some of the centers that Vavilov (155) recognized might be questionable, centers of origin for domesticated crops are usually clear (76,128,135). Genetic diversity is often greatest in the primary centers (where the crop first evolved), but can also be considerable in secondary centers. In extreme cases, distinct types of host plants may be found in secondary centers: for example, the East African Highland cooking bananas, highly diversified in upland East Africa but not found or unrecognized in the primary Southeast Asian home of banana (71,134).

Given the heterogeneous nature of tropical environments, one might assume that tropical crops perform best where they evolved, i.e., under conditions to which they had adapted over time. In fact, significant production for many tropical crops occurs outside the native ranges (Table 3). Why is this so? Although several factors have been proposed, the absence of coevolved plant pathogens often plays a significant role. When species display enhanced fitness in new habitats, they have often been "released" from important coevolved enemies (54,96).

The so-called "Enemy Release Hypothesis" has been used by ecologists to explain the development of weed species in new habitats. In an investigation of the hypothesis, Mitchell and Power (97) found 24% fewer viruses and 84% fewer rust, smut, and powdery mildew fungi on 473 nonendemic plant species in the United States than in their native habitats in Europe. Invasive weed species (those that were most fit) were more completely released from the pathogens (had fewer) than their nonweedy counterparts.

There are many examples of tropical crops that are most productive in non-native habitats (114,135). For some of these crops, the absence of a single or a few key pathogens is a pivotal reason for this productivity. The continued production of such crops in the new areas depends upon the continued exclusion of the pivotal (most dangerous) pathogens, and failure to do so can be costly. For example, the coevolved Sigatoka leafspot pathogens, *Mycosphaerella musicola* and *M. fijiensis*, dramatically affected banana (*Musa* spp.) production whenever they were reunited with their host in new production areas.

Other tropical perennial crops that have been released from destructive, coevolved pathogens in new production areas include:

- banana, major production of which occurs outside Southeast Asia where tropical race 4 of *F. oxysporum* f. sp. *cubense* does not occur (109);
- Para rubber, production of which predominates in Southeast Asia in the absence of South American leaf blight (40);
- pineapple, *Ananas comosus*, major production of which occurs where the coevolved fusariosis pathotype of *Fusarium guttiforme* is not found (117);
- coffee, *Coffea arabica* and *C. robusta*, most of which is produced outside Africa where coffee wilt disease (aka tracheomycosis), caused by *Gibberella xylarioides* (anamorph: *Fusarium xylarioides*) is found (123) (dissemination of another coevolved disease, yellow rust, has had a major impact on *C. arabica* production worldwide) (92) (Fig. 1);
- cacao, *Theobroma cacao*, 85% of which is produced where the coevolved witches'-broom pathogen, *Moniliophthora* (syn. *Crinipellis*) *perniciosa*, does not occur (110) (Fig. 2); and
- oil palm, *Elaeis guineensis*, more than 90% of which is produced outside West Africa (42). Until recently, Fusarium wilt, caused by *F. oxysporum* f.

sp. *elaeidis*, was found only in West Africa, where it coevolved with its host (45). Fusarium wilt has a major influence on oil palm production in Africa, and would undoubtedly impact the primary Southeast Asian production centers if it was moved there.

As mentioned above, resistant parents for coevolved hosts are often found in the respective centers of origin (81,136). Prospecting in these areas for resistant parents is a common strategy used by breeding programs. Unfortunately, habitat destruction, deforestation, and mismanagement cause losses of these genetic resources (21,30,40). The extinction of these valuable sources of disease and pest resistance, productivity, and environmental adaptibility is a serious problem.

Although resistant parents are usually available for the coevolved diseases, they may not be available for new-encounter diseases. Thus, new-encounter diseases can be just as devastating as coevolved diseases, but may be more difficult to control. Serious new-encounter examples for which little conventional resistance is known include Phytophthora root rot of avocado, caused by *P. cinnamomi* (166), and citrus greening, caused by three different '*Candidatus* Liberobacter' spp. (S. Halbert, *personal communication*).

New-encounter diseases develop when a plant is confronted with a pathogen with which it has not had an evolutionary

Table 3. Selected coevolved and new encounter pathogens of tropical perennial crops

Crop	Relative production[x]	Pathogen (disease)[w]		References
		Coevolved	New encounter	
Avocado	Moderate	**Sphaceloma perseae* (scab), *Mycosphaerella perseae* (silver spot)	**Phytophthora cinnamomi* (Phytophthora root rot)	39, 95, 166
Banana	Major	**Fusarium oxysporum* f. sp. *cubense* (Panama disease), **Mycosphaerella fijiensis* and *M. musicola* (Sigatoka leafspots), *Uredo musae* (rust)	**Ralstonia solanacearum* phylotype II (Moko disease), **Xanthomonas campestris* pv. *musaearum* (xanthomonas bacterial wilt)	13, 43, 112, 140, 141, 145, 149, 151, 164[y]
Cacao	Major	**Moniliophthora perniciosa* (witches'-broom)	**Moniliophthora rorei* (frosty pod), **Cacao swollen shoot virus* (swollen shoot), **Oncobasidium theobromae* (vascular streak dieback), **Phytophthora megakarya* (black pod), **Ceratocystis cacaofunesta* (vascular wilt)	8, 19, 37, 40, 41, 52
Cinchona	Major	*Phytophthora quininea*	*Phytophthora cinnamomi, Phytophthora nicotianae*	39, 161
Citrus	Major		*'*Candidatus* Liberibacter africanus', '*Candidatus* Liberibacter asiaticus' and '*Candidatus* Liberibacter americanus' (huanglongbing [greening])[z], *Xylella fastidiosa* (variegated chlorosis), phytoplasma (witches'-broom of lime)	115, 150
Coconut	Moderate		*Phytoplasmas (lethal yellowing, Awka wilt, coconut lethal disease, etc.), *Bursaphelenchus cocophilus* (red ring), *Phytophthora katsurae* (bud rot), *Phytomonas* (hart rot)	58
Coffee, *Coffea arabica*	Major	**Gibberella* (*Fusarium*) *xylarioides* (tracheomycosis), *Hemileia coffeicola* (grey rust), **Hemileia vastatrix* (yellow leaf rust)	**Mycena citricolor* (ojo de gallo), *Xylella fastidiosa* (variegated chlorosis)	92, 115, 118, 123, 133, 152
Eucalyptus	Major		*Puccinia psidii* (rust)	24
Guava, *Psidium guajava*	Moderate	*Puccinia psidii* (rust)	*Penicillium vermoesini* ? (guava wilt)	24, 83
Mango	Moderate	**Fusarium mangiferae* (malformation)	**Fusarium sterilihyphosum* and **Fusarium* sp. (malformation); **Ceratocystis fimbriata* (seca, sudden wilt)	3, 89, 106, and footnote y
Oil palm	Major	**Fusarium oxysporum* f. sp. *elaeidis* (Fusarium wilt)	**Thielaviopsis paradoxa*? (pudricion cogilla [bud rot]), *Phytomonas* (marchitez sopresiva), **Ganoderma boninense* (ganoderma butt rot), *Phytoplasma? (marchitez letal [lethal wilt])	12, 31, 36, 45, 104
Papaya	Major		**Papaya ringspot virus* (papaya ringspot), **Phytophthora palmivora* (fruit, root, and stem rot), *'*Candidatus* Phytoplasma australasia' (papaya dieback, yellow crinkle and mosaic)	9, 103
Pineapple	Major	**Fusarium guttiforme* (fusariosis)		117
Rubber	Major	**Microcylis ulei* (South American leaf blight)		40

[w] Coevolved and new encounter pathogens are defined using criteria listed in the text. Those marked with an asterisk are major problems.
[x] Relative production: Major = more than 70% of all production for crop occurs outside endemic range(s); moderate = 30 to 69%; minor = 5 to 29%; negligible = less than 5%.
[y] C. S. Lima, L. H. Pfenning, S. S. Costa, M. A. Campos, and J. F. Leslie, *unpublished.*
[z] The *Candidatus* species that are associated with citrus greening (huanglongbing) appear to be new encounters in Africa (Liberobacter africanus), Asia (originally India?) (Liberobacter asiaticus), and Brazil (Liberobacter americanus) (S. Halbert, *personal communication*).

history (102). Two types of new encounters have been described (17).

The first, apparently uncommon (or at least not commonly documented), results from an evolutionary host jump. Genetic changes in the pathogen (somatic hybridization, chromosome loss, and recombination are among the mechanisms) result in its adaptation to a co-occurring, previously nonsusceptible host (9,122,138).

The second kind of host jump results from dissemination of either the host or pathogen to effect a new interaction (14,57). Often, the original host of the new-encounter pathogen is not known; examples include:

- Ceratocystis wilt of cacao, caused by *Ceratocystis cacaofunesta* in tropical America (8,37);
- seca or sudden decline of mango caused in Brazil and Oman by *Ceratocystis fimbriata* (3,106) (Fig. 3);
- wilt of guava, *Psidium guajava*, caused in Malaysia, South Africa, and Taiwan by a fungus with unclear taxonomic affiliations (83);
- witches'-broom of lime, *Citrus aurantifolia*, caused in the Middle East by a phytoplasma (150) (Fig. 4);
- mango malformation, caused in Brazil (and possibly elsewhere in the Americas) by *Fusarium sterilihyphosum*, an unnamed mating population of the *Gibberella fujikuroi* species complex, and possibly other taxa (119; C. S. Lima, L. H. Pfenning, S. S. Costa, M. A. Campos, and J. F. Leslie, *unpublished*) (Fig. 5);
- vascular streak dieback of cacao, caused in Asia by *Oncobasidium theobromae* (52); and
- xanthomonas wilt of banana, caused in Africa by *Xanthomonas campestris* pv. *musaearum* (it was reported initially on a banana relative, *Ensete ventricossum*, but it is not clear whether this first host was coevolved or new encounter [149,151,164]) (Fig. 6).

When the original hosts of new-encounter diseases are known, they are usually closely related to the newly encountered host. For example:

- *Colletotrichum kahawae*, cause of coffee berry disease, originated on *Coffea eugenioides*, a close relative (precursor?) of *C. arabica* (152) (Fig. 7);
- *Moniliophthora rorei*, cause of frosty pod of cacao, probably originated on *Theobroma gileri* (40) (Fig. 8);
- *Ralstonia solanacearum* phylotype II, cause of Moko disease of banana, evolved on banana relatives in the Americas, *Heliconia* spp. (13,43) (Fig. 6);
- *Ganoderma boninense*, the basal stem rot pathogen of African oil palm, originated on coconut palm, *Cocos nucifera*, in Asia (36,104); and
- *Puccinia psidii*, cause of rust of eucalyptus, *Eucalyptus* spp., originated on other genera and species in the Myrtaceae in the Americas (24).

Although new encounters usually occur over great distances, this is not always the case, and there are instances when new-encounter pathogens evolved in close proximity to the new-encounter host. For example, *M. rorei* probably originated on

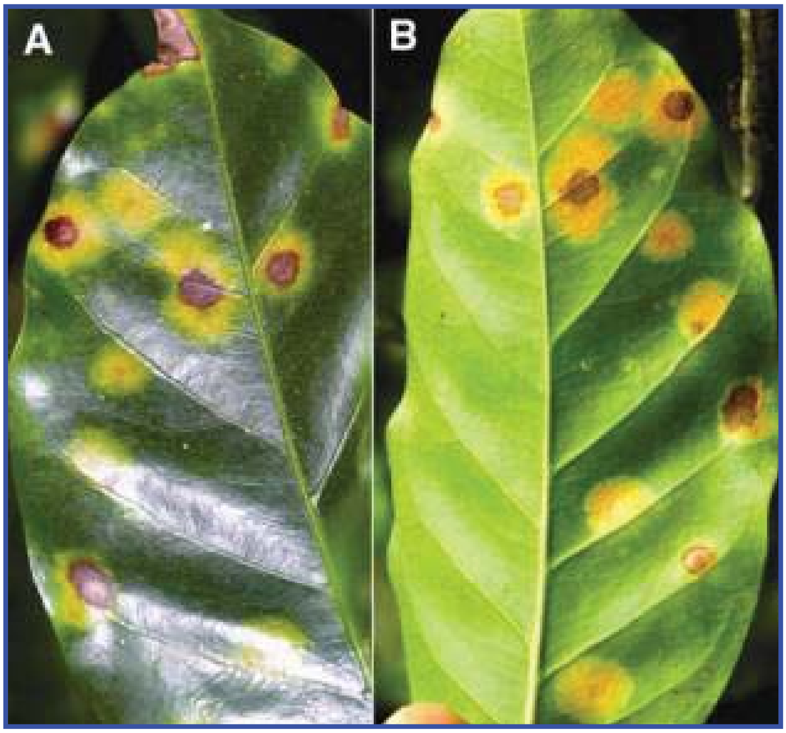

Fig. 1. A, Adaxial and B, abaxial surface of a leaf of coffee, *Coffea arabica*, affected by yellow rust, caused by *Hemileia vastatrix*. Rust caused little damage in natural, heterogeneous stands of coffee in Ethiopia, and in the arid Arabian Peninsula where the crop was first produced outside Africa. However, beginning in the late 1800s in humid Sri Lanka and India, the disease started to spread and cause serious damage in monoculture production.

Fig. 2. Witches'-broom, caused by the hemibiotroph *Moniliophthora perniciosa*, is the most serious coevolved disease of cacao. A, Hypertrophied brooms are induced during the pathogen's biotrophic phase. B, Brooms die as the disease transitions from the biotrophic to the necrotic phase. C, Basidiomes of the pathogen form later on necrotic tissues, such as this pod.

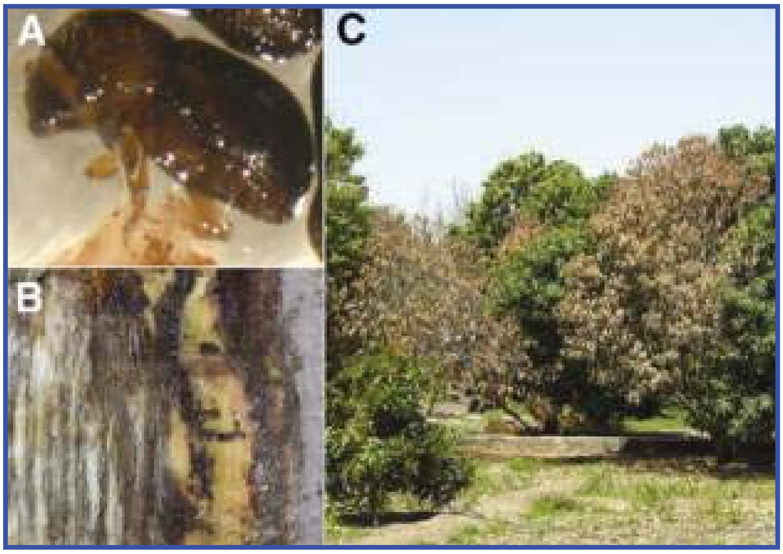

Fig. 3. The new-encounter disease known as seca and Recife sickness in Brazil and sudden wilt in Oman is caused by *Ceratocystis fimbriata* and vectored by A, the scolytid beetle, *Hypocryphalus mangiferae*. B, Internal symptoms caused by the disease and galleries of *H. mangiferae*. C, Unilateral death of portions of affected trees in Oman; ultimately trees are killed. This disease is an example of failed quarantine measures, in that it was restricted to Brazil until it was recently introduced into Pakistan and Oman; it poses a grave threat to a primary center of mango germplasm in India.

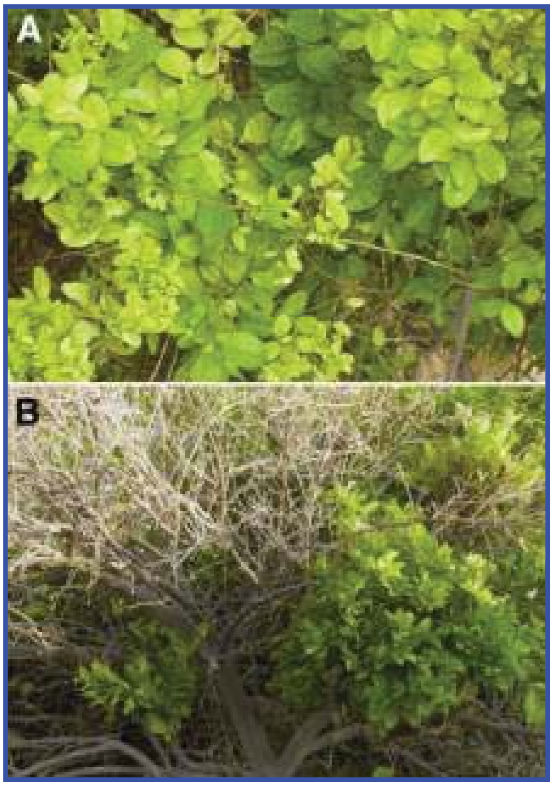

Fig. 4. Lime witches'-broom is one of several serious new-encounter diseases of citrus (here on *Citrus aurantifolia*). Found in the Middle East and caused by a phytoplasma, it initially, A, dwarfs and malforms terminal portions of the canopy and, B, later kills large portions of the tree.

the western flank of the Andes, a short distance from the cacao center on the range's eastern flank (40).

Disease Management in Tropical Perennial Crops

To devise effective management strategies, it is usually necessary to understand the disease's etiology and epidemiology. When causal agents are not known, or when they cannot be cultured and used to artificially induce disease, it is usually not possible to test treatment efficacy in a controlled manner. Two debilitating citrus diseases provide examples: blight, which has an unknown etiology, and greening, which has at least three unculturable, putative agents (150). And even when causal agents are known, unclear epidemiologies or an inability to reproduce symptoms artificially with a given agent are significant handicaps. Both of these factors contribute to management problems with basal stem rot of oil palm, a disease that kills as many as 70% of the palms in plantations in Indonesia and Malaysia (36,104).

In general, effective disease management relies on a delay in the onset or reduction in the intial levels of disease (x_O), or a reduction in the rate at which disease develops over time (r) (154,165). Below, I briefly relate these epidemiological principles to the following tactics: avoidance, exclusion, and eradication of causal agents; protection of, or development of resistance in, the host plant; and treatment of affected plants.

Avoidance. Planting site selection is an important first step in establishing a production area, and can be an important tactic for disease avoidance (101,165). In general, the conditions under which disease development is favored or hosts are predisposed to disease development should be considered. For example, swamp spot of banana, caused by *Deightoniella torulosa*, is exacerbated in low-lying and poorly drained situations, as are numerous root rots that are caused by stramenopiles (39,107,141,153) (Fig. 9). By avoiding chronically wet sites, it is possible to reduce x_O for these diseases, but especially r.

Likewise, production areas in which hosts might be predisposed to disease development should be avoided. Predisposing factors are usually physical, but indirect in their impact (131). Water and temperature extremes are most often indicated, although optimal temperatures for the host might still lead to enhanced disease if it also favors the pathogen (101). For example, Phytophthora root rot of avocado is most severe between 15 and 27°C, temperatures that are also optimum for the host (166). Physical damage to the host might also predispose it to disease development, and this can be abiotic, as is the case with wind damage and the development of bacterial black spot of mango, caused by *Xanthomonas* sp. pv. *mangifer-*

aeindicae, or biotic, as for the enhanced development of citrus canker in leaves damaged by the citrus leafminer (48,150). Managing the predisposing factors is always helpful.

The importance of using disease-free planting materials cannot be overstated, and any measure or legislation that would produce disease/pathogen free materials and disseminate them to growers would be useful (66). For example, clean nursery stock and budwood schemes are hallmarks of successful citrus programs (113).

Vegetative propagules can harbor bacteria, fungi, nematodes, viruses, and viroids, and it is with them that many economically important pathogens are moved and established (65). True seed are less apt to carry pathogens, but they can also pose significant risks. The key with both vegetative materials and true seed is to know what diseases can be moved in these ways on a given crop.

Tissue-culture plantlets should be used whenever possible, since they are free of fungal, bacterial, and nematode pathogens ($x_O = 0$) (66). They are also free of virus and viroid pathogens when they are produced from indexed mother plants. Only in rare cases are tissue-culture plantlets not safe (the badnaviruses, such as *Banana streak virus*, cause exceptional problems; see ref. 84).

Many diseases of perennial crops originate in propagation nurseries, and soilborne diseases whose symptoms are not readily apparent can be most problematic. Phytophthora root rot of avocado is a good example. *P. cinnamomi* originated in New Guinea, but has been disseminated worldwide in contaminated planting stock (166). Its establishment in new avocado orchards usually results from planting trees that were infected in the nursery (95).

Exclusion. Diverse tactics exist for the exclusion of plant pathogens (66,101). Although the idea that "there is no disease without the pathogen" is a simple one, excluding pathogens from production areas ($x_O = 0$) can be difficult. When it is possible, exclusion is a most cost-effective disease management strategy.

The early detection and accurate identification of pathogens are often important first steps in exclusion, and the certification of pathogen-free status and safe movement of germplasm rely on their success (66,101,113). All too frequently, pathogens move via human intervention. Quarantines can be an important first line of defense against their intended or unintended movement, and most countries have lists of forbidden or restricted pathogens and host plants (66,88,113,143). Unfortunately, these rules are not always enforced sufficiently to ensure border safety, and there are numerous examples of destructive agents moving despite quarantines. The recent accidental introduction of *Xanthomonas axonopodis* pv. *citri* into citrus-growing areas in Florida and Queensland, Australia, and the purposeful movement of *Moniliophthora perniciosa* into cacao plantations in Bahia, Brazil, are good examples of the anthropogenic dissemination of harmful plant pathogens (51,65,72,73). The removal of trade barriers may also be problematic; the concerns that nonendemic pathotypes of *Guignardia musae* and *Ralstonia solanacearum* might be introduced into Australia if Philippine bananas are shipped to this country are examples (70,113).

Pathogens that are moved in debris and on machinery, tools, and other implements can be excluded by surface disinfestation with chemical and physical measures (Fig. 10). Likewise, seed and planting material can be treated to kill pathogens. Heat treatment (thermotherapy) of vegetative propagation materials is useful against bacteria, fungi, nematode, and virus pathogens. However, there must be a significant difference between the temperatures at which a pathogen dies and the host is adversely affected. This can be a fine line, and heat-sensitive plants can be damaged if exacting temperature controls are not available. Only some pathogens lend themselves to this approach, and most of the successful examples that are available are for annual and/or temperate crops (101). However, heat treatment is effective for some tropical perennials. For example, heat treatment eliminates the ratoon stunt pathogen, *Clavibacter xyli* subsp. *xyli*, from sugarcane cuttings (50), and the burrowing nematode, *Radopholus similis*, from banana suckers (126).

Some pathogens can be eliminated from true seed, especially if contamination is restricted to the seed exterior. Although heat treatment is also used for this purpose (77), surface disinfestation with chlorine or fungicides is most frequent. For seedborne pathogens of quarantine concern, such as *Fusarium oxysporum* f. sp. *elaeidis* (Fusarium wilt of oil palm), extra precautions are needed to ensure that <u>all</u> seedborne inoculum is killed or intercepted (45). This has been of vital concern when oil palm seed from Africa has been disseminated. In

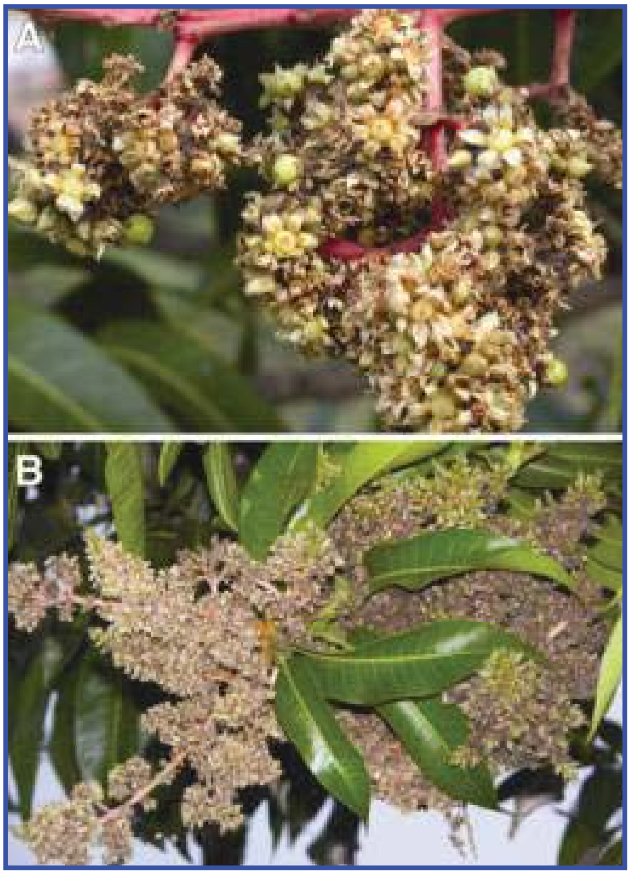

Fig. 5. Mango malformation is caused by several different fungi. In most of the world, including a presumed coevolved center in India, *Fusarium mangiferae* is responsible for the disease. However, in tropical America, *F. sterilhyphosum*, an unnamed mating population of the *Gibberella fujikuroi* species complex, and possibly other taxa cause and/or are associated with malformation. Note the similar panicle symptoms induced by A, *F. mangiferae* in Florida and B, *Fusarium* sp. in Mexico.

these cases, seed have been vacuum infiltrated with fungicides and the resultant seedlings placed in intermediate (UK) and postentry (Malaysia) quarantine before release to breeding programs.

Pathogen vectors can also be eliminated to exclude pathogens of concern, but there are obvious requirements, including knowledge of which vectors are problematic, where they reside, and how and whether they can be managed effectively. As for the causal agents, complete elimination of vectors is often difficult.

Eradication. If pathogen exclusion has failed or is not possible, a different set of strategies is needed. These measures are diverse, always more expensive than pathogen exclusion, and seldom entirely effective. The recent investment of ca. $1 billion to eradicate citrus canker in Florida is an extreme example of the expense of an unsuccessful effort to eliminate a pathogen (51; T. Gottwald, *personal communication*). Among these options, pathogen eradication is often considered first. Although the goal of eradication is to reduce x_O to 0, in practice these measures are most often rate limiting.

When they are significant reservoirs of inoculum, alternate (i.e., hosts of heteroecious rusts) and alternative hosts are removed from plantations and destroyed. Disease pressure is usually reduced in such cases and, when alternative host species are involved, is most effective when their host ranges are limited. However, pathogens with wide host ranges can also be managed in this manner: for example, weed hosts of *Cucumber mosaic virus* in banana plantations (85). The effectiveness of removing alternate and alternative hosts depends on their size (is accomplished most readily when plants are small enough to be easily uprooted and removed) and the pathogen's mobility (the regional barberry eradication programs that were instituted to manage wheat stem rust is a prominent, albeit annual and nontropical, example of extreme measures that were used for a highly mobile pathogen on a widely dispersed alternate host [18]).

Sanitation, the removal of infested debris and host materials, is another common eradication strategy. As above, its impact depends upon the ease with which these reservoirs of inoculum can be removed from plantations. Roguing infected plants is a key strategy, especially if the crop plant is the primary or sole source of inoculum. For example, bunchy top of banana, caused by *Banana bunchy top virus*, can be managed only if affected plants are identified frequently (Fig. 11A), removed from plantations, and destroyed (Fig. 11B) (145). Successful control can also result

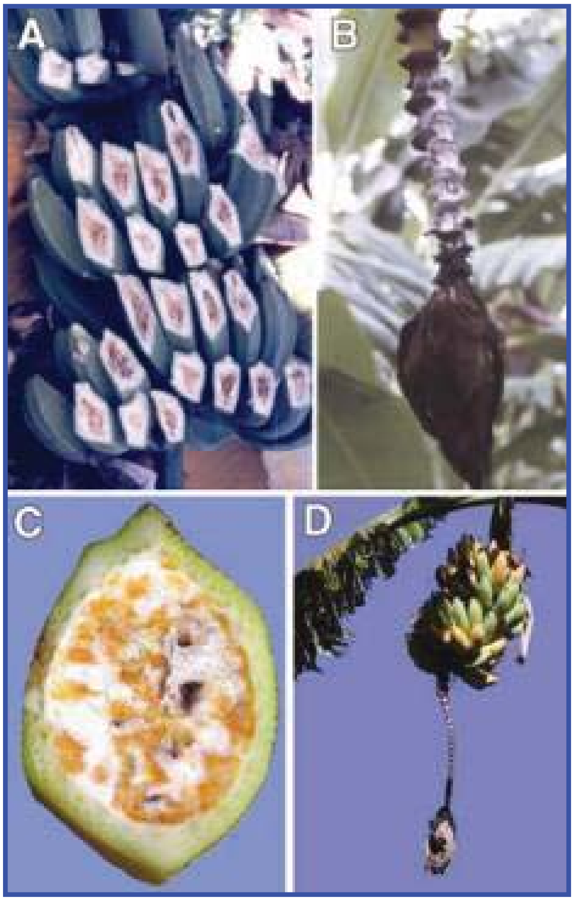

Fig. 6. Two new-encounter diseases of banana, A and B, Moko disease, caused by phylotype II of *Ralstonia solanacearum*, and C and D, xanthomonas bacterial wilt, caused by *Xanthomonas campestris* pv. *musaearum*, cause similar symptoms and have similar epidemiologies, despite their different geographic origins (respectively, tropical America and Ethiopia) and etiologies. Photos A and B courtesy of I. W. Buddenhagen, and C and D courtesy of Eric Boa.

Fig. 7. *Colletotrichum kahawae*, cause of coffee berry disease, probably coevolved with a close relative of *Coffea arabica*, *C. eugenioides.*

Fig. 8. The new-encounter disease frosty pod, caused by *Moniliophthora rorei*, is the most destructive disease of cacao, due in large part to the billions of thick-walled, long-lived infective spores that are produced on affected pods. Dissemination of frosty pod and witches'-broom (Fig. 2) to the important West African production areas would be disastrous for the world's chocolate trades.

when specific organs of the host are removed. For example, the black pod and frosty pod diseases of cacao can be effectively and economically managed via the removal of affected pods (137). In contrast, root pathogens that have wide host ranges can be difficult to manage in this way since it is usually impossible to completely remove these host parts when preparing a site for planting. *Armillaria* spp., *Ganoderma* spp., *Phellinus noxious,* and *Rigidoporus lignosus* are among the most notorious examples of these pathogens because they are good saprophytes and colonize dead roots and stumps in disturbed sites (99,107). Once affected materials are removed from plantations, it is important that they be destroyed (Fig. 11B). "Cull piles" are significant sources of inoculum for many diseases.

Different biocidal measures can be used to eliminate pathogens from soil. Their impacts range from nonspecific to somewhat specific, and due to their expense, they are used only for high-value crops. Flooding and broad-spectrum fumigants, such as methyl bromide + chloropicrin, eliminate large portions of the soil biota, resulting in what is essentially a biological vacuum. This can be a serious problem when the targeted pathogen has saprophytic capabilities. For example, formae speciales of *Fusarium oxysporum* rapidly recolonize treated soils since they are facultative saprophytes (59,90,140). Other treatments such as steam and solarization have less dramatic effects and usually eliminate only temperature sensitive organisms (most plant pathogens are killed at the 60 to 70°C that is generated by steam or the recurring more moderate temperatures, 45 to 55°C, that are generated in solarized soils) (75,101). Most of these treatments, including fumigation, solarization, steam, and chemical drenches, affect only the surface horizons of soil. This can be a significant problem with pathogens that survive at lower depths.

Protection. Diverse chemical, physical, and biological measures can be used to protect tropical perennial hosts from diseases. Ultimately, these are all rate-limiting measures.

Protectant fungicides are among the most common disease-management tools in agriculture. In tropical perennials, they are used at all stages of production and are key in the management of foliar and fruit diseases; without them, many high-value commodities could not be produced (102). Those that are highly susceptible to damaging diseases are among the most prominent examples; they include: banana (primarily Sigatoka leafspots), citrus (several fruit and foliar diseases), coffee (rust), and mango (primarily anthracnose) (5,7,105,107,133).

Vector control can be used to indirectly protect the host from the pathogen, but there are several caveats. Pesticide applications that are needed to effect disease control may not be cost effective unless the crop is valuable, the treatments are highly effective, and region-wide programs are utilized. The successful management of citrus greening in South Africa is a relevant example, in that large areas are treated for the psyllid vector (82). And even when these conditions are met, additional measures may be needed, such as the use of pathogen-free planting stock and the removal of alternative weed hosts of a pathogen. For diseases in which a single feeding event by the vector is sufficient to infect the host, effective host protection is impossible; papaya ringspot, which is caused by *Papaya ringspot virus* and vectored by transitory populations of aphids that do not establish on papaya (it is not a preferred host), is one such disease (103). Some vectors reside in protected locations that are relatively inaccessible to pesticides and thus are difficult to control. Examples include the phytophagous mango bud mite, *Aceria mangiferae*, which vectors *Fusarium mangiferae* and resides under leaf bud scales, and the banana aphid, *Pentalonia nigronervosa*, which vectors *Banana bunchy top virus* and lives at the bases of and underneath leaf sheaths (107). Finally, efficacious measures for controlling vectors may not

Fig. 9. Severity of Phytophthora root rot of avocado, caused by the new-encounter pathogen *P. cinnamomi*, is increased dramatically in flooded soil. These plants have been flooded for 2 weeks. Those on the left are in noninfested soil and those on the right are in soil infested with *P. cinnamomi*.

Fig. 10. Precautions against the movement of subtropical race 4 of *Fusarium oxysporum* f. sp. *cubense* in South Africa: A, Altus Viljoen disinfests the soles of Mike Rutherford's shoes before he moves from an infested area, and B, the pathogen is isolated in a former production area by a fence; note the fine-mesh barbed wire at the fence's base for small animals.

be available. For example, papaya bunchy top was effectively managed with DDT, since it controlled the leafhopper vectors, *Empoasca papayae* and *E. stevensi*; however, an effective replacement for this insecticide has not been indentified (28).

Other issues that surround pesticide usage will not be covered here for lack of space, including: different chemistries that are available and their spectrums of activity; the development and use of disease forecasting models; application formulations, equipment, and methods; the use of spray oils, spreader stickers, and other amendments; applicator safety; and environmental concerns that are associated with pesticide usage (113).

Modifications of the producing environments are often useful. The density of plant cover/canopy has a pronounced effect on several diseases, although its impact varies depending upon the disease (101). Shade reduces the severity of black Sigatoka of banana, but it promotes the development of diseases that require high humidity or free moisture, such as black pod of cacao and coffee berry disease (107,141,152). In the later cases, orienting rows such that prevailing winds and the morning sun have the greatest opportunity to dry the canopy can be helpful (111).

Diverse edaphic modifications are used. Improved drainage and the use of mounds or beds can significantly reduce stramenopile-induced root diseases (22,39,95,147). Soil pH impacts many soilborne diseases. Acidic reactions generally favor Fusarium wilts and those caused by *Rosellinia* spp., whereas basic conditions favor diseases caused by *Phymatotrichum omnivorum* (101). Cultural practices may indirectly effect detrimental changes; for example, monoculture and the fertilizer that was used in Hawaiian pineapple production reduced soil pH and thereby favored *Rotylenchus reniformis*, a serious pathogen of this crop (14). Although it may be possible to change a soil's pH with amendments (e.g., lime to raise the pH of acidic soils or sulfur to acidify those that are basic), it is not possible to do so with all soils. For example, it is virtually impossible to lower the pH of calcareous soils due to their buffering capacity.

Host nutrition and fertilization practices can have a large impact on disease development (27,101). Although most examples are for annual or short-season crops, some perennials that are grown in the tropics have been studied. The amounts of certain elements can be important; for example, applications of silicon-based amendments decreased the severity of ring spot of sugarcane (27). And the forms of nutrients can be important. For example, ammoniacal nitrogen increased the severity of Phytophthora root rot of citrus, whereas nitrate nitrogen decreased its severity (94).

Physical exclusion is useful in some situations. Greenhouse production of banana in Morocco creates a requisite warm environment, but also protects plants from important leaf and fruit pathogens. Likewise, bags that are used to cover banana bunches in export plantations provide physical protection from insects and mechanical damage, but also assist postharvest disease control by protecting fruit from inoculum in the field. Physical barriers, such as fences, are also used to keep inoculum out of clean fields or inside those that are affected by an important disease (Fig. 10B). In export banana production in the Americas, mats that are affected by Moko disease are routinely isolated from the rest of the plantation until they have decayed and no longer pose a threat to the rest of the plantation (149).

Biological disease control measures are receiving increased attention in tropical perennial crops due to declines in the numbers of pesticides that are available, decreased efficacy of some pesticides due to resistance, and concerns about human and environmental safety that are associated with pesticide use (69,108,124,125). Biocontrol of postharvest diseases of tropical fruits, caused mainly by fungi, has been studied extensively (69). The unique niches that are protected and the postharvest environmental control that is possible for many of these commodities have assisted the development of effective treatments, and commercial products exist that reduce disease to levels achieved by chemical measures (69,78,79). Some virus-induced diseases have also been managed biologically, primarily with strains of the causal agents with attenuated virulence. For example, a nitrous acid–induced mutant of *Papaya ringspot virus* was used to cross-protect papaya plantings in Hawaii (163) in much the same way that mild strains of *Citrus tristeza virus* have been used to protect citrus (150).

Biological control of plant disease is never easy, and can be especially difficult for systemic diseases that increase in severity over the lifespan of a given planting. Research on the biological control of Panama disease illustrates the point with a crop that is typically grown for several years (108). Although numerous researchers have investigated the biological control of this disease, to date an 18% annual loss has been the best result achieved that has been reported in a refereed journal (127). This loss rate might be acceptable in a short-season crop, but would be disastrous in a perennial crop like banana (for example, a compounded loss of 63% would result after 5 years of ratoon production).

Resistance. Resistance to disease can be a formidable, rate-limiting tool in disease management. Genetic resistance obtained via conventional breeding has been responsible for some of the most important advances in production agriculture during the last century (136). For an interesting synopsis on disease resistance and breeding in tropical crops, see Buddenhagen (14).

The source and effectiveness of the genes that are used depend on whether the pathogen is a generalist (resistance to diseases they cause is usually poor) or host-specialized. As mentioned above, resistance is often available for the coevolved, host-specialized diseases in the centers of origin (81,136). Many breeding success stories result from the use of such resistance.

Useful resistance may be available to some new-encounter diseases. For example, cacao parents that resist swollen shoot and vascular streak dieback are important in breeding programs in, respectively, Ghana and Papua New Guinea (R. J. Schnell, *personal communication*). However, useful genes may be infrequent in the new-encounter host crop. The poor resistance that exists in new-encounter situations can be circumvented if the original host of the new-encounter disease is sexually compatible with the new-encounter host. Intertaxon hybrids may be immediately useful. For example, interspecific hybrids between African oil palm, *E.*

Fig. 11. The management of banana bunchy top, caused by *Banana bunchy top virus*, in Egypt and elsewhere relies on: A, frequently identifying symptomatic plants, and B, removing and destroying such plants. Banana cannot be grown successfully wherever this disease is found and these practices are not followed.

guineensis, and American oil palm, *E. oleifera*, resist two new-encounter diseases in the Western Hemisphere, bud rot and lethal wilt (12,31) (Fig. 12). Or resistance genes can be introgressed into the host crop. The late Phil Rowe's success in breeding disease-resistant banana hybrids relied on incorporating genes from disparate taxonomic backgrounds into hybrid diploids that were then used as pollen parents (121).

The need for and usefulness of resistant perennial crops in the tropics should consider the type of disease that is addressed. Although they may be critical for foliar diseases that progress rapidly (high *r*), susceptible genotypes may be used for years before they need to be replaced if a slow-developing soilborne disease is involved. McDonald and Linde (93) classified the durability of host resistance based on the life strategies and niches of the causal agents.

Genetic resistance obtained via conventional breeding is often classified as vertical (usually controlled by one or a few major genes) or horizontal (several genes) (93,154). Much has been written about the dangers of vertical resistance. Although high levels of resistance can be achieved with it, it is almost always pathotype specific. Its use in perennial crops is dangerous since it can be easily overcome by the evolution or selection of virulent pathotypes. Coffee/*Hemileia vastatrix* and rubber/*Microcylis ulei* are two tropical perennial pathosystems for which vertical resistance has not been durable (80,118, 133,136).

The phenomenon of initial, excellent disease control that eventually erodes in vertically resistant hosts has been called the "boom-and-bust" cycle. It is most common with foliar diseases that have the potential for rapid epidemic development and are caused by genetically variable pathogens with both sexual and asexual life cycles, i.e., those classified by McDonald and Linde (93) as having "a high evolutionary potential." Although vertical resistance is usually not durable, it can be useful in some situations. For valuable crops in which good production (the "boom" part of the cycle) can be very profitable, long-term resistance may not be necessary. Acceptable production may be possible during the time that is needed to develop new resistant germplasm to combat the eventual, resistance-breaking pathotypes, especially when the pathogen has a low evolutionary potential (93,136).

When considering horizontal resistance, disease impact must be taken into account. Horizontal resistance in perennial crops might be valuable against nonlethal diseases but less so against those that kill plants. Coffee improvement schemes have developed both vertical resistance to rust in *C. arabica* selections and hybrids as well as horizontal resistance in intra- and interspecific hybrids (the other parental species, *C. canephora*, is highly tolerant) (118,133).

Genetic transformation for disease resistance (the creation of Genetically Modified Organisms, GMOs) can be quite effective (93,143). Virus-induced diseases have lent themselves to this approach far more often than diseases caused by other pathogen groups, and there are some notable success stories. For example, the papaya industry in Hawaii was saved by selections that were genetically engineered for resistance to *Papaya ringspot virus* (44). In general, conventional materials are more accepted in the marketplace than are GMOs, especially in Europe. As consumers become better educated about the benefits and safety of GMOs, a greater acceptance of these products may occur.

Treatment of diseased plants. Diseased plants can be treated effectively with various curative (systemic) chemicals, and by the removal of affected portions of the host (i.e., surgery) to reduce inoculum levels. These are rate-limiting measures.

Since the development of the first systemic fungicides, an increasing number of these compounds have been developed for

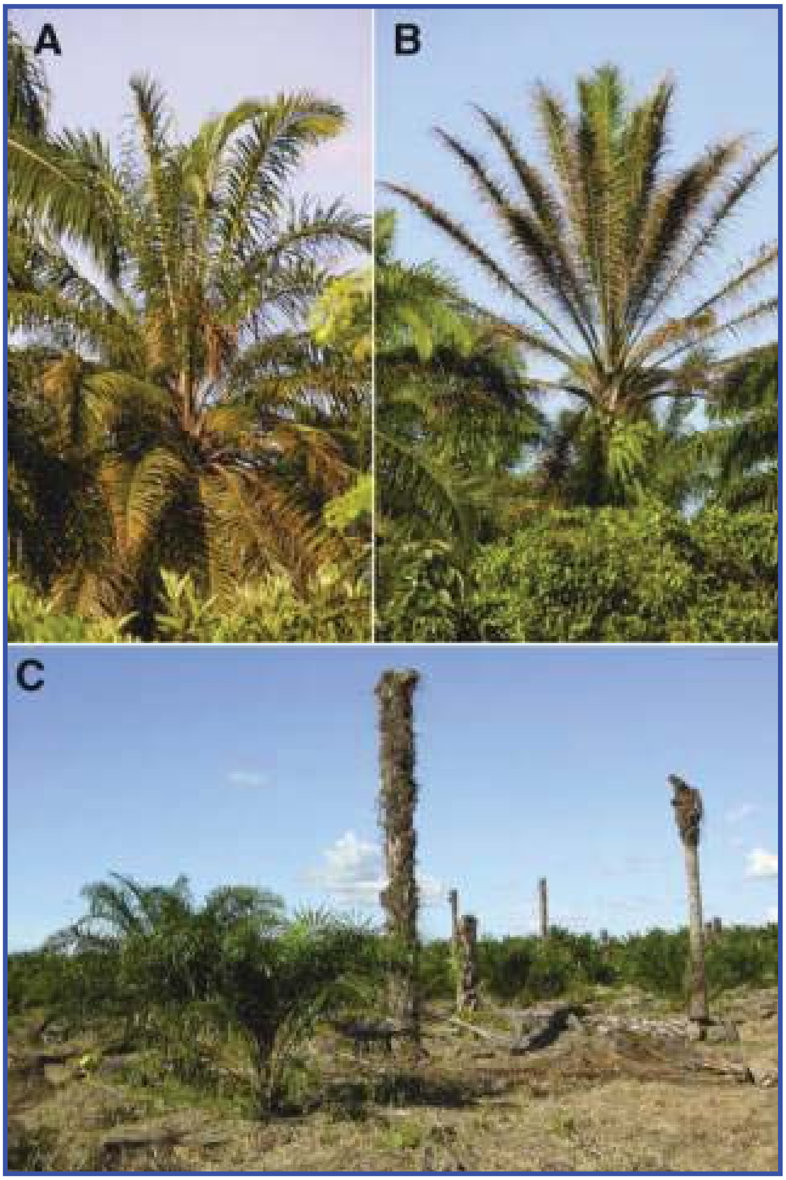

Fig. 12. The new-encounter disease lethal wilt (marchitez letal) rapidly kills oil palm in the Llanos region of Colombia. A and B, From the first stages of the disease until C, death, usually takes less than 6 months. Although its cause is not known, useful resistance is found in the American oil palm, *Elaeis oleifera*, which has been utilized in interspecific hybrids with *E. guineensis* (note that hybrids have been planted in the disease focus in C).

agricultural use. Benzimidazoles (1973), triazoles (1984), and strobilurins (1997) are among the most common systemic fungicides. Their primary activity is as protectants, but a portion of the applied compound is absorbed into treated organs. The curative, "kick-back" impact of these compounds revolutionized the management of many diseases (142).

An unfortunate attribute of some of the most effective systemic fungicides is the ease with which their efficacy is lost; their specific modes of action often make them vulnerable to the development of resistance. Black Sigatoka management in the Americas provides examples (105). Within 2 to 3 years of the introduction of benomyl for the control of black Sigatoka, resistance in *M. fijiensis* began to be observed in Central America, and by the late 1970s the chemical could no longer be used effectively in many areas (142). More recently, strobilurins have become increasingly ineffective in tropical America against this disease (68,105).

Brent and Hollomon (11) discussed the propensity of different classes of fungicides to lose effectiveness over time. They noted a wide range in the inherent risk of resistance to develop in different classes. Among the systemics that have been used against black Sigatoka, the benzimidazoles were ranked as high risk and the strobilurins as moderate. They also classified the risk of resistance developing in various pathosystems. The banana/*M. fijiensis* system was classified as high risk since the pathogen had a short generation time, sporulated abundantly, and had a sexual cycle that facilitated the development of resistance. Working groups of the Fungicide Resistance Action Committee (FRAC) of the Global Crop Protection Federation (an international consortium of agrochemical producers) have created use guidelines to prolong the effective life of vulnerable fungicides (11).

Two systemic pesticides, metalaxyl and fosetyl-Al (and its phosphonate derivatives), are effective against stramenopiles (23). Although metalaxyl is effective against a wider range of species than the phosphonates, it is more prone to the development of resistance and can also be microbially degraded in the soil, resulting in a rapid loss of activity (95,107). Fosetyl-Al and its active metabolite phosphorous acid are phloem, as well as xylem, mobile. This mobility enables effective concentrations of phosphonate metabolites to be translocated to above- and below-ground portions of plants when these compounds are trunk injected. Phytophthora root rot of avocado and *P. palmivora*–induced diseases of other tropical perennials are among the diseases that are managed effectively via trunk injection (35).

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Dr. Ploetz was born in Gastonia, NC, where his father pitched for a minor league baseball team. Most of his boyhood was spent in the Midwest. He graduated from Purdue University in 1974 with a B.Sc. in forestry and in 1976 with an M.Sc. in plant pathology. In 1984, he received a Ph.D. in plant pathology from the University of Florida, and in 1986 he joined the faculty at the university's Tropical Research and Education Center. He was promoted to professor in 1996 and received the University of Florida Research Foundation Professor Award in 2004. His primary research responsibilities are on diseases of crops that are produced in South Florida, particularly tropical fruits. He has written/edited four books and several hundred book chapters, refereed papers and technical publications. He is currently writing a two-volume book, *Tropical Plant Pathology*, for Springer-Verlag. He has served APS in diverse capacities including, Editor-in-Chief of APS Press and Director of the Office of International Programs. He now chairs an ad hoc committee that investigates APS's international activities.

Conclusions

Ideally, crop production entails a holistic view of the health and productivity of a given crop. Disease management should be considered as part of an integrated approach to crop production that also includes the nutrition, water, and environmental needs of the crop, and its economic constraints.

Just as diverse facets of plant health should be considered during production, disease management should also embrace a holistic view. Diseases of tropical perennials that can be managed effectively with a single tool are rare, and in most cases an integrated approach should be considered that utilizes several different approaches. The integrated management of Phytophthora root rot of avocado is an excellent example of how the concerted use of hygiene and sanitation, cultural and biological controls, resistance, and pesticides could be used to manage a most difficult disease of a tropical perennial crop (22).

The management of diseases of tropical perennials is one of the greatest challenges in production agriculture. Long-term criteria must be used to judge the efficacy of the chosen strategies due in large part to the polycyclic nature of these diseases, the corresponding compound interest increase in disease that develops over time, and the disease-conducive environments that prevail in the tropics. Diverse factors that are mediated by time and money are far more critical for these problems than for those that face producers of other crops. Disease management strategies in tropical perennials must be effective and durable, yet responsive to changing environmental and market conditions. It is difficult to conceive of a more interesting and difficult set of problems in plant pathology.

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Annex 15

Expert Report of Dr R.I. Krieger, Ph.D. prepared for the Defendants in *Arias/Quinteros v. Dyncorp* (D.D.C.), 19 January 2011

(United States District Court for the District of Columbia,
Cases No. 1:01-cv01908 (RWR-DAR) and 1:07-cv01042 (RWR-DAR).
Cases consolidated for Case Management and Discovery)

EXHIBIT 9

(Redacted Pursuant to Protective Order)

EXPERT REPORT OF ROBERT I. KRIEGER
Prepared for the DynCorp Defendants in
Arias/Quinteros v. DynCorp (D.D.C.)

Table of Contents

BACKGROUND & CREDENTIALS

My name is Robert I. Krieger, and I submit this report on behalf of the DynCorp defendants in the Arias/Quinteros v. DynCorp litigation. I am a Cooperative Extension Toxicologist in the Department of Entomology, University of California, Riverside and a member of the Graduate Program in Environmental Toxicology. I hold a B.S. *cum laude* in Chemistry from Pacific Lutheran University (1967) and a Ph.D. from Cornell University (1970), where I was a student in the Department of Entomology and a National Institute of Environmental Health Sciences Trainee in Environmental Toxicology. My graduate study fields included toxicology, physiology, and biochemistry.

I am a board certified Fellow of the American Academy of Toxicological Sciences (1983 to present) and a Fellow of the American College of Toxicology (2007-present). I am a longtime member of the American Chemical Society (1970-present), and I have been a full member of the Society of Toxicology since 1975. I became a Fellow of the American Association for the Advancement of Science in 2011.

I have taught toxicology at both the undergraduate and graduate levels and received several professional awards, including the Society of Toxicology's Education Award in 1986, the Society of Toxicology Public Communications Award in 2005, and the Entomological Society of America Pacific Branch Distinguished Achievement Award in Extension in 2006.

I have published over 150 manuscripts in peer-reviewed journals and technical publications and made numerous other contributions as reports, proceedings, and abstracts. In 2005, I received the American Chemical Society's International Award for Research in Agrochemicals in recognition of contributions to pesticide science. I recently headed the distinguished editorial team that produced the Hayes' Handbook of Pesticide Toxicology (2010).

Throughout my career, I have held tenured academic appointments at U.C. Davis (1971-1980) and at the Washington-Oregon-Idaho (WOI) Regional Veterinary Medical Education Program (1981-1986), where I was Professor of Veterinary and Comparative Toxicology. I was a Veterinary Toxicologist in the Washington Animal Disease Diagnostic Laboratory (WADDL) while in the WOI Program. There I teamed with WADDL veterinarians in the investigation and diagnosis of disease in cattle, horses, swine, poultry, companion animals and wildlife potentially related to pesticide, poisonous plants or other chemical exposures.

In 1986, I became a staff toxicologist and in 1988, Branch Chief, Worker Health and Safety, at the California Department of Food and Agriculture (now California EPA). The Branch was important in pesticide registration and regulation and had responsibility for the collection and analysis of pesticide illness reports. While there, I directed and participated in innovative pesticide exposure and risk assessments in residential and agricultural settings conducted by the Department.

I next served as Senior Scientist with Technical Assessment Systems (1991-1992) and Jellinek, Schwartz & Connolly (1992-1994), two major Washington, D.C. consulting firms, where I developed occupational and residential exposure assessments as part of the risk characterization process for new and registered pesticides. I returned to the University of California, Riverside, as an Extension Toxicologist (1994-present), with a fulltime research appointment specializing in pesticide exposure assessment and worker health and safety.

At the University of California, Riverside, I currently head the Personal Chemical Exposure Program. In this position, I am involved in research and extension activities in urban and agricultural settings related to the fate and effects of pesticides in humans, risk assessments, and risk communication. My current research and published studies largely concern methods and techniques for determining the availability of chemical residues on surfaces, and exposure biomonitoring of urban and agricultural populations that are potentially exposed to pesticides and other chemicals. One focus, for instance, includes the identification and movement of pesticides and other chemical residues from the diet, contaminated surfaces, water, and air to children and adults.

Additional information about my professional experience is set out in my curriculum vitae, which is attached to this report as **Exhibit A**. My curriculum vitae also contains a list of my publications.

STATEMENT OF COMPENSATION

I am being compensated at a rate of $300 per hour for my work in this matter, including deposition and trial testimony.

PRIOR TESTIMONY

Within the last four years I have testified in the following cases:

Date	Nature of Testimony	Case Information
2009	Deposition and Trial	Bober v. Killroy Pest Control, Inc., No. 1:06-cv-062427 (Superior Court, Santa Clara County, CA)
2009	Deposition	Hermes v. Marriott Vacation Club, No. 30-2008-00109997-CU-PO-CJC (Superior Court, Orange County, CA)

SUMMARY OF EXPERT OPINIONS

As a human and animal toxicologist with an expertise in pesticide exposure assessment and risk characterization, I was asked to (1) evaluate the test plaintiffs' allegations that exposure to the Plan Colombia spray mixture caused a wide range of acute and chronic injuries in humans and animals, and then (2) respond more specifically to the opinions offered by plaintiffs' expert witness, Dr. Wolfson. Having done so, my opinions can be summarized as follows:

1. There is no scientific basis to conclude that the test plaintiffs' alleged ailments could have been caused by exposure to the Plan Colombia spray mixture.

2. There is no scientific basis to conclude that the test plaintiffs' alleged injuries to their livestock could have been caused by exposure to the Plan Colombia spray mixture.

These opinions are based upon my background, training, and experience in environmental, human and animal toxicology; risk characterization; and risk assessment. My opinions are also based upon my review of numerous materials consulted throughout the course of my work on this matter, many of which are cited throughout this written report. A more comprehensive list of data and information considered in reaching my opinions is attached to this report as **Exhibit B**.

INTRODUCTION

Broadly defined, "toxicology" is the study of the effects of chemicals upon humans and other living organisms. The study of toxicology has its roots in ancient human experience. Primitive societies, for instance, identified poisons – some extremely toxic – in their diets. Some of the poisons were then used to make poison arrows for hunting, while others were routinely used as medicines for the treatment of illness or mind-altering drugs for spiritual commune. These early examples (and many examples from our present experience) illustrate the importance of the notion that the way chemicals are used (or pattern of use) determines the extent of and effects associated with human exposure, and they validate the fundamental principle of toxicology: The "dose determines a poison" (a phrase formally attributed to the 16^{th} Century Physician-Chemist-Philosopher Paracelsus).

The field of toxicology has evolved significantly over the course of many centuries. Toxicology was first recognized as a separate discipline in the early 19^{th} Century in the works of Orfila. In fact, Orfila first demonstrated in the courtroom setting the linkage between clinical findings, pathology, and ultimately the effects of poisonous substances when administered in doses capable of producing serious symptoms in man or animals. His work required the best chemistry of the times to detect poison in biological samples (vomitus, tissues, excreta) to make a distinction between harmless and harmful amounts.

Today, toxicologists are often called upon to make similar distinctions based upon ultrasensitive analytical procedures and *in vivo* and *in vitro* tissue, enzyme, and receptor studies. Using these types of tests and more, toxicologists conduct carefully planned scientific studies to achieve the following goals:

1. Identify the harmful effects or hazards that can result from contact and absorption of chemicals;

2. Determine the relationship between dose and the appearance of adverse effects in exposed populations of humans and other living things; and

3. Assess the extent of exposure for the characterization of risk associated with particular patterns of use of natural and synthetic chemicals.

In short, modern toxicology is the scientific study of the detection, occurrence, properties, effects and regulation of toxic substances. At each step of the analysis, sound methodology dictates that one critically evaluate the most relevant and scientifically reliable data and information in order to reach an accurate conclusion about the potential risks presented by a chemical exposure.

In my work as an environmental toxicologist, I am often called upon to assist in the evaluation of potential health effects of accidental, unintended, or unavoidable pesticide exposures. For example, I have evaluated public exposures to: malathion oversprays during medfly eradication programs, to pyrethroid mosquito adulticides during public health spray programs, to pre-plant soil fumigant drift from fields being prepared for row crops, to insecticide drift from orchard crops, and to fumigants used against structural pest termites. In analyzing these situations and in addressing the public's concerns, it is centrally important to understand not only the potential health hazard of the pesticides at issue but the extent of the potential exposures of the human populations to the pesticides. While the possibility of pesticide exposures can often create public concern, if these exposures do not reach "dose" levels that have been associated with a health risk, those concerns will not have any toxicological basis in fact. Getting the science right is a critical first step toward building an understanding of whether a pesticide exposure represents a threat to health.

In the continuing discussion of the occurrence of, exposure to, and study of chemicals (such as glyphosate and/or the Plan Colombia spray mixture) in our environments, it is also important to understand the prevalence and nature of so-called "toxic" exposures in every aspect of our lives. While the public often focuses on chemical exposures – and, indeed, there are certain chemicals that are highly toxic – virtually any substance can have toxic effects if ingested or absorbed at a high enough dose. For example, the caffeine in a cup of brewed coffee could be considered a normal dose, but 100 times that amount would contain a lethal level of caffeine. Spinach and rhubarb both contain oxalates that, in extreme amounts, could cause illness or death if consumed. Even essential vitamins in excess can be associated with toxicity. The tolerable upper limit of vitamin C, for example, is about 2 grams per person per day. A medium orange, however, provides 70 mg of vitamin C, and therefore oranges, consumed in excess, could result in illness. Again, it is our common experience that the "dose determines a poison," and consequently simple contact or "exposure" to a chemical does not in itself constitute a so-called "toxic" exposure capable of producing an adverse effect. This principle is borne out under the circumstances presented here.

THERE IS NO BASIS TO CONCLUDE THAT THE TEST PLAINTIFFS' ALLEGED AILMENTS COULD HAVE BEEN CAUSED BY EXPOSURE TO THE PLAN COLOMBIA SPRAY MIXTURE.

The test plaintiffs allege that their exposure to the Plan Colombia spray mixture has caused them a wide variety of ailments, none of which are supported by any contemporaneous medical documentation in which it has been concluded that their ailments were caused by exposure to the Plan Colombia herbicide. Furthermore, no one has independently verified – much less *characterized or quantified* – the test plaintiffs' alleged exposure to the Plan Colombia spray mixture or the supposedly toxic dose that each plaintiff may have derived from that exposure.

Despite this absence of critical evidence, Dr. Wolfson, the test plaintiffs' sole (initial) expert witness, has opined that "most, if not all, of the health complaints experienced by these [test] plaintiffs"[1] are "consistent with exposure to glyphosate-based herbicide spray" (Wolfson Rpt. 3). Notably, Dr. Wolfson limits his opinion primarily to plaintiffs' complaints of transient skin, eye, gastrointestinal, and respiratory symptoms, making no mention whatsoever of the test plaintiffs' allegations of persistent or chronic health effects.[2] Furthermore, Dr. Wolfson stops short of offering the opinion that the test plaintiffs' alleged injuries were, in fact, *caused by* exposure to the Plan Colombia spray mixture. But even the tentative opinion offered by Dr. Wolfson – namely that the test plaintiffs' alleged injuries are "consistent with" exposure to the Plan Colombia spray mixture – is without foundation.

In arriving at his opinion, Dr. Wolfson ignores the most fundamental principle of toxicology: The dose makes the poison. While Dr. Wolfson does not provide any explanation for his opinion in his expert report, the only studies that he includes in his reference list that even arguably relate to the plaintiffs' alleged injuries involve suicide attempts in which individuals ingested large amounts of concentrated glyphosate herbicides.[3] These extreme exposure scenarios cannot support Dr. Wolfson's "consistent with" opinion. To the contrary, they generally demonstrate the lack of toxicity of glyphosate-based herbicides at exposure levels that would be relevant to their normal use and, most certainly, their use in the Plan Colombia program and the plaintiffs' allegations here. Yet, Dr. Wolfson makes no attempt to characterize or quantify the doses at which the test plaintiffs could even conceivably have been exposed to Plan Colombia herbicide, and plaintiffs have presented no such evidence in any other reliable manner. Without reliable exposure data and some estimate of the dose that each test plaintiff may have received from each alleged exposure – and reliable scientific evidence demonstrating some health effect of the Plan

[1] Dr. Wolfson identifies the test plaintiffs' alleged health complaints as "itchiness to the skin, nose, and eyes; skin irritation; burning sensation to the skin and eyes; rash; vomiting; respiratory problems; headaches; dizziness; stomach aches; diarrhea; and burning throat" (Wolfson Rpt. 3).

[2] Dr. Wolfson does not identify any studies that associate glyphosate exposure with any of the test plaintiffs' alleged chronic health effects – e.g., aching bones; kidney problems; persisting eye, skin, GI, or respiratory illnesses – and I am not aware of any evidence linking exposure to the various chronic health effects alleged by the plaintiffs here.

[3] In addition to the suicide studies, Dr. Wolfson identifies the review article by Bradberry et al. (2004), but this article does not support his conclusions (it largely reviews the same suicide data), nor does it go to the more fundamental question whether the test plaintiffs' alleged exposure to the Plan Colombia herbicide could have caused their various injuries. If anything, the article makes it clear that there is no evidence that exposure to glyphosate formulations in any relevant amount can cause chronic injuries.

Colombia herbicide at those dose levels – Dr. Wolfson's "consistent with" opinion is simply meaningless. Dr. Wolfson offers no reasonable basis to conclude either that the test plaintiffs' ailments are "consistent with" their alleged exposure to the Plan Colombia spray mixture, or that those ailments could have been caused by such exposure.

The gap in the logic behind Dr. Wolfson's opinion is all the more glaring here because the constituents of the glyphosate-based Plan Colombia spray mixture are well known, and the potential toxicity of the Plan Colombia spray mixture to humans and animals is known.

- **Glyphosate formulations are safely used worldwide and have been extensively studied.**

  The spray mixture used in coca eradication in Colombia is made up of the following:

  - Water, which constitutes 74% by volume of the final spray mixture.
  - Glyphosate, the active ingredient, which constitutes 18% by volume of the final spray mixture.
  - Surfactants (POEA and Cosmo-Flux), which together constitute approximately 8% of the final spray mixture.

  (Solomon et al. 2005; Solomon et al. 2007; U.S. Dept. of State Memorandum of Justification 2002). The properties of glyphosate and the surfactants at issue are well known under the conditions of use.

  Glyphosate has long been used as an herbicide, and it is regularly formulated with water and surfactants to make it a more effective product. The original glyphosate formulation, Roundup, was introduced by Monsanto in the early 1970s. In 2005, glyphosate-based herbicides were registered in 130 countries for weed control and vegetation management in more than 100 crops (Monsanto 2005). In addition, glyphosate is widely used in non-agricultural applications including home lawns and gardens, rights-of-way maintenance, and forestry where control of undesirable vegetation is required.

  Today, glyphosate is among the most extensively used conventional pesticides in the United States (Duke and Powles 2008). No other herbicide active ingredient has as many approved uses. In part, this results from development of glyphosate-resistant crops which allow commercial growers to make over-the-top applications of this non-selective herbicide to control weeds in a variety of glyphosate-tolerant crops. But it is also testament to the fact that glyphosate and glyphosate-based formulations are virtually non-toxic to humans and terrestrial animals at typical levels of exposure.

  Given its long history and extensive use, glyphosate – alone and in combination with its surfactants – has been frequently studied.

As an initial matter, all pesticides sold or distributed in the United States must be registered by the United States Environmental Protection Agency ("EPA"), based on scientific studies showing that they can be used without posing unreasonable risks to people or the environment. The Office of Prevention, Pesticides and Toxic Substances (OPPTS) has established guidelines for use in the testing of pesticides to develop data for submission to EPA under the Federal Food, Drug, and Cosmetic Act (FFDCA), and the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). The test guidelines prescribe premarket studies required for evaluation of health and environmental issues related to proposed pesticide use.[4] Acute (single dose), subchronic, and lifetime toxicity testing are included. Pesticide fate and transport studies are also obtained to predict the environmental behavior and exposure potential of pesticides. In addition to detailing basic test requirements, the guideline studies conducted by registrants are subject to rigorous third-party review (also known as Good Laboratory Practice review). These data are used by the EPA to perform risk assessments and make regulatory decisions. The guideline studies established by the EPA registration process are a hallmark of this sound regulatory process, and pesticides are the most fully evaluated chemical technology of the EPA.

EPA comprehensively reviewed the uses of and science supporting glyphosate (and its formulations) in 1993. The result of this review was published in the 1993 Registration Eligibility Decision ("RED") for glyphosate. This RED includes a comprehensive summary of the human health assessment of glyphosate based upon the results of guidance toxicity studies, dietary exposure, occupational and residential exposure, and a human health risk assessment. The document represents a complete database in support of the many uses of glyphosate, with the conclusion that the use of glyphosate "will not pose unreasonable risks or adverse effects to humans or the environment" (USEPA 1993).

Subsequent reviews and research have extended and confirmed the findings published by EPA in 1993. Institutional reviews of glyphosate and its formulations contributed by the World Health Organization (1994) and comprehensive reviews prepared by Williams et al. (2000), Giesy et al. (2000), and Solomon et al. (2005, 2007)[5] illustrate the extensive amount of studies concerning glyphosate herbicide toxicology. EPA has repeatedly reaffirmed its conclusion as to the safety of glyphosate (USEPA 2002, 2004, 2006, 2008, 2009).

The studies and data considered by EPA and others have led to generally-accepted acute ("NOAEL") and chronic ("RfD") exposure standards. In layman's terms, these are levels of exposure that are shown to produce *no* adverse health effects. The Reference Dose

[4] Similar guidelines are used in other places such as Canada, European Union, and Japan, all of which have evidence-based pesticide regulatory systems.

[5] Recently, these comprehensive publications have been supplemented with a series of eight original papers prepared as part of a follow up study "Production of Illicit Drugs, the Environment and Human Health" commissioned by the Organization of American States' CICAD group and published in the Journal of Toxicology and Environmental Health (Solomon et al. 2009).

("RfD") for glyphosate is set at 2 mg/kg bw/day, meaning that combined exposures amounting to 2 milligrams per kilogram bodyweight (mg/kg bw) each day for an entire lifetime would not produce any adverse health effects even in sensitive populations. Translated further, the 2 mg/kg bw/day standard for glyphosate means that a 150 lb person could be exposed to approximately 136 mg of glyphosate daily, for an entire lifetime, and experience no adverse health effects. The RfD is derived from the No Observed Adverse Effect Level ("NOAEL") for glyphosate, which was determined to be 175 mg/kg in a developmental toxicity study in which pregnant rabbits were given oral dosages of 0, 75, 175, and 350 mg/kg bw from days 6 through 27 of gestation. No effects were observed in the rabbit fetuses at any dose, but diarrhea, nasal discharge and some deaths were observed in the maternal rabbits at the highest dose of 350 mg/kg. The NOAEL for glyphosate has thus been set at 175 mg/kg bw. It represents the dose at which no adverse effects (including developmental effects) occured. The NOAEL is divided by two 10-fold "uncertainty factors" (for animal to human and intra-individual uncertainty) to yield the RfD of 2 mg/kg/day.

A number of risk assessments have compared these no-effect levels to the levels of exposure encountered by pesticide applicators, bystanders, and the public (Williams et al. 2000; Solomon et al. 2005, 2007), and demonstrated that the use of glyphosate-based herbicides poses no significant health risks.

- **Reliable exposure/dose information – which is lacking here – is a prerequisite to any opinion concerning the potential human health effects associated with exposure to glyphosate-based herbicides.**

As noted above, numerous studies and regulatory reviews applying internationally accepted methods, principles and procedures in toxicology have revealed no grounds to suggest concern for human or animal health resulting from current patterns of use of glyphosate and its formulations (such as the Plan Colombia spray mixture). Against this backdrop, it is critical that the test plaintiffs demonstrate some quantifiable amount of exposure/dose – and scientific evidence linking that amount of exposure to human health effects – before one can reasonably conclude that the plaintiffs' alleged exposures could have caused any of the various types of ailments identified by Dr. Wolfson. Dr. Wolfson has not done so. Nor has Dr. Wolfson made any reference whatsoever to the specific scientific toxicity studies that have been conducted on the Plan Colombia herbicide mix, which provide further evidence of the mixture's slight toxicity. And Dr. Wolfson simply ignores or is unaware of reports of DynCorp pilots, mechanics, and other personnel who were exposed to amounts of Plan Colombia herbicide that far exceed anything even suggested by the test plaintiffs without any meaningful adverse health effect.[6]

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[6] [redacted]

The failure of Dr. Wolfson's approach is best illustrated by addressing each of the categories of human illness/ailment set out in his report.

There is no basis for Dr. Wolfson's conclusions about skin irritation. Without citing any literature or other references, Dr. Wolfson opines that the test plaintiffs' complaints of skin irritation (e.g., itchiness, burning sensation, and rash) are "consistent with" exposure to the Plan Colombia spray mixture (Wolfson Rpt. 3). There is no basis for this conclusion in the absence of some meaningful and reliable assessment of each plaintiff's alleged exposure.

Standard toxicity testing was performed on the Plan Colombia spray mixture to assess its skin irritant potential. In one rabbit study, the mixture was applied directly to the skin of rabbits and then covered with a binding for four hours in order to keep the mixture in contact with the rabbits' skin. Following this, the binding was removed and the rabbits' skin was examined. After four hours of uninterrupted contact with the skin, the spray mixture was reported to produce only "slight erythema" (redness) to the skin of the rabbits, and all of these symptoms resolved completely within 24 hours (Solomon et al. 2005). Based upon this testing, the Plan Colombia spray mix was designated a slight skin irritant (Solomon et al. 2005; Springborn 2003c). In another rabbit study, there was no sign of any skin irritation whatsoever after similar applications of the Plan Colombia spray mixture (Solomon et al. 2005).

The results of the toxicity testing on the Plan Colombia spray mixture are in line with the results of prior studies on similar glyphosate formulations. For instance, studies conducted with formulated glyphosate (e.g., Roundup, consisting of 41% IPA and 15% POEA, similar to the formulation used in the Plan Colombia spray mixture) showed that the formulation was only slightly irritating to the skin (Blaszcak 1990; Williams et al. 2000), owing primarily to the POEA/surfactant component of the formulation. Putting this finding into perspective, Maibach (1986) demonstrated through testing in human volunteers that a concentrated glyphosate formulation (e.g., Roundup, consisting of 41% IPA glyphosate) applied to the skin under gauze patches for 24 hours/day for three weeks caused only slight irritation. Based upon side-by-side comparisons from the same study, Maibach concluded that the Roundup formulation was "indistinguishable in its [skin] irritant potential" from Johnson & Johnson baby shampoo and had less irritant potential than Pinesol all-purpose cleaner and Ivory dishwashing liquid. Maibach further concluded that the Roundup formulation did not induce skin sensitization, photoirritation, or photosensitization.

[redacted]

These scientific studies provide no basis to conclude that the test plaintiffs' alleged skin ailments could have been caused by exposure to the Plan Colombia spray mixture, or even that the plaintiffs' skin ailments were "consistent with" what one might expect following exposure to the Plan Colombia herbicide. Even under experimental conditions in which test animals or human subjects were purposefully subjected to relatively long term exposures to a concentrated amount of the glyphosate formulation, none of the studies reported the types of acute skin effects alleged by the test plaintiffs, let alone the types of persistent and recurring conditions that many of the plaintiffs have alleged (and that Dr. Wolfson has apparently disregarded). Given that the test plaintiffs allege transient exposure scenarios that would involve much lower levels of exposure than the direct/extended applications made in the studies, the scientific evidence plainly does not support Dr. Wolfson's opinions.

Although not mentioned by Dr. Wolfson, some literature reviews and other papers have found it useful to discuss the types of illness data collected by the California EPA Pesticide Illness Surveillance Program ("PISP"), but these data have little relevance in this case.[7] During the ten year period from 1999 to 2008, there were over 1.4 million applications of glyphosate-based formulations in California, representing the use of approximately 4.8 million pounds annually. Despite this extensive use, only nine (9) notations of skin irritation were included among the 22 PISP reports of illness resulting from drift. None of the nine were "definitely"[8] attributed to the exposure after investigation by the County Agricultural Commissioners and review of physician's reports by professionals at the Department of Pesticide Regulation. And none of the cases present exposure scenarios like those at issue here, where an aerial application is alleged to have drifted many hundreds or even thousands of meters.

There is no basis for Dr. Wolfson's conclusions about eye irritation. Without citing any literature or other references, Dr. Wolfson opines that the test plaintiffs' complaints of eye irritation (e.g., itchiness, burning sensation) are "consistent with" exposure to the Plan Colombia spray mixture (Wolfson Rpt. 3). Again, there is no basis for this conclusion.

Standard toxicity testing was conducted on the Plan Colombia spray mixture to assess its eye irritation potential. In one study, a dose of the mixture was placed directly into the conjunctival sac of a rabbit's eye and left there, undisturbed, for seven days. One hour after application, the mixture was found to have produced redness and swelling in the rabbits' eyes, but this resolved completely within the seven day timeframe of the study (Solomon et al. 2005; Springborn 2003b). In another study, a similar application of the Plan Colombia spray mixture to the eyes of rabbits produced temporary irritation; however, in the same study, some of the rabbits' eyes were rinsed following application

[7] California PISP data are publicly available at http://apps.cdpr.ca.gov/calpiq/index.cfm.

[8] The California PISP uses the following classification scheme: A **possible** relationship indicates that health effects correspond generally to the reported exposure, but evidence is not available to support a relationship. A **probable** relationship indicates that limited or circumstantial evidence supports a relationship to pesticide exposure. And a **definite** relationship indicates that both physical and medical evidence document exposure and consequent health effects. (See http://apps.cdpr.ca.gov/calpiq/index.cfm.)

of the Plan Colombia mixture, and in these animals no irritation or other symptoms were observed (Solomon et al. 2005). Based upon these studies, the Plan Colombia spray mixture is considered to have slight to moderate eye irritation potential (Solomon et al. 2005), which is analogous to the eye irritation potential of shampoo.

Analyses of reported human ocular exposures to glyphosate formulations like the Plan Colombia spray mixture show that minor/transient effects are sometimes reported. Acquavella et al. (1999) reviewed more than 1,500 reports to a regional poison control center of confirmed ocular exposure to Roundup formulations, and found that 91% of the reports involved either no resultant ocular effects (21%) or reports of only minor/transient symptoms such as eye pain, watery eyes, and blurred vision (70%). Acquavella et al. (1999) found no appreciable trend between exposures to increasingly concentrated formulations of Roundup (e.g., 41% IPA glyphosate with more than 11% surfactant) and the severity of blurred vision and tearing, and they found no reported cases of permanent eye damage. Having reviewed a number of studies and other data (not detailed here), Williams et al. (2000) concluded that the eye irritation potential of Roundup formulations in humans is low.

The scientific studies of the eye-irritation potential of the Plan Colombia herbicide and/or Roundup provide no basis for Dr. Wolfson's opinion that plaintiffs' alleged eye injuries are "consistent with" their alleged exposures. While the studies do indicate that the Plan Colombia herbicide might result in some minor and transient eye symptoms (such as redness, irritation, and watery eyes) if directly applied to the eye, none of the studies indicate that these symptoms would result under the exposure scenarios alleged here (where the diluted herbicide is applied aerially so that only minute amounts would reach any given location on the ground). No studies suggest that the alleged exposures to Plan Colombia herbicide and/or Roundup could cause the permanent eye injuries alleged by some of the test plaintiffs.

Some literature reviews and other papers (not including Dr. Wolfson's report) have made reference the California PISP data. The PISP data indicate eye irritation following exposure to glyphosate drift, but again, these data are not informative in this case. Despite the extensive use of glyphosate-based herbicides, from 1999 to 2008 only twelve (12) notations of eye irritation were included among the 22 PISP reports of illness resulting from drift. None of these twelve cases were "definitely" associated with the exposure after investigation by the County Agricultural Commissioners and Department of Pesticide Regulation professionals, and none of the cases present exposure scenarios quite as attenuated as those alleged in this case.

There is no basis for Dr. Wolfson's conclusions about gastrointestinal symptoms. Without citing any literature or other references, Dr. Wolfson opines that the test plaintiffs' complaints of gastrointestinal symptoms (e.g., burning throat, stomach aches, diarrhea) are "consistent with" exposure to the Plan Colombia spray mixture (Wolfson Rpt. 3). As before, there is no scientific basis for this conclusion.

The only study referenced (but not discussed) by Dr. Wolfson that even discusses a potential association between gastrointestinal symptoms and exposure to glyphosate-based herbicides is Chang et al. (1999).[9] However, this study is irrelevant to the question whether the exposures alleged by the test plaintiffs could have caused gastrointestinal injuries, and it provides no support for Dr. Wolfson's opinion that such injuries are "consistent with" the test plaintiffs' alleged exposures. To the contrary, Chang et al. (2009) highlights the central importance of taking dose into account before reaching any opinion as to the potential impact of any alleged exposure. Chang et al. (1999) reviewed the course of 50 patients who attempted suicide by drinking Roundup. These patients consumed an average of 181 ml (roughly ¾ of a cup) of formulated Roundup, a dose that is orders of magnitude greater than any dose that could be reasonably expected from exposure to an aerial application or drift of the Plan Colombia herbicide. But even at this high dose, the patients experienced only relatively minor stomach injuries; in fact, roughly 30% experienced no stomach injuries whatsoever.[10] Dr. Wolfson's suggestion that this study provides any support for his opinions in this case demonstrates his complete lack of consideration of the most basic principles of dose response that must inform any scientifically reliable risk assessment.

Dr. Wolfson's reliance on suicide attempt studies is all the more notable given his failure to even reference the far more relevant scientific evidence that ingestion of glyphosate-based herbicides and their residues in foods are both expected and accepted because such exposure poses little or no human health concerns. Permissible "tolerance levels" (also known as "maximum residue levels" or "MRLs") have long existed for residues of glyphosate (and its metabolite, aminomethylphosphonic acid, or "AMPA"), anticipating its presence in or on a wide variety of crops and crop groups, as well as in many processed foods, animal feed and animal tissues (40 CFR 180.364, 40 CFR 185.3500 and 40 CFR 186.3500). These tolerances or MRLs are established as safe levels of a pesticide that may occur on commodities at the highest and most frequent levels of application.[11] In light of their use and safety profile, POEA and Cosmo-Flux have been

[9] The "list of references" attached to Dr. Wolfson's report identifies the article by Chang et al. (1999), but as with the rest of the references cited there Dr. Wolfson does not discuss the relevance of this article in the body of his report.

[10] According to the assessment criteria utilized by Chang et al. (1999), none of the patients involved in the study experienced grade 3 gastrointestinal injuries, which would be characterized by "multiple ulcerations and areas of necrosis," and the most significant findings were of esophageal injuries, not stomach injuries.

[11] "Before allowing the use of a pesticide on food crops, EPA sets a tolerance, or maximum residue limit, which is the amount of pesticide residue allowed to remain in or on each treated food commodity. The tolerance is the residue level that triggers enforcement actions. That is, if residues are found above that level, the commodity will be subject to seizure by the government. In setting the tolerance, EPA must make a safety finding that the pesticide can be used with 'reasonable certainty of no harm.' To make this finding, EPA considers (1) the toxicity of the pesticide and its break-down products, (2) how much of the pesticide is applied and how often, (3) how much of the pesticide (i.e., the residue) remains in or on food by the time it is marketed and prepared. EPA ensures that the tolerance selected will be safe. The tolerance applies to food imported into this country, as well as to food grown here in the U.S." (http://www.epa.gov/pesticides/factsheets/stprf.htm#tolerances (last visited December 2010).)

exempted from the requirement of tolerances in food and feed, meaning that there is no concern that ingestion of these surfactants could cause any health effect.[12]

Similar to the tolerance levels established for food and feed products, EPA has contemplated the presence of glyphosate in drinking water and established an acceptable maximum contaminant level ("MCL") for its presence there.[13] The MCL is set at 0.7 mg/L which in the case of glyphosate is a level "below which there is no known or expected risk to health."[14] The MCL for glyphosate sets a relatively high threshold considering it is nearly 15 times greater than the highest level ever found in well water (according to the published literature),[15] and "many orders of magnitude" beyond the average levels of glyphosate that EPA has predicted could be present in U.S. drinking water (Williams et al. 2000).[16]

In light of the foregoing, there is no basis for Dr. Wolfson to conclude, as he does, that the test plaintiffs' alleged gastrointestinal injuries are "consistent with" their alleged exposures to the Plan Colombia spray mixture.

There is no basis for Dr. Wolfson's conclusions about respiratory injuries. Without citing any literature or other references, Dr. Wolfson opines that the test plaintiffs' respiratory complaints (e.g., respiratory problems) are "consistent with" exposure to the Plan Colombia spray mixture (Wolfson Rpt. 3). Once again, there is no basis for this conclusion.

Toxicity studies have been conducted to determine the inhalation toxicity potential of the Plan Colombia spray mixture. In one study, increasing concentrations of the Plan Colombia spray mixture (5, 10, and 20 mg/L of air) were pumped into nose-only exposure manifolds where rats are restrained during four hour exposure periods. The condition of the rats was then followed for 14 days afterward, and throughout this study the rats showed no acute or systemic toxicity (Solomon et al. 2005). In another study, however, rats were similarly exposed to airborne concentrations of the Plan Colombia mixture at a rate of 2.60 mg/L for four continuous hours. Following this exposure, some

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[12] The EPA determined that all of the ingredients of Cosmo-Flux 411F are exempt under 40 CFR 180.1001 from the requirement of tolerances when included in pesticides applied to food, feeds, and livestock (U.S. Dept. of State Memorandum of Justification 2002).

[13] Water sampling conducted by Solomon et al. (2005) in areas where Plan Colombia aerial eradication operations were actually carried out failed to detect glyphosate in any of the samples collected (0.025 mg/L detection limit).

[14] EPA's established maximum contaminant levels are available at http://water.epa.gov/drink/contaminants/index.cfm#List (last visited January 2011).

[15] Williams et al. (2000) reported that the highest level of glyphosate found in well water following application was a single unvalidated finding of .045 mg/L.

[16] Williams et al. (2000) reviewed EPA's chemical "fate" modeling results, and stated EPA's conclusion that glyphosate could be present in U.S. surface and ground water at average concentrations of 0.000063 and 0.0000011 mg/L, respectively, amounts deemed insignificant in terms of potential health risks.

non-specific clinical symptoms (such as breathing abnormalities, decreased defecation, urine staining, rough hair coat, and decreased food consumption) were observed (Springborn 2003f). Based upon the totality of the evidence presented by these studies, the Plan Colombia spray mixture is considered to have very low toxicity (practically non-toxic) via inhalation exposure.

Under more realistic conditions, there actually would be little opportunity for any inhalation exposure to the Plan Colombia spray mixture. In the first place, glyphosate (isopropylamine salt) has a very low vapor pressure (2.1×10^{-3} mPa at 25°C) and a low Henry's Law Constant (4.6×10^{-10} Pa $m^3 mol^{-1}$), which indicate that glyphosate vapor will not be present in air in any significant amount (Solomon et al. 2005). In addition, Hewitt et al. (2009) have shown that aerial application of the Plan Colombia spray mixture produces relatively large droplets, ranging from 120 to 140 microns in diameter. Aerodynamically, particles of this size do not remain airborne for long; rather, they reach the ground within the spray swath or immediately downwind of the swath, thus creating little opportunity for inhalation exposure in the drift scenario alleged by the test plaintiffs. In any event, the large particles created by the aerial spraying apparatus are less likely to be inhaled into the lungs as small particles (generally 10 microns or less).

Based upon the foregoing, there is no basis for Dr. Wolfson's conclusion that the respiratory injuries alleged by the plaintiffs are "consistent with" their claimed exposures to the Plan Colombia spray mixture.

THERE IS NO BASIS TO CONCLUDE THAT THE TEST PLAINTIFFS' ALLEGED INJURIES TO THEIR LIVESTOCK COULD HAVE BEEN CAUSED BY EXPOSURE TO THE PLAN COLOMBIA SPRAY MIXTURE.

Deaths. The test plaintiffs variously allege that numerous types of farm animals were killed following alleged exposure to the Plan Colombia spray mixture. The plaintiffs have presented no expert testimony to substantiate these claims, nor could they. There is absolutely no scientific evidence that an aerial or drift application of Plan Colombia spray mixture could have killed any the plaintiffs' livestock.

Toxicity studies – which are conducted as a matter of course in various animal species – have identified acutely toxic concentrations of the Plan Colombia spray mixture, and these levels are many orders of magnitude higher than what could reasonably be encountered by the test plaintiffs' livestock – whether it be through dermal exposure, inhalation exposure, dietary and drinking water exposure, or a combination thereof. For example, rats exposed to a 5,000 mg/kg dermal application of the Plan Colombia mixture were largely unharmed (Solomon et al. 2005; Springborn 2003d). Rats fed the mixture at doses up to 5,000 mg/kg were not killed and often exhibited no effects whatsoever (Solomon et al. 2005; Springborn 2003g). Consequently, the acute oral and dermal LD50 values (i.e., doses shown to be lethal for 50% of the test population) for the Plan Colombia spray mixture have been determined to be more than 5000 mg/kg (Solomon et al. 2005; Springborn 2003d, 2003g).

While most of the animal toxicity studies of glyphosate-based herbicides – like the studies of the Plan Colombia herbicide mixture – have been conducted on laboratory animals (e.g., rats), there have been as well a number of toxicity studies of glyphosate and Roundup conducted on various other animals, and each of these studies have confirmed that glyphosate-based herbicides do not pose unpredictable or unexpected risk to the lives of such animals. For example, beagle dogs fed doses of glyphosate up to 500 mg/kg bw/day for one year showed no ill effects (Williams et al. 2000). Cows (Brahama-cross heifers) force-fed Roundup through a nasogastric tube for seven days experienced no adverse effect whatsoever at doses as high as 400 mg/kg bw, and no deaths were seen until the cows were force fed a dose of 790 mg/kg bw, the equivalent of a 1/3 pound brick of glyphosate salt (WHO 1994). A number of oral toxicity studies in goats reported LD50 doses for glyphosate and Roundup ranging from 3,500 mg/kg bw to 5,700 mg/kg bw (WHO 1994). Broiler chickens fed a diet of glyphosate for 21 consecutive days following the day of their hatching in doses up to 6080 mg/kg bw (i.e., doses "rarely . . . encountered except in accidental exposures") exhibited no observable effects, aside from a reduction in body weight at the highest dose (Kubena et al. 1981), likely attributable to loss of nutrients from the feed replaced by glyphosate. Oral toxicity studies in mallard ducks reported LD50's of 4,640 mg/kg bw and 5,620 mg/kg bw for glyphosate and Roundup, respectively, and a separate long term study found no effects whatsoever in ducks exposed to 1,000 mg/kg bw for a period of six months. In sum, the toxicity database from studies conducted in these alternate species confirms the traditional database established by the guidance studies conducted with glyphosate-based herbicides.

Even accidental poisonings of domestic and farm animals with glyphosate formulations rarely cause any serious adverse health effects. Burgat et al. (1998) reviewed data from hundreds of calls to animal poison centers in France concerning accidental glyphosate exposures/poisonings in dogs, cats, cattle, horses, and sheep. The most common symptoms following accidental exposures (i.e., via direct ingestion of glyphosate or its formulation) were near-immediate vomiting, increased salivation, mild diarrhea, and similar symptoms. No animal deaths were recorded, and no chronic toxicity was reported. Interestingly, the study found that some exposures were completely asymptomatic; in fact, "[i]n 6 cases the ingestion of significant amounts of commercial preparations did not produce clinical signs," which "confirm[ed] the low toxicity of glyphosate under field conditions." Guitart et al. (2010) reviewed animal poisoning data collected from the literature and other sources in Belgium, France, Greece, Italy and Spain, and noted that "[a]mongst herbicides, only chlorate is regularly reported" as a cause of animal poisonings.

These findings mirror my own experience investigating domestic animal/livestock illnesses and deaths. I have never received a complaint about an accidental exposure or toxicity from glyphosate-based herbicides. However, I have personally reviewed claims of chlorate pesticide poisoning in cattle, for instance. I have investigated (and in doing so refuted) multiple claims of equine illness and death following methomyl pesticide drift (Krieger et al. 1998). On another occasion I took part in an investigation where a rancher initially accused a neighboring farmer of poisoning his dairy cows, but after thorough review we determined that the cattle actually died from eating hay from the farmer's own field that contained toxic levels of nitrate.

Most supposed pesticide poisoning cases can be ruled out by a detailed history, a thorough analysis of the pesticide use at issue, and accounting for other common/background diseases (such as the foot and mouth disease epidemic in Ecuador, as discussed in Lindholm et al. (2007)) or natural toxins.[17]

In sum, the scientific evidence provides no basis for any opinion that exposure to the Plan Colombia spray mixture could cause the death of the test plaintiffs' livestock as alleged, and this is true regardless of whether the animal(s) allegedly died the day of, the day following, or in the days and months after the alleged exposure to the Plan Colombia herbicide.

Birth defects and miscarriages. To the extent some of the plaintiffs – such as the Calero family[18] – allege that exposure to the Plan Colombia spray mixture caused birth defects or miscarriages in their livestock, there is no scientific basis for this claim. Reproductive and developmental toxicity studies conducted in animals utilizing repeated, high-dose exposures have shown that glyphosate does not produce these types of effects (Williams et al. 2000; Bradberry et al. 2004).

CONCLUSION

The potential toxicity of the Plan Colombia herbicide mixture and each of its components (glyphosate, POEA, and Cosmo-Flux) have been studied, and there is no scientific evidence to support the allegation that the aerial or drift application of the herbicide could cause animal injuries or any of the health effects alleged by the plaintiffs. Under certain conditions and at certain doses, glyphosate-based herbicides have been associated with minor and transient health effects, like eye and skin irritation, but the plaintiffs here do not provide any evidence of the doses at which they or their animals were allegedly exposed to Plan Colombia herbicide, let alone evidence that these alleged exposures could or did rise to the levels necessary to cause such injuries. There accordingly is no scientific basis to opine that the alleged exposures to Plan Colombia herbicide caused or – as Dr. Wolfson instead opines – are "consistent with" any of the alleged personal injuries in this case.

Dated: January 19, 2011

Bob Krieger

Robert I. Krieger

CR Note: Dr. Krieger's CV (Exhibit A), found in CD - Original Annexes

[17] Natural toxins are a common cause of livestock poisonings. I once investigated suspected poisonings in cattle, and determined that a toxic strain of blue-green algae had contaminated the farmer's water supply to such an extent that some cattle entering the pond to drink were incapacitated within minutes of entering the water.

[18] According to Mr. Santos Calero, cows that survived initial exposure to the Plan Colombia spray events are alleged to have given birth to deformed calves (Dep. 58). His wife, Ms. Calixta Pineda, also testified that deformed calves were born and that other of their cows had miscarriages (Dep. 78, 81-82, 89).

Exhibit B
(Materials Considered)

Publications

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13) Hewitt, A.J., K.R. Solomon and E.J.P. Marshall. 2009. Spray Droplet Size, Drift Potential, and Risks to Nontarget Organisms from Aerially Applied Glyphosate for Coca Control in Colombia. Journal of Toxicology and Environmental Health, Part A. 72(15):921-929.

14) Immunopharmos a. Cruz, O.S. 2002. Glifosato 5% + Cosmoflux 1% + Agua 94%, (unpublished Toxicological Study Report, Colombia: Inmunopharmos LTDA).

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49) Williams, G.M., R. Kroes and I.C. Munro. 2000. Safety evaluation and risk assessment of the herbicide Roundup and its active ingredient, glyphosate, for humans. Regulatory Toxicology and Pharmacology. 31(2: Part 1):117-165.

Other Materials Considered

1) Expert Report submitted on behalf of Plaintiffs by Dr. Michael Wolfson, December 17, 2010

2) Deposition testimony:

   a. Test Plaintiff depositions

   b. Excerpts of DynCorp Employee Dave Crago Deposition Transcript, December 9, 2009

   c. Excerpts of DynCorp Employee Devin Ranck Deposition Transcript, March 3, 2010

   d. Excerpts of DynCorp Employee Julian Medina Deposition Transcript, April 27, 2010

3) Binders for each Test Plaintiff family, provided by defense counsel, including:

   a. A table with citations to claims of physical injuries and animal injuries in certain evidentiary submissions of the test plaintiffs (initial disclosures, questionnaire responses, declaration of Marco Campana, deposition testimony excerpts, Accion Ecologica toxicology sheet and survey)

   b. the following information for each test plaintiff (if applicable to the test plaintiff and/or family):

      i. initial disclosure

      ii. questionnaire responses

      iii. excerpt from the Marco Campana declaration specific to each plaintiff

      iv. all deposition testimony excerpts re alleged animal injuries, personal injuries/illnesses, and related issues

      v. other test plaintiff-specific information relating to their alleged physical injuries (e.g., medical records, photographs and/or video, excerpts from prior lawsuits, prior certifications, Accion Ecologica toxicology sheet and survey)

      vi. excerpts of certain non-governmental organization and other third party reports that mention the test plaintiffs or the areas in which they live with respect to diseases or public health conditions

vii. a map showing the approximate location of the test plaintiffs' farm and spray lines (if any) for the dates of spray exposure alleged by any of the family members in their depositions

4) DynCorp Incident Reports:

a. DEDP- 00105966

b. DEMP-00144555 – 58

c. DEDP-00105992 – 94

d. DEMP-00037503 - 04

e. DEMP-00087983 – 85

f. DEMP-00149056 – 58

5) U.S. Department of State materials:

a. U.S. Department of State Memorandum of Justification. 2002. Aerial Eradication of Illicit Coca in Colombia.

b. U.S. EPA 2003. 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.

c. U.S. EPA 2004. 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.

Annex 16

Expert Report of Dr G.M. Williams, M.D. on Behalf of the Defendants in *Arias/Quinteros v. Dyncorp*, 18 January 2011

(United States District Court for the District of Columbia,
Cases No. 1:01-cv01908 (RWR-DAR) and 1:07-cv01042 (RWR-DAR).
Cases consolidated for Case Management and Discovery)

EXHIBIT 14

EXPERT REPORT OF GARY M. WILLIAMS ON BEHALF OF THE DEFENDANTS IN *ARIAS/QUINTEROS V. DYNCORP*

I. Credentials and Expert Disclosures

A. Relevant Expertise

I am presently Professor of Pathology and Professor of Clinical Public Health at New York Medical College, Valhalla, NY. I have been affiliated with the College since 1975. My curriculum vitae, which includes a list of my publications over the past 40+ years, is attached as Exhibit A.

I have published 513 papers or chapters, most dealing with chemical toxicology, genetic toxicology or carcinogenesis.

I have served on the editorial boards of Cell Biology and Toxicology (Founding Editor), Chemico-Biological Interactions, Drug and Chemical Toxicology (Area Editor for Carcinogenesis), European Journal of Cancer Prevention, Fundamental and Applied Toxicology, In Vitro, Mutation Research, Nutrition and Cancer, Toxicologic Pathology (Associate Editor), Toxicology and Applied Pharmacology and I currently serve on the editorial boards of Archives of Toxicology, and Food and Chemical Toxicology (Associate Editor). I have also frequently served as an expert advisor on carcinogenicity and toxicology issues for the U.S. Environmental Protection Agency, the National Institutes of Health, the International Agency for Research and Cancer, and the World Health Organization, among others.

I have received the following awards: Sheard-Sandford Award, American Society of Clinical Pathologists and Alpha Omega Alpha, University of Pittsburgh School of Medicine, 1967; Research Training Fellowship, International Agency for Research on Cancer, 1971; Arnold J. Lehman Award, Society of Toxicology, 1982; Ambassador in Toxicology Award, Mid-Atlantic Chapter of the Society of Toxicology, 2001; Enhancement of Animal Welfare Award, Society of Toxicology, 2002; Distinguished Scientist Award, Westchester Chemical Society, American Chemical Society, New York Section, Inc., 2005; New York Medical College Dean's Distinguished Research Award, 2006; Merit Award, Society of Toxicology, 2009.

B. Compensation and Prior Expert Work

I am being compensated for my work in this matter at the rate of $500 per hour.

I have not provided expert testimony in any other matter during the past four years.

C. Materials Relied Upon.

The materials upon which I have relied in preparing this expert report are cited herein and are included in the attached Exhibit B.

II. Summary of Expert Opinions

I have been asked to review the December 17, 2010 expert report issued by Dr. Michael Wolfson on behalf of plaintiffs in this action and respond to his opinion that "glyphosate and glyphosate-based herbicides have been recognized in the peer-reviewed literature as likely causative agents in the development of several cancers" and that the alleged "exposure of plaintiffs, as a result of the aerial spraying, very likely places them at significant risk for the development of cancers in the future." As set forth in detail below, the available scientific evidence does not support Dr. Wolfson's opinion.

III. Detailed Discussion of Expert Opinion

In 2000, I co-authored a comprehensive review of the toxicology data available on glyphosate and Roundup®, the commercial herbicide containing glyphosate commonly formulated with a surfactant predominantly polyethoxylated tallow amine (POEA) (Williams et al., 2000). Incidentally, Dr. Wolfson does not refer to this widely cited review. That review found that the chronic toxicity and oncogenic potential of glyphosate have been evaluated in one study with mice (Knezevich, 1983) and two studies with rats (Lankas, 1981; Stout and Ruecker, 1980). Few chronic effects occurred, and those were limited to the highest dietary levels tested (20,000 ppm in rats or 30,000 ppm in mice). Glyphosate was not oncogenic to either species.

Genotoxicity is considered to be an indicator of potential carcinogenicity, particularly in humans (Williams, 1987). The extensive genotoxicity data base on glyphosate and formulations in a wide variety of *in vitro* and *in vivo* assays was reviewed by Williams et al. (2000). No genotoxic activity of glyphosate was observed in standard assays conducted according to international guidelines. These assays include the *S. typhimurium* (Ames assay) and *E. coli* WP-2 reversion assays, recombination (rec-assay) with *Bacillus subtilis*, Chinese hamster ovary cell gene mutation assay, hepatocyte primary culture/DNA repair assay, and *in vivo* mouse bone marrow micronucleus and rat bone marrow cytogenetics assays. Some investigators have reported evidence of genotoxic effects mainly chromosome aberrations, of formulations in a limited number of studies. These assays however, used toxic dose levels, and/or deficient testing methodology, and/or endpoints/test systems not relevant to potential carcinogenicity and were not confirmed by other investigators.

The review by Williams et al. (2000) affirmed the earlier assessments by the US Environmental Protection Agency (US EPA, 1993, 1998) and the World Health

Organization (WHO, 1994) that glyphosate is not mutagenic or carcinogenic. The US EPA has repeatedly reaffirmed its conclusion that glyphosate is not mutagenic or carcinogenic during the past decade (US EPA, 2002, 2004, 2006, 2008). In a December 3, 2008 Final Rule on glyphosate tolerances for certain plant commodities and all animal commodities published in the Federal Register, EPA stated: "There is an extensive database available on glyphosate, which indicate that glyphosate is not mutagenic, not a carcinogen, and not a developmental or reproductive toxicant." (US EPA, 2008).

Dr. Wolfson's expert report lists in references, without comment, several toxicological studies (Marc et al., 2002, 2004; Richard et al., 2005 and Raipulis et al., 2009). Richard et al. (2005) did not address carcinogenicity but instead investigated potential impacts of glyphosate on aromatase activity in placental cells as a potential indication of potential effects on estrogen synthesis. Richard et al. (2005) noted, moreover, that "[t]he physiologic significant of these effects can be questioned, in regard to the concentration used." The other papers identified by Dr. Wolfson involved studies of glyphosate in nonstandard systems such as sea urchins (Marc et al., 2002, 2004) and *Daphnia magna* (Raipulis et al., 2009). Marc et al. (2002) noted that the "concentration of Roundup that provokes cell cycle disruption [in his sea urchin model] appears to largely exceed the recommended usage concentration as an herbicide." Marc et al. (2004) stated of their findings, "they do not establish a direct link with the development of cancer."

Raipulis et al. (2009) reported positive results for Roundup in a single experiment using the *Escherichia coli* SOS chromatest, which indicates induction of the bacterial SOS DNA repair system. The authors conclude that their results "suggest that glyphosate, especially, Roundup, possesses both toxic and genotoxic properties." However, the single experiment is inadequately described to evaluate. Importantly, there is no mention of controls, negative or positive, or the use of an exogenous bioactivation system, implying that none was used. The finding of an effect in the absence of an activation system would indicate that a component of the formulation was directly reactive, which is not supported by abundant previous reports reviewed by Williams et al. (2000). In view of the clear negative responses in relevant, well-validated assays conducted under accepted conditions, I do not consider that the single experiment of Raipulis et al. (2009) alters the conclusion of Williams et al. (2000) that glyphosate and its formulations are not genotoxic. This conclusion is supported by the more recent evaluation of Solomon et al. (2009). Accordingly, no carcinogenic potential of glyphosate or Roundup® has been identified in genotoxicity tests, consistent with the negative carcinogenicity studies.

Two studies have reported on biomonitoring of genetic alterations in circulating white blood cells of individuals potentially exposed to glyphosate (Paz-y-Miño et al., 2007; Bolognesi et al., 2009). The small study of Paz-y-Miño et al. (2007) examined a group of allegedly exposed individuals, compared to unexposed individuals, from an area close to the border between Ecuador and Colombia. They reported a genotoxic effect in the allegedly exposed individuals, but methodological deficiencies, including lack of precise information on intervals between exposure and sampling in the study groups and inadequate measurement procedures, preclude any reliable scientific conclusion, and the reported genetic differences were in any event too small to be of any biological significance. A much larger study by Bolognesi et al. (2009) examined groups in Colombia before and after exposure. These authors concluded that the genotoxic risk of exposure is low.

The Bolognesi study had the potential to confirm the Paz-y-Miño report, but did not. I agree with the conclusion of the Bolognesi study and moreover conclude that neither report presents findings indicative of a cancer hazard.

IV. Conclusions

The available scientific literature identified in the reference list to the Expert Witness Report for Plaintiffs, December 17, 2010 by Michael A. Wolfson, MD, MPH and discussed herein, do not provide a scientifically reliable basis to opine that exposure to glyphosate or glyphosate-based herbicides would give rise to a "significant increased risk for the development of cancers in the future." To the contrary, the available evidence attests to the noncarcinogencity of glyphosate and glyphosate-based herbicides.

Dated: Jan. 18, 2011

G. Williams

Gary M. Williams, M.D.

CR Note: Dr. Williams' CV (Exhibit A), found in CD - Original Annexes

Exhibit B

Dr. Gary Williams Expert Report

Materials Considered

Exhibit B

Gary M. Williams Expert Report

Publications

1) Bolognesi, C., G. Carrasquilla, S. Volpi, K.R. Solomon, E.J.P. Marshall. 2009. Biomonitoring of Genotoxic Risk in Agricultural Workers from Five Colombian Regions: Association to Occupational Exposure to Glyphosate. J. Toxicol. Environ. Health A. 72(15):986-87.
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6) Paz-y-Miño, C., M. Eugenia Sanchez, M. Arevalo, M. Jose Munoz, T. Witte, G. Oleas De-la-Carrera, P.E. Leone. 2007. Evaluation of DNA damage in an Ecuadorian population exposed to glyphosate. Genet Mol Biolog. 30(2):456-460.
7) Raipulis, J., MM Toma, and M. Balode. 2009. Toxicity and genotoxicity testing of Roundup. Proceedings of the Latvian Academy of Sciences, Section B. 63(1/2):29-32.
8) Richard, S., S. Moslomi, et al. 2005. Differential effects of glyphosate and Roundup on human placental cells and aromatase. Environ Health Perspect. 113:716-720.
9) Solomon, K.R., E.J.P. Marshall, G. Carrasquilla. 2009. Human Health and Environmental Risks from the Use of Glyphosate Formulations to Control the Production of Coca in Colombia: Overview and Conclusions. Journal of Toxicology and Environmental Health, Part A. 72:914-920.
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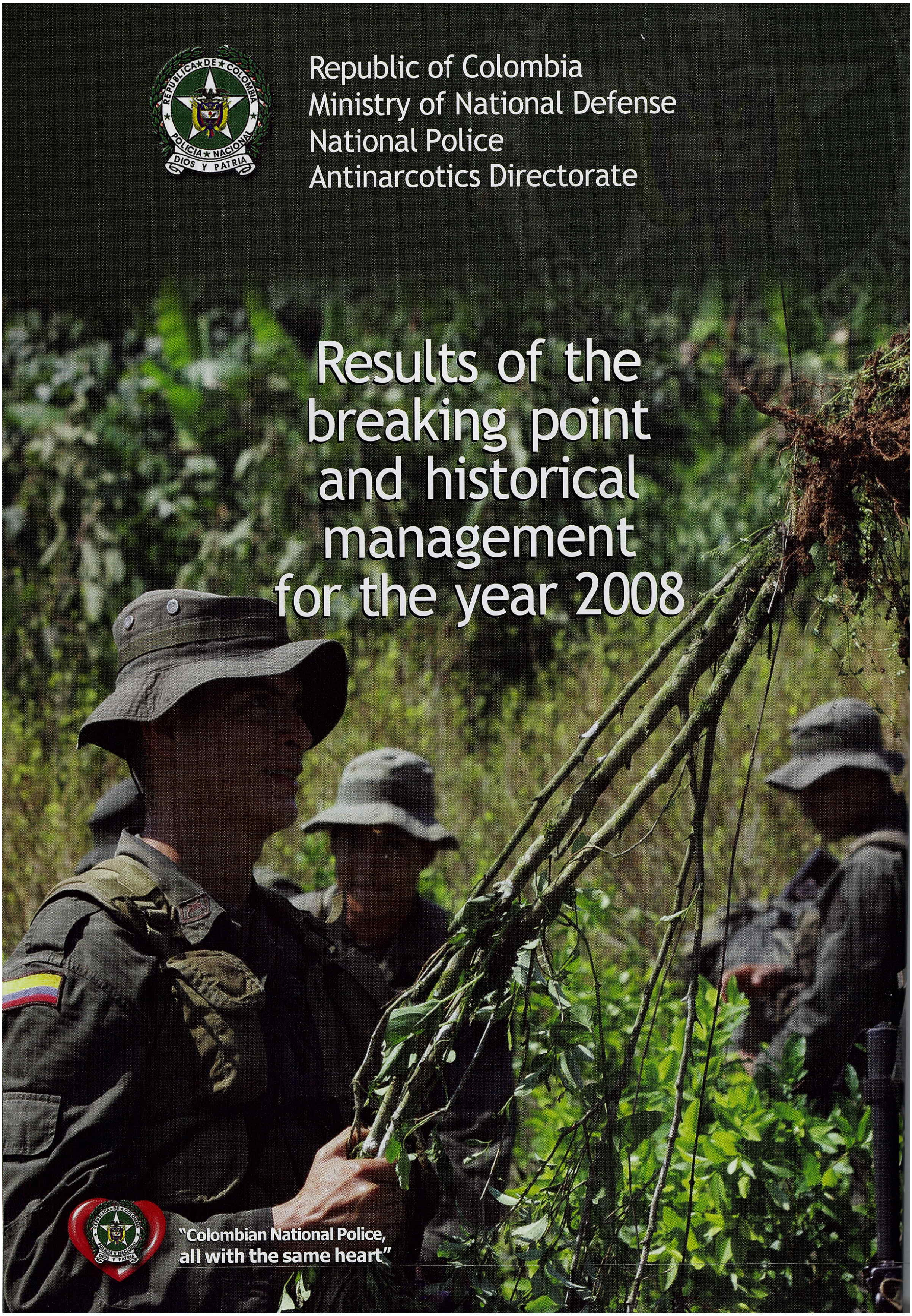
Annex 17

Testimony of a Police Officer victim of a land mine, Annual Report by the Anti-Narcotics Directorate of the Colombian National Police (DIRAN), "*Results of the Breaking Point and Historical Management in the Fight Against Drug Trafficking for the year 2008*"

(Ministry of National Defense, National Police Antinarcotics Directorate, 2008, p.48)

Republic of Colombia
Ministry of National Defense
National Police
Antinarcotics Directorate

Results of the breaking point and historical management for the year 2008



"Colombian National Police,
all with the same heart"

Cost of the fight

The cost of the fight against the drug trafficking mafias is not only in terms of money or of material goods, many police officers have offered their lives with the motto of freeing the world from the flagella of drugs. The institution has lost 85 of its best men, both in operational activities and in intelligence activities, as well as in their duty, without forgetting the 157 injured, mainly in combat with the enemy in cultivation eradication tasks and in the defense of facilities.

790
POLICE OFFICERS DEATH: (2000-2008)

157
POLICE OFFICERS INJURED (2000-2008)

358
AIRPLANES AND HELICOPTERS SHOT DOWN

29
AIRPLANES AND HELICOPTERS IMPACTED

In testimony of the courage and devotion of police officers' work in the fight against drug trafficking, we present at the experience lived by Patrol Officer Herber Fabian Gutierrez Sotomonte, lost his limbs in cultivations manual eradication duties.

«Some partners have given their lives , I gave part of my body for ending with drugs»

Herber Fabian Gutierrez Sotomonte is a Patrol Officer from the National Police, who at the age of 22, full of life and of dreams, he lost his left leg and his fertility due to one of these devices. This is one more case of intolerance and violence, but most of all it is an example of self-improvement.

Sotomonte, belonged to the Antinarcotics Directorate (DIRAN) of the National Police and he was accomplishing manual eradication duties at Caucasia, department of Antioquia. Eight days before completing the third stage of eradication, he was sent to cover the top part of the place where cultivations were, when he was arriving to that place a terrible roar sent him away from reality, «no one knew what had happened, one feels lost because the roar is so strong, and I looked everywhere but I couldn't see my legs, when I looked at myself, and realized that one of my legs was missing, and the other leg was completely destroyed, because I almost lose it as well, the doctors saved my life».

The despair, rage, the pain and the uncertainty over to this group of police officers who only wanted to save his partner's life. After a long time, they were able to transfer him in a helicopter to a hospital of Caucasia, with other three police officers who were also injured. After remaining eight days in the intensive care unit at the hospital of Monteria where he was sent, the physicians were able to stabilize him and save one of his legs. Later he was transferred to Bogotá. «The impression I had is that I had lost half of my body and I mentally said farewell to my family, my mom and my siblings, says Fabian.

And differently from what many were afraid of, patrol officer Sotomonte was aware of what had happened to him, and he thought this would not impede him going on with his life, this indeed would change his life completely, but it would not defeat him, «Everybody told me that», we came to cheer you up, but you are cheering up us», says Fabian, smiling.

The support of his family, his friends and of the Anti-Narcotics Directorate, as well as the optimism and the strength of our company at this police officer day and night in his rehabilitation. At the end of December, he was honored by the Anti-Narcotics Directorate as the Police Officer of the Year for his Courage and Self-improvement.

Today he is waiting for his prosthesis, the only thing that really hurts him is not being able to continue with his police career, because he was very devoted to it, and he used to dream about working with the GAULA or the DIJIN.

Now, four months after the accident he continues with his dreams as he has a life ahead of him for making them come true. Currently, he is studying English and soon he will begin a professional career.

Annex 18

Anti-Narcotics Directorate of the Colombian National Police (DIRAN), Eradication of Illicit Crops Division, Analysis of Certain Spraying Operational Aspects
October 2011:

I. Analysis of time records
II. Verification of wind conditions (beeper)
III. Spraying mission cancellation due to weather
IV. Spraying data and witness statements confronted

MINISTRY OF NATIONAL DEFENSE
NATIONAL POLICE
[Seal]
ANTINARCOTICS DIRECTION

No. S-2011 – 019814 / ARECI – GUVGA-22

Bogota D.C. 10 October 2011

Sirs
MINISTRY OF FOREIGN AFFAIRS
Affairs before the International Court of Justice Group
Calle 10 No. 5-51 Oficina LM 301

Reference: Submission of information

I am submitting in hard copy and digital file the report in which some aspects of the execution of the Programme for the Eradication of Illicit Crops by Aerial Spraying with Glyphosate are analyzed. The report includes, among others, the following information:

1. Spraying missions time of day
2. Space – time analysis of witness statements produced in the Memorial of Ecuador v. spraying events recorded in DEL NORTE System.
3. Verification of wind conditions (through Beeper)
4. Record of non-spraying days due to bad weather conditions.

Sincerely,

Colonel EDUARDO CARDENAS VELEZ

Chief Illicit Crops Eradication Division

Enclosure: As announced

Prepared by: Ofc. Manuel Sanchez Pinzon
Drafted and revised by: Mj. Miguel Tunjano Villaraga
Date of preparation: 10 October 2011
File: D\Respaldo_gruve_01\Oficios

COLOMBIAN NATIONAL POLICE

Anti-Narcotics Direction

Eradication of Illicit Crops Division

ANALYSIS OF CERTAIN SPRAYING OPERATIONAL ASPECTS

Bogotá, October 2011

TABLE OF CONTENTS

I. ANALYSIS OF TIME RECORDS

No aerial spraying operations for the eradication of illicit crops in the Nariño or Putumayo provinces have been conducted during night time. The records documenting night times referred to by Ecuador and obtained from the SATLOC and DelNorte softwares do not reflect the actual spraying time, but are rather the result of a discrepancy caused when the pilots manually set the offset of the system's clocks.

Given that the default software time is GMT + 0:00 (Greenwich Meridian Time) and local time in Colombia is GMT minus 5 hours (– 5:00), pilots would have to key in "– 5" (minus five) on the DelNorte software's offset in order for it to record the local time at which the spraying actually took place.

However, some pilots key in "5" as offset, which the software records as GMT + 5:00 causing a 10-hour time-lag with regard to the real local time of spraying. Other pilots do not make any such adjustment, and therefore the software remains at GMT + 0:00, causing a time-lag of 5 hours with regard to local time.

These differences of 10 or 5 hours plus, between the software time and Colombian local time are evidenced on the spraying records. For instance, in the case of a 10-hour time-lag, spray events conducted at 13:00 local time, were recorded by the software as if they had been conducted at 23:00; if the time-lag was 5 hours, spray events were recorded as conducted at 18:00. That is the reason why the DelNorte software recorded numerous spray events as if they had taken place at night, when they were actually conducted in broad daylight.

It should be noted that there is a format that allows for corroboration of the times at which each spraying mission was carried out. On this hand-written format, called **Pilot's Spray Data Sheet** (*Figure 1)*, pilots are required to fill out the local start time of the spraying mission (takeoff). When returning to base, the pilots deliver the Pilot's Spray Data Sheet duly filled out to the Mission Planner, along with the SATLOC or DelNorte Software card that contains the data with the records of the spray events.

The Mission Planner transcribes all the data relevant to the mission on an Excel spreadsheet called **Daily Flight Summary –DFS**- (*Figure 2*), based on the Software Card, except for the start (takeoff, TO) time and duration. This is due to the fact that SATLOC or DelNorte softwares only record the start and duration of each of the tens of spray events[1] comprised within a single spraying mission. Therefore, the start (takeoff, TO) time and duration of the spraying mission itself, as a whole, are taken from the **Pilot's Spray Data Sheet.**

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[1] Spray event is understood as each instance in which the pilot presses and releases the button (trigger) for releasing the spray mix.

In sum, whenever pilots correctly adjusted local time (GMT - 5:00), the records in the SATLOC or DelNorte softwares will be within the range of the time recorded on the DFS. Otherwise, a time-lag of plus 5 or 10 hours between the DFS and the Software Card will appear. Therefore, to determine the actual time of spraying it is necessary to refer to the one recorded on the DFS.

Figure 1. (Pilot's Spray Data Sheet)

Pilot's Spray Data Sheet Card Number_______________

Date__________. Pilot ______________________ A/C__________.

Cal Code________________. **Rate**________________________.

Mission #__________Mission Area________________________

Take Off __________. Land __________. Total Time ____________

Gal. Loaded _________ Gal. Remain _________Gal Sprayed_______

From Cockpit Display: Sec .__________ Ha. _________Gal._______

Wind Direction______. Wind Speed____. Cloud Cond.__________.

Coca: Good_________. Fair__________. Sparse_______________.

Coca under trees?____. Coordinates____________________________.

Mixed with other crops?___. What Crops?______________________.

Avg. Field size_______. Nursery?__________. Labs?_____________.

Better suited to other Tactic? ________. Which?________________.

Del Norte Problems?____.

Additional
Comments:____

____

R&A Download: Sec__________**Hectares**_________**Gal.**_________

R&A: Calibration________**Log File Name**____________________

Version 5.1---13 Feb 07 14:30

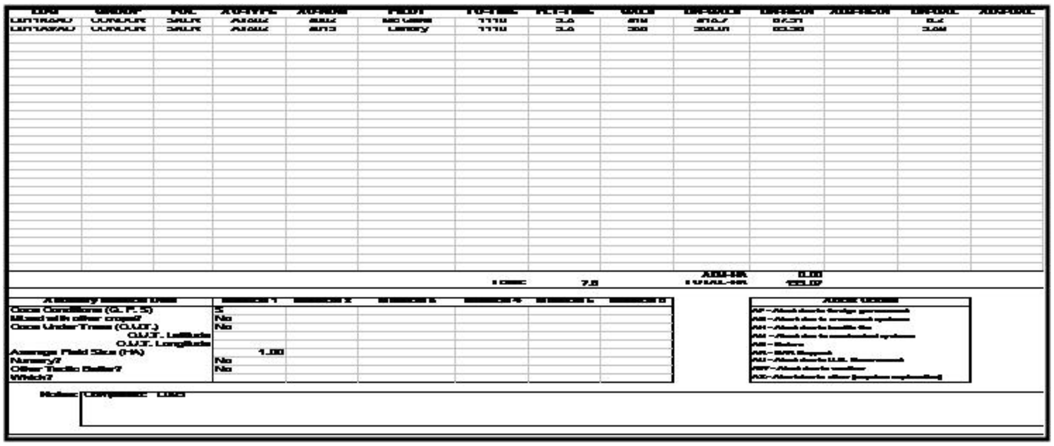


Figure 2. DFS. (Daily Flight Summary)

Records of the DelNorte software for spraying operations

The DelNorte software records the following data for each of the spray event:

FID:	A field maintained by ArcGIS that guarantees a unique ID for each row in the table.
SHAPE:	File format.
SEG:	Event number generated by DelNorte software.
FILE NAME:	Binary Log filename.
MISSION:	Job number.
SIDE:	Right or Left flight patterns.
LINE:	Target line within a job area being flown.
START TIME:	Start time of spray event.
LATITUDE:	World Geographic Coordinate System, expressed in decimal degrees.
LONGITUDE:	World Geographic Coordinate System, expressed in decimal degrees.
ALTITUDE:	Altitude over mean sea level, MSL, of the spray event.
DOP:	(Dilution of precision), term used in global positioning satellites (GPS) to specify GPS precision.
FLT TIME:	Length of time of spray event in seconds.
FLT LENGTH:	Spray event length calculated in metres.
OTE:	Deviation from planned flight path measured in meters, off track error (same as XTRACK).
SPEED GPS:	Ground speed calculated in miles per hour.
VOLUME:	Chemical application rate in gallons per hectare
AREA:	Calculated area for each spray event in hectares.
LENGTH:	Spray event length calculated in metres.
MONTH:	Month of spray event.
SWATH:	Half of the effective swath width in feet (used to buffer the lines in ArcGIS).
AIRCRAFT:	Describes the aircraft type.
A_C_CROP:	Describes the aircraft type and target crop.
GROUP:	Assigned names given to groups or squadrons.

The foregoing explanation will now be demonstrated by analysing cases in which the software recorded different times for the 3 or 4 aircraft taking part in a single spraying mission:

1. Spray Mission with three aircraft departing from Tumaco Spraying Base, on 17 February 2003:

MISSION CODE	ACTUAL TIME DFS RECORDS	DELNORTE SOFTWARE RECORDED TIME	TIME-LAG	DURATION OF THE SPRAY MISSION
B17325AC	11:55	17:18	05:23	01:00
B17300CAC	11:55	12:18	00:23	01:00
B17311QAC	11:55	22:18	10:23	01:00

Line Code:
Each mission is assigned a code as follows: **A011LWAC**
A: Indicates the month in which the spraying mission took place:
A → JANUARY
B → FEBRUARY
C → MARCH
D → APRIL
…L → DECEMBER
01: Day on which the spraying mission took place
1: Year in which the spraying mission took place (last digit of the year is taken)
L: Code assigned to each aircraft (alphanumeric)
W: Code assigned to each pilot (alphanumeric)
A: Number of each spray mission of the day
A: First mission.
B: Second mission.
C: Third mission.
D: Fourth mission.

C: Type of crop to be sprayed (C=coca)

In this particular case, mission code B17325AC stands for:

B = February
17 = day
3 = last digit of the year, i.e., 2003.
2 = aircraft code
5 = pilot code
A = number of mission of the day
C = coca crops

From the chart above, it may be seen that it refers to a mission carried out on 17 February 2003 on coca crops, in which 3 aircraft identified with codes 2, 0, 1 took part. Rows 1 and 3 show the time-lag in the start time, as follows:

- Row 1 corresponds to the aircraft with code **2**. It may be seen that the time recorded by DelNorte software was 17:18, while the time recorded on the DFS (Daily Flight Summary) was 11:55, evidencing a time-lag of plus 5 hours and 23 minutes of the aircraft's flight to spray area and preparation for spraying.

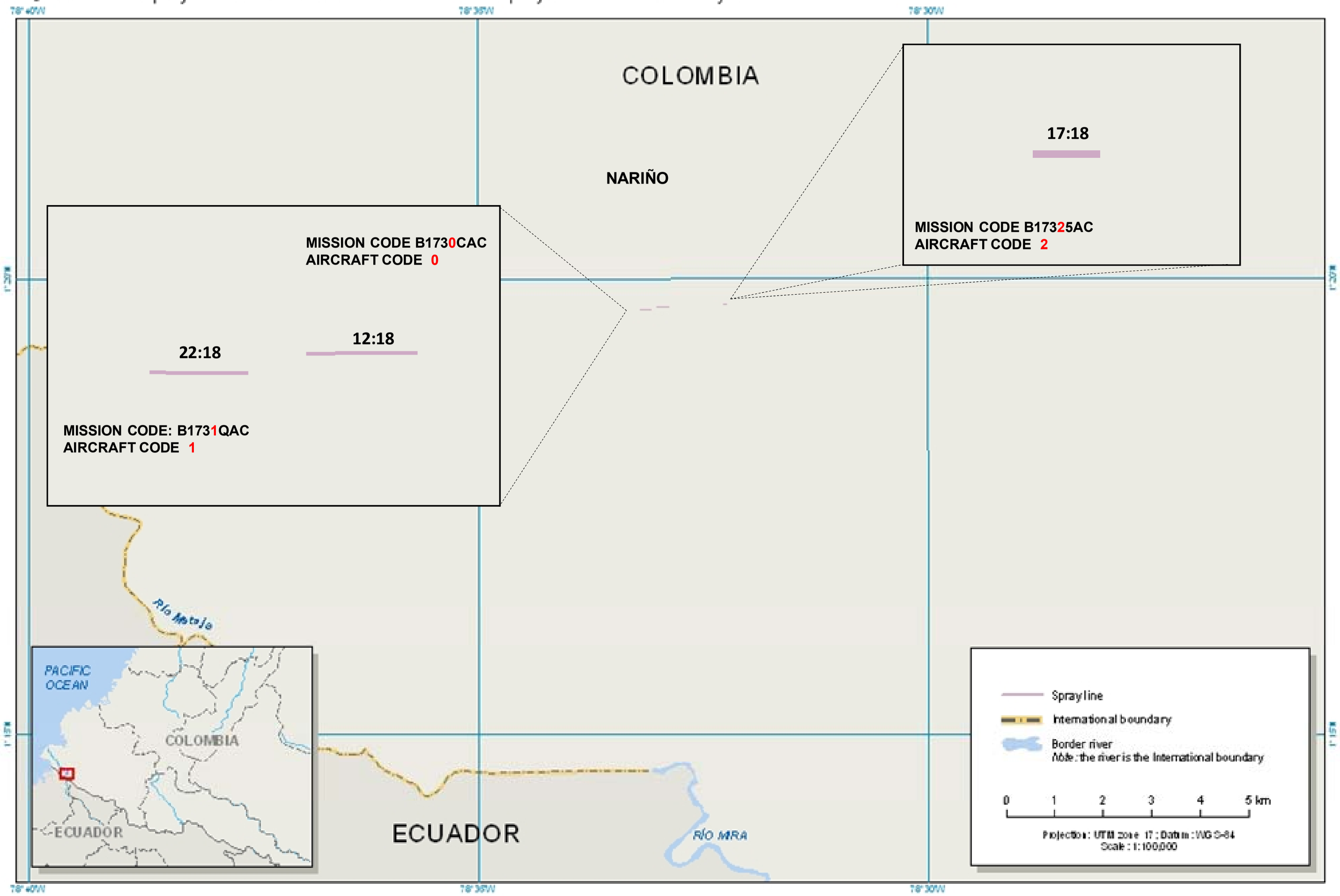
- Row 2 corresponds to the aircraft with code **0**. It may be seen that the time recorded by DelNorte software was 12:18, and that on the DFS was 11:55, thus showing that the pilot set the offset correctly (GMT – 5:00), and therefore there was no time-lag, and the only difference is that of the minutes corresponding to the aircraft's flight to spray area and preparation for spraying.

- Row 3 corresponds to the aircraft with code **1**. It may be seen that the time recorded by DelNorte was 22:18, while the time recorded on the DFS was 11:55, evidencing a time-lag of plus 10 hours, and the 23 minutes of the aircraft's flight to spray area and preparation for spraying.

Additionally, it is worth recalling that the flight range of spray aircraft and escort helicopters is approximately 4 hours and, therefore, it would be impossible for planes departing from the base at the same time, to remain in flight for 9 or 14 hours as the DelNorte software records would allow to infer, when the time-lag of 5 or 10 hours is present.

This all shows that no spraying operations take place after sunrise, and thus none were conducted at night, but rather the situation is that the times recorded by DelNorte software often appear as such due to a discrepancy caused by the offset of the system's clocks set by the pilots. The example explained above is a clear evidence of this. In Row 3, the DelNorte software recorded a spray event at 22:18, when it actually took place at 12:18 as is borne out of Row 2 (where the offset was correct) and is consistent with the time recorded on the DFS.

Figure 3. One Spray Mission with 3 Aircraft from Tumaco Spray Base on 17 February 2003



1/2

One Spray Mission with 3 Aircraft from Tumaco Spray Base on February 17, 2003

FID	SEG	FILE_NAME	MISSION	SIDE	LINE	START_TIME	LATITUDE	LONGITUDE	ALTITUDE	DOP	FLT_TIME	FLT_LENGTH	OTE	SPEED	VOLUME	AREA	LOG	LENGTH	MONTH	SWATH	AIRCRAFT	CROP	A_C_CROP
6181	1	B17325AC.B99	99-1	Right	11	17:18:00:17	1.32864219	-78.53715917	478	0,89	0,96	242,6	1,5	172,30	2,50	0,947	B17325AC	73,93	0302	85	AT802	Coca	AT802_Coca
6302	122	B1731QAC.B99	99-1	Right	13	22:18:23:30	1.32771289	-78.55131592	541	0,89	3	724,8	4,5	164,70	2,40	2,829	B1731QAC	221,30	0302	85	AT802	Coca	AT802_Coca
6388	209	B1730CAC.B99	99-1	Right	12	12:18:17:30	1.32810729	-78.54791271	504	0,89	3,4	818,5	23,20	164,10	2,40	3,194	B1730CAC	249,94	0302	85	AT802	Coca	AT802_Coca

DELNORTE System Record .

DAILY FLIGHT SUMMARY - TUMACO
AT-802

Date: 2/17/2003

LOG Name	TO	AC#	PILOT	FLT	MSN	GALS	DN	DN	ADJ	ADJ	DN	PLOT	RATING	REASONS	COORDS	DEPT
	TIME			TIME		Sprayed	GALS	Hect.	Hect.	CAL	CAL					
B17325AC	1155	4003	MILLER	1.0	E	510	510.05	81.71			6.24	09901			N01°19.72 W78°33.18	NARINO
B1730CAC	1155	4005	COKER	1.0	E	527	527.37	89.19			5.91	09901			N01°19.61 W78°39.86	NARINO
B1731QAC	1155	4004	MCPHERSON	1.0	E	342	341.22	56.40			6.05	09901			N01°19.66 W78°33.08	NARINO
															Mission Terminated	
															Due to:	
															Lobo Mechanical Problem	
							SubTotal	227.30	0.00							
							Total HA	227.30								

DFS Record.

2. Spray Mission with four aircraft departing from Tumaco Spray Base, on 13 May 2003:

MISSION CODE	ACTUAL TIME DFS RECORDS	DELNORTE SOFTWARE RECORDED TIME	TIME-LAG	DURATION OF THE SPRAY MISSION
E1334RAC	09:15	19:34	10:19	00:48
E1330QAC	09:15	09:34	00:19	00:48
E1331CAC	09:15	19:34	10:19	00:48
E1332PAC	09:15	14:34	05:19	00:48

From the chart above, it may be seen that it refers to a mission carried out on 13 May 2003 on coca crops, in which 4 aircraft identified with codes 4, 0, 1 and 2 took part. Rows 1, 3 and 4 show the time-lag in the start time, as follows:

- Row 1 corresponds to the aircraft with code **4**. It may be seen that the time recorded by DelNorte software was 19:34, while the time recorded on the DFS was 09:15, evidencing a time-lag of 10 hours, and the 19 minutes of the aircraft's flight to spray area and preparation for spraying.

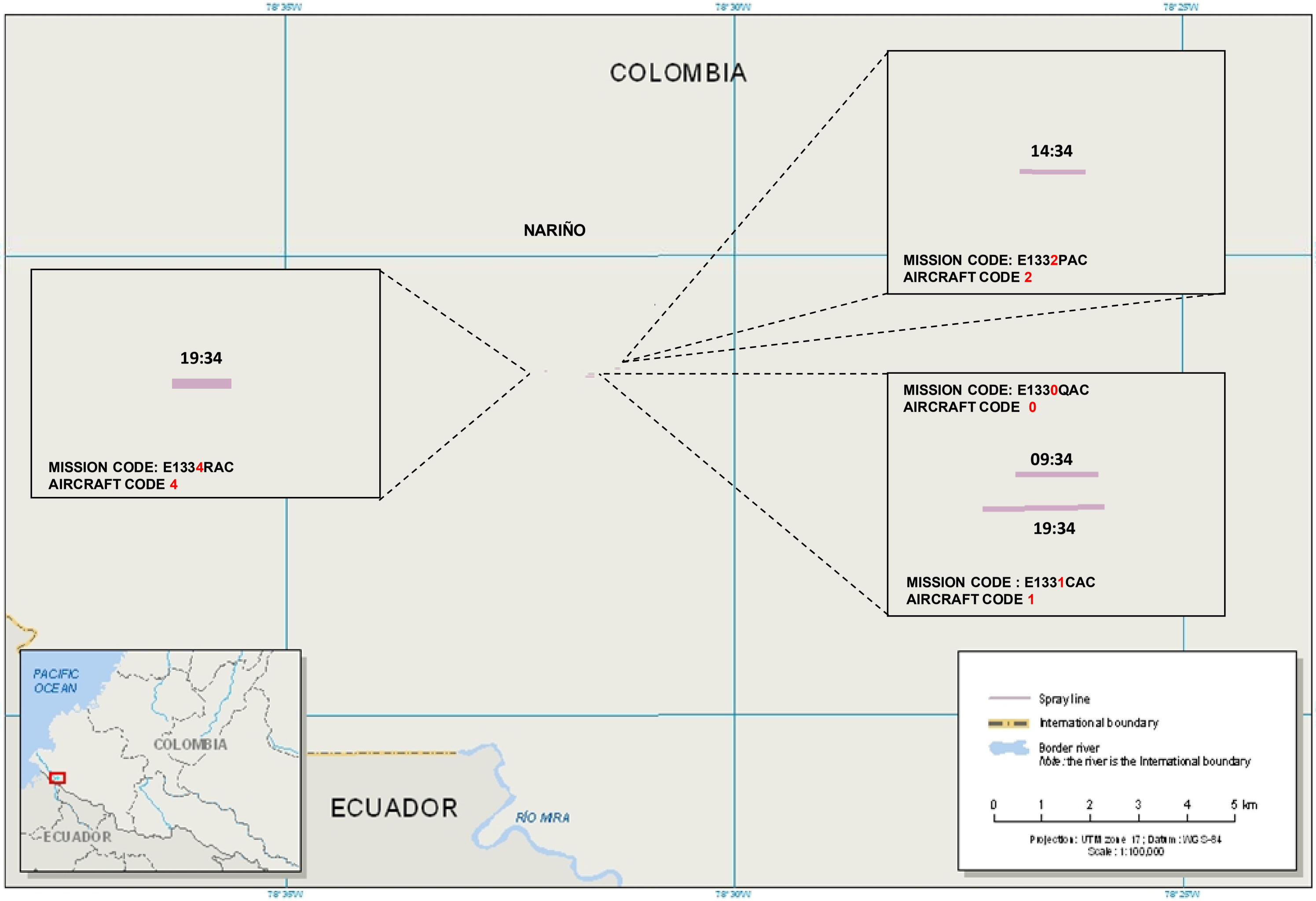
- Row 2 corresponds to the aircraft with code **0**. It may be seen that the time recorded by DelNorte software was 09:34, and that on the DFS was 09:15, thus showing that the pilot set the offset correctly (GMT – 5:00), and therefore there was no time-lag, and the only difference is that of the minutes corresponding to the aircraft's flight to spray area and preparation for spraying.

- Row 3 corresponds to the aircraft with code **1**. It may be seen that the time recorded by DelNorte was 19:34, while the time recorded on the DFS was 09:15, evidencing a time-lag of 10 hours, and the 19 minutes of the aircraft's flight to spray area and preparation for spraying.

- Row 4 corresponds to the aircraft with code **2**. It may be seen that the time recorded by DelNorte was 14:34, while the time recorded on the DFS was 09:15, evidencing a time-lag of 5 hours, and the 19 minutes of the aircraft's flight to spray area and preparation for spraying.

Consequently, it may be seen that on the time recorded by the DelNorte software for the aircraft shown in Row 2 the offset was set correctly by the pilot and is thus consistent with the time recorded on the DFS.

Figure 4. One Spray Mission with 4 Aircraft from Tumaco Spray Base on 13 May 2003



1/2

11

One Spray Mission with 4 Aircraft from Tumaco Spray Base on May 13, 2003

FID	SEG	FILE_NAME	MISSION	SIDE	LINE	START_TIME	LATITUDE	LONGITUDE	ALTITUDE	DOP	FLT_TIME	FLT_LENGTH	OTE	SPEED	VOLUME	AREA	LOG	LENGTH	MONTH	SWATH	AIRCRAFT	CROP	A_C_CROP
3516	358	E1331CAC.B99	99-1	Right	48	19:34:47:50	1.31135201	-78.52588468	538	0,770	2,3	643,2	11,000	190,700	2,500	2,510	E1331CAC	196,518	0305	85	AT802	Coca	AT802_Coca
3728	618	E1332PAC.B99	99-1	Right	45	14:34:32:67	1.31270997	-78.52119190	592	0,770	1,27	338,5	1,600	181,700	2,800	1,321	E1332PAC	103,721	0305	85	AT802	Coca	AT802_Coca
4011	945	E1334RAC.B99	99-1	Right	46	19:34:54:00	1.31224453	-78.53466683	553	0,770	0,6	162	0,300	184,100	2,400	0,632	E1334RAC	49,479	0305	85	AT802	Coca	AT802_Coca
4226	1163	E1330QAC.B99	99-1	Right	47	9:34:46:50	1.31179339	-78.52596305	555	0,770	1,6	440,5	6,300	187,700	2,800	1,719	E1330QAC	134,548	0305	85	AT802	Coca	AT802_Coca

DELNORTE System Record .

DAILY FLIGHT SUMMARY - TUMACO

AT-802

Date: **13/05/2003**

LOG Name	TO TIME	AC#	PILOT	FLT TIME	MSN	GALS Sprayed	DN GALS	DN Hect.	ADJ Hect.	ADJ CAL	DN CAL	PLOT	RATING	REASONS	COORDS	DEPT
E1331CAC	0915	4004		0,8	E	456	456,3	73,02			6,25	09901			N 01° 18.68' - W 78° 37.70'	NARINO
E1331CBC	1035	4004		1,1	E	458	457,54	73,35			6,24	09901			N 01° 17.39' - W 78° 31.13'	NARINO
E1331CCC	1240	4004		1,8	E	440	440,1	71,20			6,18	09901/09001			N 01° 37.27' - W 78° 04.21'	NARINO
E1332PAC	0915	4003		0,8	E	500	480,54	79,04			6,08	09901			N 01° 18.14' - W 78° 31.80'	NARINO
E1332PBC	1035	4003		1,1	E	500	487,72	79,40			6,14	09901			N 01° 17.02' - W 78° 33.81'	NARINO
E1332PCC	1240	4003		1,8	E	500	477,77	78,46			6,09	09901/09001			N 01° 16.04' - W 78° 31.44'	NARINO
E1334RAC	0915	4006		0,8	E	379	378,76	60,72			6,24	09901			N 01° 18.73' - W 78° 32.08'	NARINO
E1334RBC	1035	4006		1,1	E	446	445,76	72,40			6,16	09901			N 01° 17.56' - W 78° 35.22'	NARINO
E1334RCC	1240	4006		1,8	E	500	485,4	78,46			6,19	09901/09001			N 01° 37.33' - W 78° 07.48'	NARINO
E1330QAC	0915	4005		0,8	E	448	448,16	72,31			6,20	09901			N 01° 18.71' - W 78° 32.70'	NARINO
E1330QBC	1035	4005		1,1	E	459	459,06	74,35			6,17	09901			N 01° 17.41' - W 78° 31.36'	NARINO
E1330QCC	1240	4005		1,8	E	423	423,10	69,42			6,09	09901/09001			N 01° 16.10' - W 78° 32.62'	NARINO
															Mission Terminated	
							SubTotal	882,13	0,00						**Due to:**	
															Duty Day	
							Total HA	882,13								

DFS Record.

2/2

3. Spray Mission with five aircraft departing from Tumaco Spray Base, on 16 March 2004:

MISSION CODE	ACTUAL TIME DFS RECORDS	DELNORTE SOFTWARE RECORDED TIME	TIME-LAG	DURATION OF THE SPRAY MISSION
C16445AC	12:05	23:16	11:11	01:48
C1640RAC	12:05	13:17	01:12	01:48
C1646CAC	12:05	23:17	11:12	01:48
C1642~AC	12:05	13:17	01:12	01:48
C1641QAC	12:05	13:17	01:12	01:48

From the chart above, it may be seen that it refers to a mission carried out on 16 March 2004 on coca crops, in which 5 aircraft identified with codes 4, 0, 6, 2 and 1 took part. Rows 1 and 3 show the time-lag in the start time, as follows:

- Row 1 corresponds to the aircraft with code **4**. It may be seen that the time recorded by DelNorte software was 23:16, while that on the DFS was 12:05, evidencing a time-lag of plus 10 hours, and the 1 hour and 11 minutes of the aircraft's flight to spray area and preparation for spraying.

- Row 2 corresponds to the aircraft with code **0**. It may be seen that the time recorded by DelNorte software was 13:17, and that on the DFS was 12:05, thus showing that the pilot set the offset correctly (GMT – 5:00), and therefore there was no time-lag, but only the difference due to the aircraft's flight to spray area and preparation for spraying (1 hour and 12 minutes).

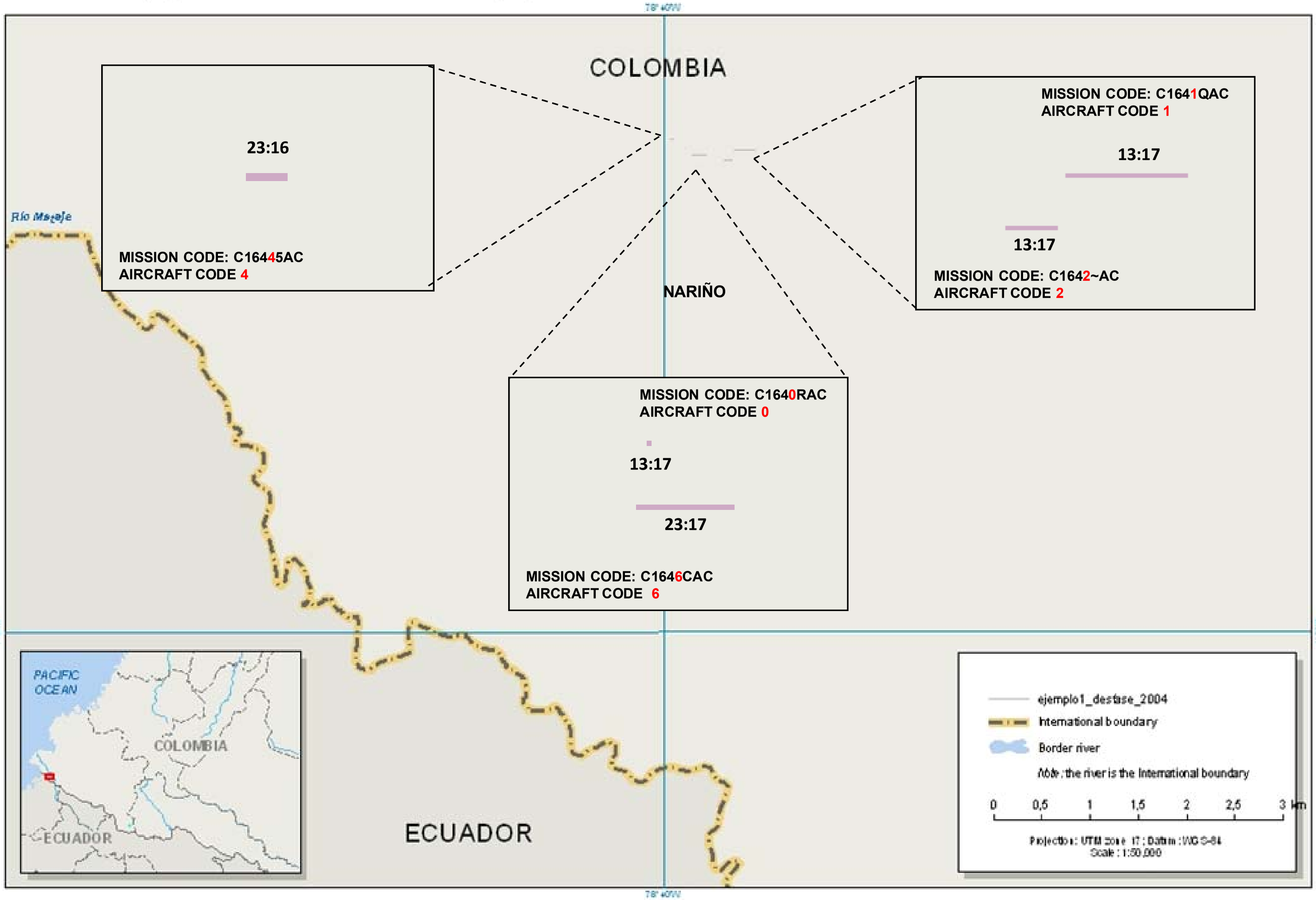
- Row 3 corresponds to the aircraft with code **6**. It may be seen that the time recorded by DelNorte was 23:17, while that on the DFS was 12:05, evidencing a time-lag of plus 10 hours, and the 1 hour and 12 minutes of the aircraft's flight to spray area and preparation for spraying.

- Row 4 corresponds to the aircraft with code **2**. It may be seen that the time recorded by DelNorte was 13:17, and that on the DFS was 12:05, thus showing that the pilot set the offset correctly (GMT – 5:00), and therefore there was no time-lag, but only the difference due to the aircraft's flight to spray area and preparation for spraying (1 hour and 12 minutes).

- Row 5 corresponds to the aircraft with code **1**. It may be seen that the time recorded by DelNorte was 13:17, and that on the DFS was 12:05, thus showing that the pilot set the offset correctly (GMT – 5:00), and therefore there was no time-lag, but only the difference due to the aircraft's flight to spray area and preparation for spraying (1 hour and 12 minutes).

Consequently, it may be seen that on the time recorded by the DelNorte software for the aircraft shown in Rows 2, 4 and 5, the offset was set correctly by the pilot and is thus consistent with the time recorded on the DFS.

Figure 5. One Spray Mission with 5 Aircraft from Tumaco Spray Base on 16 March 2004



1/2

One Spray Mission with 5 Aircraft from Tumaco Spray Base on March 16, 2004

FID	SEG	FILE_NAME	MISSION	SIDE	LINE	START_TIME	LATITUDE	LONGITUDE	ALTITUDE	DOP	FLT_TIME	FLT_LENGTH	OTE	SPEED	VOLUME	AREA	LENGTH	MONTH	SWATH	AIRCRAFT	AC_CROP	CROP
8823	1	C1646CAC.B99	93-5	Right	4	23:17:07:10	1.37658455	-78.66398084	120	0,630	1,8	145,5	2,700	180,900	1,600	0,754	145,86	0403	85	AT802	AT802_Coca	Coca
8862	56	C1641QAC.B99	93-5	Right	3	13:17:06:60	1.37704456	-78.66012840	121	0,630	2,9	223,2	0,800	172,200	1,600	1,156	223,763	0403	85	AT802	AT802_Coca	Coca
8915	133	C1642~AC.B99	93-5	Right	5	13:17:15:46	1.37608107	-78.66111002	125	0,630	1,25	95,5	1,800	170,900	1,700	0,495	95,465	0403	85	AT802	AT802_Coca	Coca
8947	182	C16445AC.B99	93-5	- - -	1	23:16:55:78	1.37796741	-78.66609509	122	0,630	0,64	49,9	0,600	174,600	1,700	0,259	49,944	0403	85	AT802	AT802_Coca	Coca
8997	251	C1640RAC.B99	93-5	Right	2	13:17:00:30	1.37756115	-78.66384276	119	0,630	0,1	7,8	7,100	175,400	1,700	0,041	7,848	0403	85	AT802	AT802_Coca	Coca

DELNORTE System Record .

DAILY FLIGHT SUMMARY - TUMACO

AT-802

Date: 3/16/2004

LOG Name	TO	AC#	PILOT	FLT	MSN	GALS	DN	DN	ADJ	ADJ	DN	PLOT	REASONS	COORDS	DEPT
	TIME			TIME		Sprayed	GALS	Hect.	Hect.	CAL	CAL				
C1642~AC	1205	4003	LINEBERGER	1.8	E	293	292.92	47.09			6.22	09305		N 01° 22.28' - W 78° 38.56'	NARINO
C1646CAC	1205	4002	COKER	1.8	E	279	278.62	44.94			6.20	09305		N 01° 22.47' - W 78° 31.59'	NARINO
C16445AC	1205	4006	MILLER	1.8	E	259	258.44	41.01			6.30	09305		N 01° 22.69' - W 78° 34.58'	NARINO
C1640RAC	1205	4005	ISAAC	1.8	E	268	267.65	41.60			6.43	09305		N 01° 22.38' - W 78° 33.21'	NARINO
C1641QAC	1205	4004	McPHERSON	1.8	E	228	227.56	37.10			6.13	09305		N 01° 22.49' - W 78° 32.64'	NARINO
							Adj Ha	0.00	0.00						
							Total HA	211.74							

DFS Record.

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4. Spray Mission with three aircraft departing from Larandia Spray Base, on 11 June 2004:

MISSION CODE	ACTUAL TIME DFS RECORDS	DELNORTE SOFTWARE RECORDED TIME	TIME-LAG	DURATION OF THE SPRAY MISSION
F114**U**HBC	11:48	22:04	11:28	00:54
F114**W**4BC	11:50	12:04	00:14	01:12
F114**I**SBC	11:45	12:04	00:19	01:18

From the chart above, it may be seen that it refers to a mission carried out on 11 June 2004 on coca crops, in which 3 aircraft identified with codes U, W, I took part. Row 1 shows the time-lag in the start time, as follows:

- Row 1 corresponds to the aircraft with code **U**. It may be seen that the time recorded by DelNorte software was 22:04, while that on the DFS was 11:48, evidencing a time-lag of plus 10 hours, and 16 minutes of the aircraft's flight to spray area and preparation for spraying.

- Row 2 corresponds to the aircraft with code **W**. It may be seen that the time recorded by DelNorte software was 12:04, and that on the DFS was 11:50, thus showing that the pilot set the offset correctly (GMT – 5:00), and therefore there was no time-lag, and the only difference is that of the 14 minutes of the aircraft's flight to spray area and preparation for spraying.

- Row 3 corresponds to the aircraft with code **I**. It may be seen that the time recorded by DelNorte was 12:04, and that on the DFS was 11:45, thus showing that the pilot set the offset correctly (GMT – 5:00), and therefore there was no time-lag, and the only difference is that of the 19 minutes of the aircraft's flight to spray area and preparation for spraying.

Consequently, it may be seen that on the time recorded by the DelNorte software for the aircraft shown in Rows 2 and 3, the offset was set correctly by the pilot and is thus consistent with the time recorded on the DFS.

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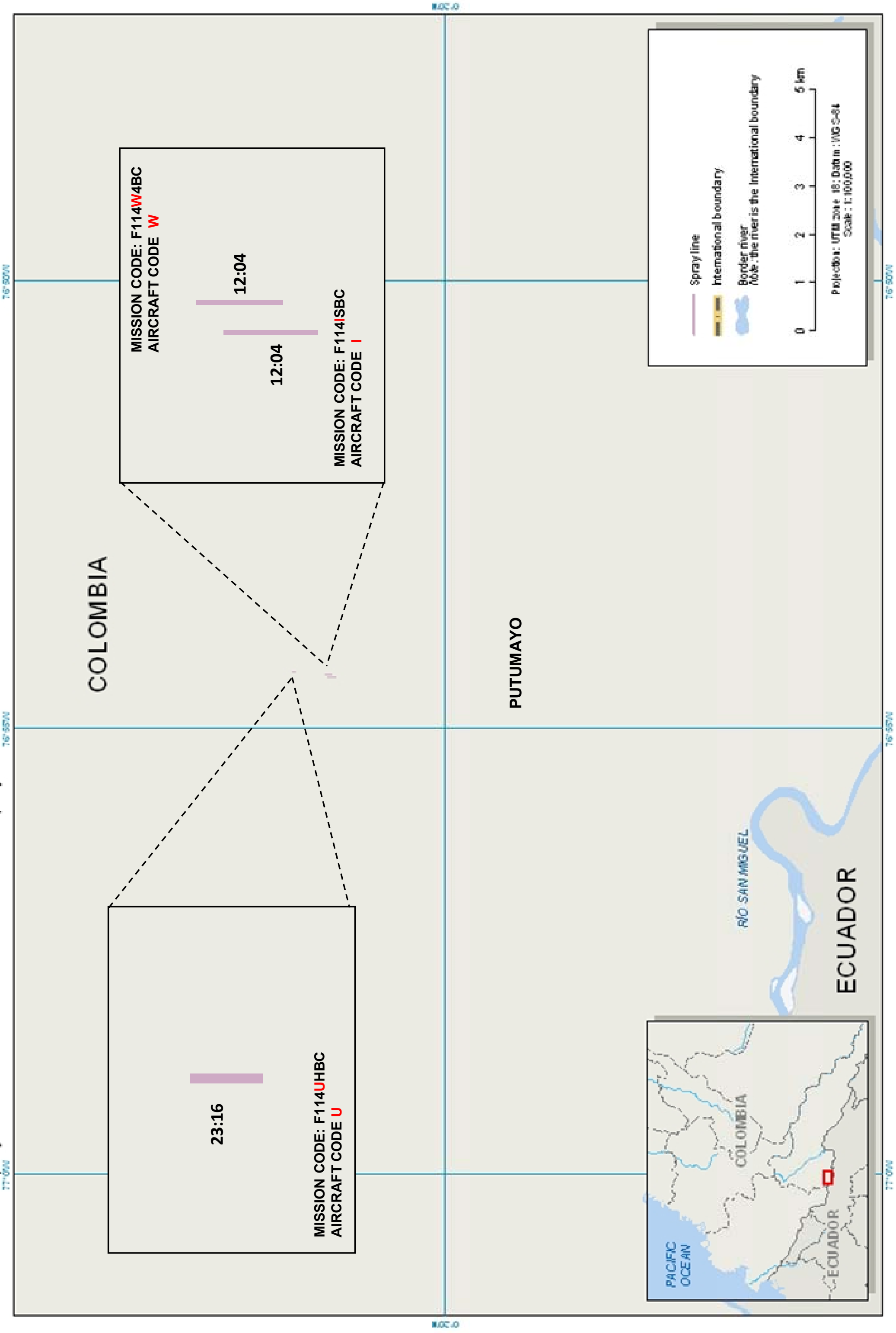
Figure 6. One Spray Mission with 3 Aircraft from Larandia Spray Base on 11 June 2004



1/2

One Spray Mission with 3 Aircraft from Larandia Spray Base on 11 June 2004

18

FID	SEG	FILE_NAME	MISSION	SIDE	LINE	START_TIME	LATITUDE	LONGITUDE	ALTITUDE	DOP	FLT_TIME	FLT_LENGTH	OTE	SPEED	VOLUME	AREA	LENGTH	MONTH	SWATH	AIRCRAFT	AC_CROP	CROP
1055	492	F114ISBC.B99	289-4	Right	57	12:04:30:60	0.35464654	-76.90725773	1145	0,630	1,9	593,9	5,100	213,100	2,700	2,318	181,138	0406	85	OV-10	OV-10_Coca	Coca
1075	885	F114UHBC.B99	289-4	Right	59	22:04:24:80	0.36101815	-76.90632151	1159	0,630	0,8	247,2	2,500	210,700	2,500	0,965	75,317	0406	85	OV-10	OV-10_Coca	Coca
1115	1119	F114W4BC.B99	289-4	Right	58	12:04:30:90	0.35513290	-76.90677118	1148	0,630	1,8	552,7	2,700	209,400	2,600	2,157	168,558	0406	85	OV-10	OV-10_Coca	Coca

DELNORTE System Record .

OV-10 Daily Flight Summary

6/11/2004

LOG Name	TO TIME	AC#	PILOT	FLT TIME	MSN	GALS Sprayed	DN GALS	DN Hect.	ADJ Hect.	ADJ CAL	DN CAL	PLOT	RATING	REASONS	COORDS	DEPT
F114TAAC	0935	3041	MARTINEZ	1.7	E	246	245.68	41.20			5.96	27602			N00°39.08 W77°02.30	PUTUMAYO/NARINO
F114UHAC	0935	3050	THIGPEN	1.6	E	242	242.25	40.07			6.05	27602			N00°38.92 W77°02.80	PUTUMAYO/NARINO
F114UHBC	1148	3050	THIGPEN	0.9	E	242	242.27	39.43			6.14	28904			N00°22.72 W76°54.21	PUTUMAYO
F114UHCC	1340	3050	THIGPEN	1.1	E	242	241.79	40.48			5.97	29004			N00°29.94 W76°48.43	PUTUMAYO
F114W4AC	0935	3040	HENAO	1.6	E	167	167.15	27.23			6.14	27602			N00°30.25 W77°02.62	PUTUMAYO/NARINO
F114W4BC	1150	3040	HENAO	1.2	E	238	237.54	36.33			6.54	28904			N00°22.88 W76°54.24	PUTUMAYO
F114W4CC	1335	3040	HENAO	1.1	E	103	102.55	18.85			5.44	29004			N00°24.19 W76°48.28	PUTUMAYO
F114R{AC	0935	3043	ROCA	1.7	E	172	171.52	27.52			6.23	27602			N00°38.88 W77°02.78	PUTUMAYO/NARINO
F114R{BC	1335	3043	ROCA	1.3	E	145	144.99	24.37			5.95	29004			N00°27.56 W76°48.31	PUTUMAYO
F114ISAC	0930	3046	STAMM	1.7	E	238	237.57	38.89			6.11	27602			N00°37.27 W77°02.83	PUTUMAYO/NARINO
F114ISBC	1145	3046	STAMM	1.3	E	236	235.74	33.21			7.10	28904			N00°28.76 W76°54.27	PUTUMAYO
F114ISCC	1330	3046	STAMM	1.3	E	28	34.09		4.53	6.18		29004		@_1	N00°19.88 W76°46.36	PUTUMAYO

TOT FLIGHT TIME: 16.5

@_1 Spray system malfunctioned - mission aborted

Total Ha	367.58	4.53	Adjusted Ha
Total Ha with Adjusted	372.11		

Mission Terminated Due To:

Weather

DFS Record.

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5. Spray Mission with six aircraft departing from Tumaco Spray Base, on 20 January 2005:

MISSION CODE	ACTUAL TIME DFS RECORDS	DELNORTE SOFTWARE RECORDED TIME	TIME-LAG	DURATION OF THE SPRAY MISSION
A205**B**YAC	08:45	09:03	00:18	00:48
A205**P**&AC	08:45	09:03	00:18	00:48
A205**M**VAC	08:45	19:03	10:18	00:54
A205**L**%AC	08:45	19:03	10:18	00:54
A205**N**TAC	08:45	19:03	10:18	00:54
A205**K**6AC	08:45	19:03	10:18	00:54

From the chart above, it may be seen that it refers to a mission carried out on 20 January 2005 on coca crops, in which 6 aircraft identified with codes B, P, M, L, N and K took part. Rows 3, 4, 5 and 6 show the time-lag in the start time, as follows:

- Row 1 corresponds to the aircraft with code **B**. It may be seen that the time recorded by DelNorte software was 09:03, and that on the DFS was 08:45, thus showing that the pilot set the offset correctly (GMT – 5:00), and therefore there was no time-lag, but only the difference in the 18 minutes of the aircraft's flight to spray area and preparation for spraying.

- Row 2 corresponds to the aircraft with code **P**. It may be seen that the time recorded by DelNorte software was 09:03, and that on the DFS was 08:45, thus showing that the pilot set the offset correctly (GMT – 5:00), and therefore there was no time-lag, but only the difference in the 18 minutes of the aircraft's flight to spray area and preparation for spraying.

- Row 3 corresponds to the aircraft with code **M**. It may be seen that the time recorded by DelNorte was 19:03, while that on the DFS was 08:45, evidencing a time-lag of plus 10 hours, and 18 minutes of the aircraft's flight to spray area and preparation for spraying.

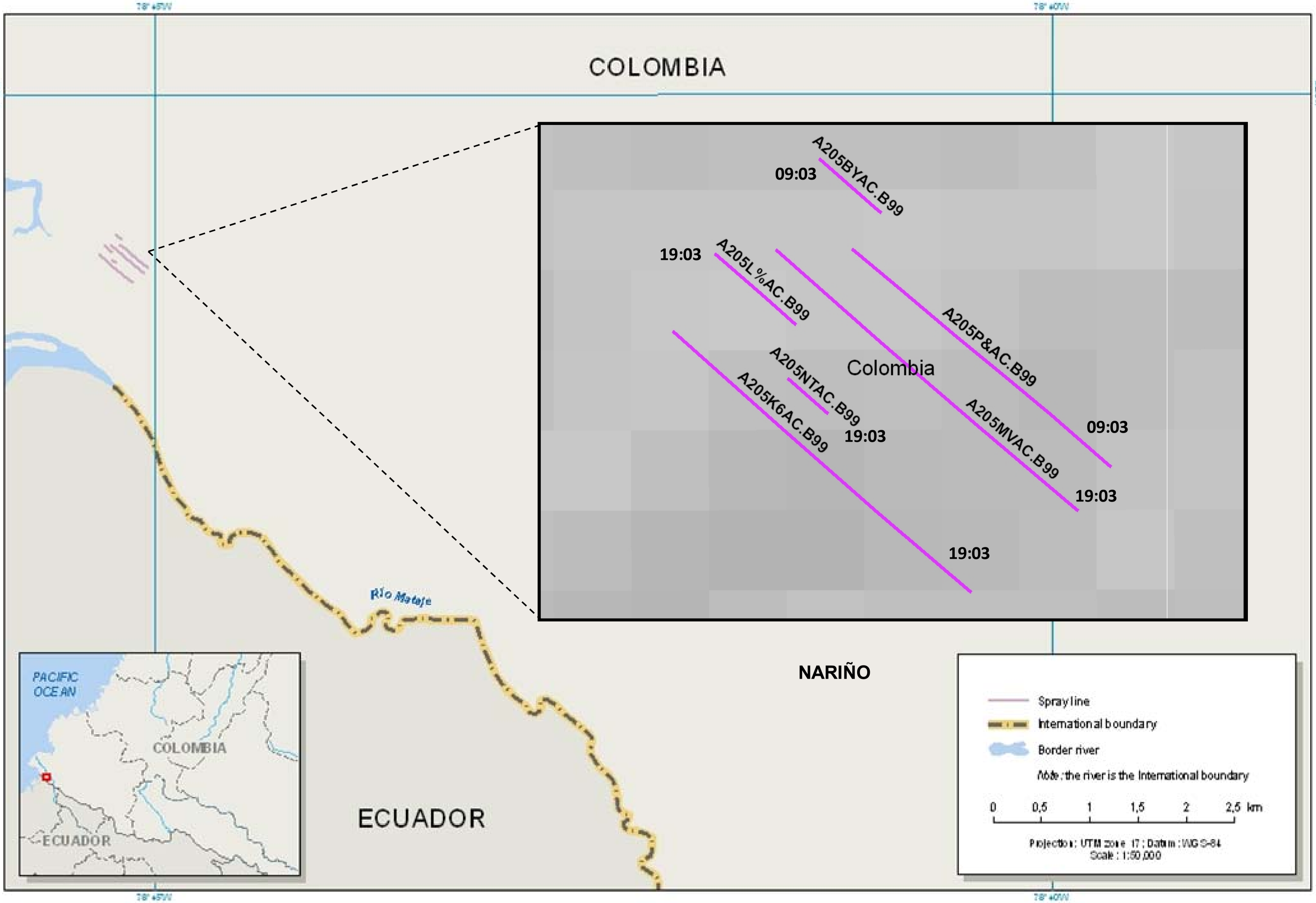
- Row 4 corresponds to the aircraft with code **L**. It may be seen that the time recorded by DelNorte was 19:03, while that on the DFS was 08:45, evidencing a time-lag of plus 10 hours, and 18 minutes of the aircraft's flight to spray area and preparation for spraying.

- Row 5 corresponds to the aircraft with code **N**. It may be seen that the time recorded by DelNorte was 19:03, while that on the DFS was 08:45, evidencing a time-lag of plus 10 hours, and 18 minutes of the aircraft's flight to spray area and preparation for spraying.

- Row 6 corresponds to the aircraft with code **K**. It may be seen that the time recorded by DelNorte was 19:03, while that on the DFS was 08:45, evidencing a time-lag of plus 10 hours, and 18 minutes of the aircraft's flight to spray area and preparation for spraying.

Consequently, it may be seen that on the time recorded by the DelNorte software for the aircraft shown in Rows 1 and 2, the offset was set correctly by the pilot and is thus consistent with the time recorded on the DFS.

Figure 7. One Spray Mission with 6 Aircraft from Tumaco Spray Base on 20 January 2005



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One Spray Mission with 6 Aircraft from Tumaco Spray Base on 20 January 2005

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FID	SEG	FILE_NAME	MISSION	SIDE	LINE	START_TIME	LATITUDE	LONGITUDE	ALTITUDE	DOP	FLT_TIME	FLT_LENGTH	OTE	SPEED	VOLUME	AREA	LENGTH	MONTH	SWATH	AIRCRAFT	AC_CROP	CROP
9817	3019	A205BYAC.B99	92-2	Right	6	9:03:40:14	1.40420773	-78.75368565	61	1,100	1,29	97	2,000	168,200	1,600	0,502	97,061	0501	85	AT802	AT802_Coca	Coca
10049	3356	A205K6AC.B99	92-2	- - -	1	19:03:35:30	1.40242792	-78.75523807	78	1,100	5,94	462	2,700	174,000	1,600	2,394	462,74	0501	85	AT802	AT802_Coca	Coca
10200	3588	A205L%AC.B99	92-2	Right	3	19:03:37:64	1.40322521	-78.75478909	81	1,100	1,7	126,1	4,900	165,900	1,700	0,654	126,185	0501	85	AT802	AT802_Coca	Coca
10399	3896	A205MVAC.B99	92-2	Right	4	19:03:38:73	1.40326986	-78.75414600	81	1,100	6,22	465,4	7,400	167,400	1,700	2,412	466,647	0501	85	AT802	AT802_Coca	Coca
10544	4178	A205NTAC.B99	92-2	Right	2	19:03:38:36	1.40193766	-78.75401920	70	1,100	0,84	62,9	6,700	167,600	1,700	0,326	62,632	0501	85	AT802	AT802_Coca	Coca
10967	4716	A205P&AC.B99	92-2	Right	5	9:03:40:53	1.40327255	-78.75333689	69	1,100	5,33	393,4	3,000	165,100	1,700	2,039	395,002	0501	85	AT802	AT802_Coca	Coca

DELNORTE System Record .

DAILY FLIGHT SUMMARY - TUMACO
AT-802

Date: 20/01/2005

LOG Name	TO TIME	AC#	PILOT	FLT TIME	MSN	GALS Sprayed	DN GALS	DN Hect.	ADJ Hect.	ADJ CAL	DN CAL	PLOT	REASONS	COORDS	DEPT
A205K6AC	0845	4002		0.9	E	398	397,97	65,47			6,08	09202		N 01° 20.19' - W 78° 40.39'	NARINO
A205K6BC	1025	4002		1.1	E	487	486,87	79,34			6,14	09202		N 01° 21.58' - W 78° 40.34'	NARINO
A205K6CC	1320	4002		1.0	E	503	502,22	82,36			6,10	08306		N 01° 48.03' - W 78° 13.53'	NARINO
A205L%AC	0845	4003		0.9	E	364	363,83	61,98			5,87	09202		N 01° 22.97' - W 78° 43.32'	NARINO
A205L%BC	1025	4003		1.3	E	485	485,16	83,06			5,84	09202		N 01° 23.24' - W 78° 42.47'	NARINO
A205L%CC	1320	4003		1.3	E	472	471,42	78,02			6,04	08306		N 01° 45.94' - W 78° 12.97'	NARINO
A205NTAC	0845	4006		0.9	E	380	380,39	62,59			6,08	09202		N 01° 21.69' - W 78° 41.38'	NARINO
A205NTBC	1025	4006		1.3	E	491	491,32	81,21			6,05	09202		N 01° 24.33' - W 78° 42.15'	NARINO
A205OTCC	1320	4007		1.3	E	502	502,18	80,16			6,26	08306		N 01° 44.35' - W 78° 12.86'	NARINO
A205MVAC	0845	4004		0.9	E	378	377,72	62,96			6,00	09202		N 01° 24.17' - W 78° 44.69'	NARINO
A205OVBC	1025	4007		1.3	E	414	414,40	68,05			6,09	09202		N 01° 22.70' - W 78° 42.04'	NARINO
A205MVCC	1320	4004		1.3	E	482	481,92	79,43			6,07	08306		N 01° 46.28' - W 78° 13.44'	NARINO
A205P&AC	0845	4008		0.8	E	384	384,23	62,94			6,10	09202		N 01° 23.46' - W 78° 44.33'	NARINO
A205P&BC	1025	4008		1.1	E	519	518,63	84,29			6,15	09202		N 01° 23.28' - W 78° 41.65'	NARINO
A205P&CC	1320	4008		1.2	E	499	499,23	80,13			6,23	08306		N 01° 45.24' - W 78° 13.25'	NARINO
A205BYAC	0845	4009		0.8	E	398	398,38	64,29			6,20	09202		N 01° 24.27' - W 78° 44.72'	NARINO
A205BYBC	1025	4009		1.0	E	502	501,33	78,62			6,38	09202		N 01° 23.30' - W 78° 41.63'	NARINO
A205BYCC	1320	4009		0.9	E	484	483,67	76,68			6,31	08306		N 01° 48.70' - W 78° 13.05'	NARINO
			Total Time	19,5											
							Adj Ha	0,00	0,00						
							Total HA	1331,58							

DFS Record.

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6. Spray Mission with two aircraft departing from Tumaco Spray Base, on 8 December 2005:

MISSION CODE	ACTUAL TIME DFS RECORDS	DELNORTE SOFTWARE RECORDED TIME	TIME-LAG	DURATION OF THE SPRAY MISSION
L085**N**QAC	13:26	23:41	10:15	00:54
L085**B**~AC	13:30	13:41	00:11	00:54

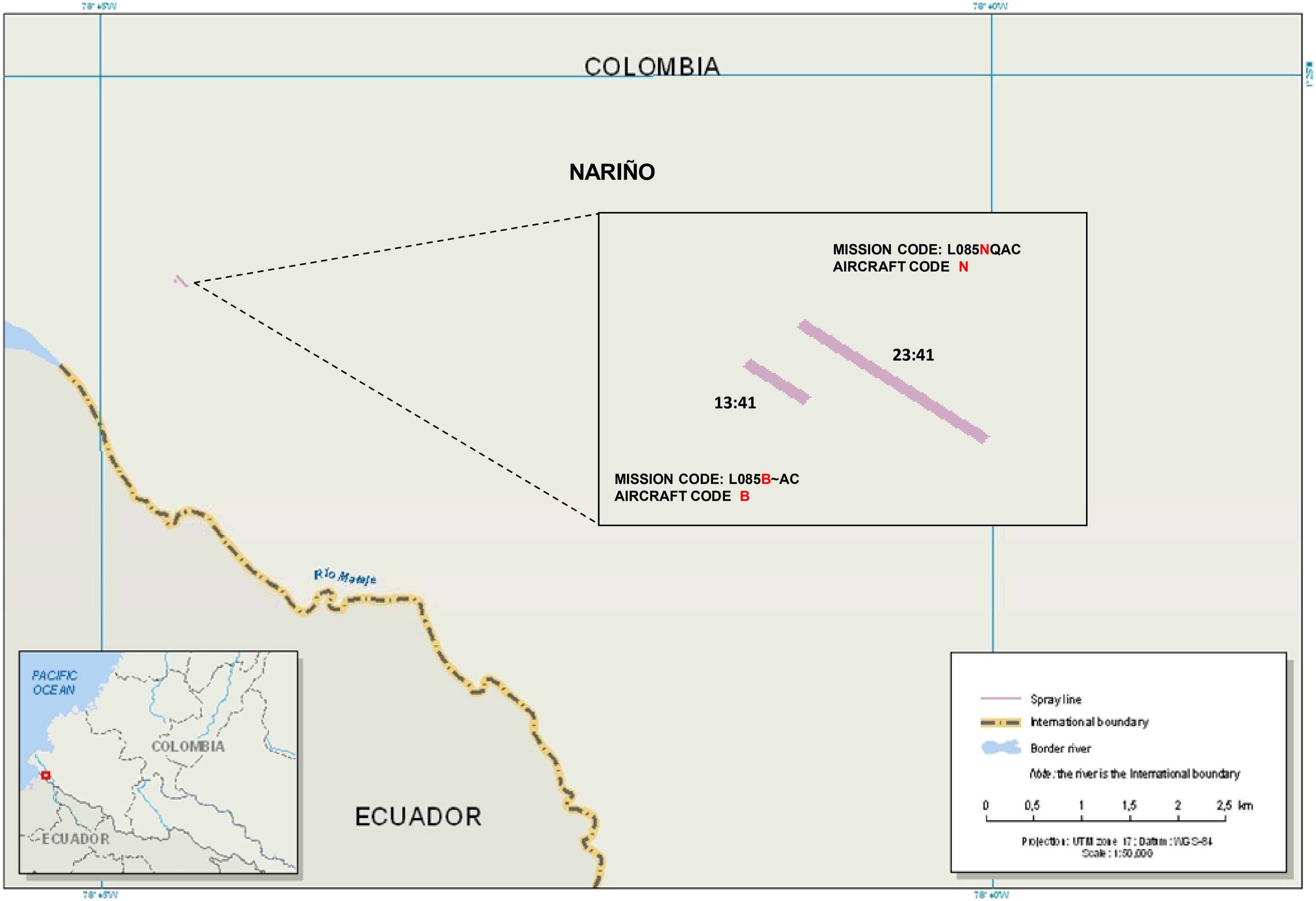
From the chart above, it may be seen that it refers to a mission carried out on 08 December 2005 on coca crops, in which 2 aircraft identified with codes N and B took part. Row 1 shows the time-lag in the start time, as follows:

- Row 1 corresponds to the aircraft with code **N**. It may be seen that the time recorded by DelNorte software was 23:41, while the time recorded on the DFS was 13:26, evidencing a time-lag of 10 hours, and the 15 minutes of the aircraft's flight to spray area and preparation for spraying.

- Row 2 corresponds to the aircraft with code **B**. It may be seen that the time recorded by DelNorte software was 13:41, and that on the DFS was 13:30, thus showing that the pilot set the offset correctly (GMT – 5:00), and therefore there was no time-lag, and the only difference is that of the minutes (11) corresponding to the aircraft's flight to spray area and preparation for spraying.

Consequently, it may be seen that on the time recorded by the DelNorte software for the aircraft shown in Row 2 the offset was set correctly by the pilot and is thus consistent with the time recorded on the DFS.

Figure 8. One Spray Mission with 2 Aircraft from Tumaco Spray Base on 8 December 2005



1/2

One Spray Mission with 2 Aircraft from Tumaco Spray Base on 8 December 2005

FID	SEG	FILE_NAME	MISSION	SIDE	LINE	START_TIME	LATITUDE	LONGITUDE	ALTITUDE	DOP	FLT_TIME	FLT_LENGTH	OTE	SPEED	VOLUME	AREA	LENGTH	MONTH	SWATH	AIRCRAFT	AC_CROP	CROP
13325	668	L085B~AC.B99	92-2	Right	11	13:41:03:23	1.39828493	-78.74322816	67	0,890	0,62	48,3	1,900	174,300	6,100	0,250	48,361	0512	85	AT802	AT802_Coca	Coca
13433	778	L085NQAC.B99	92-2	Right	12	23:41:06:22	1.39857327	-78.74293051	76	0,890	1,79	147,9	3,900	184,800	6,100	0,766	147,885	0512	85	AT802	AT802_Coca	Coca

DELNORTE System Record .

DAILY FLIGHT SUMMARY - TUMACO
AT-802

Date: 12/08/2005

LOG Name	TO	AC#	PILOT	FLT	MSN	GALS	DN	DN	ADJ	ADJ	DN	PLOT	REASONS	COORDS	DEPT
	TIME			TIME		Sprayed	GALS	Hect.	Hect.	CAL	CAL				
L085B~AC	1330	4009		0,9	E	431	430,35	65,23			6,60	09202		N 01° 20.39' - W 78° 40.37'	NARINO
L085NQAC	1326	4006		0,9	E	400	399,51	64,47			6,20	09202		N 01° 21.44' - W 78° 41.47'	NARINO
							Adj Ha	0,00							
			Total FLT Time	1,8			Total HA	129,70							

AC-Abort due to crew availability
AD-Abort due to FOD
AF-Abort due to foreign government
AG-Abort due to armament systems
AH-Abort due to hostile fire
AM-Abort due to mechanical reasons
AU-Abort due to U.S. Govt.
AW-Abort due to w eather
AX-Abort due to other (requires explaination)

DFS Record.

2/2

7. Spray Mission with two aircraft departing from Villagarzon Spray Base on 26 December 2006:

MISSION CODE	ACTUAL TIME DFS RECORDS	DELNORTE SOFTWARE RECORDED TIME	TIME-LAG	DURATION OF THE SPRAY MISSION
L266**J**DAC	09:45	19:48	10:03	00:24
L266**A**JAC	09:45	09:48	00:03	00:18

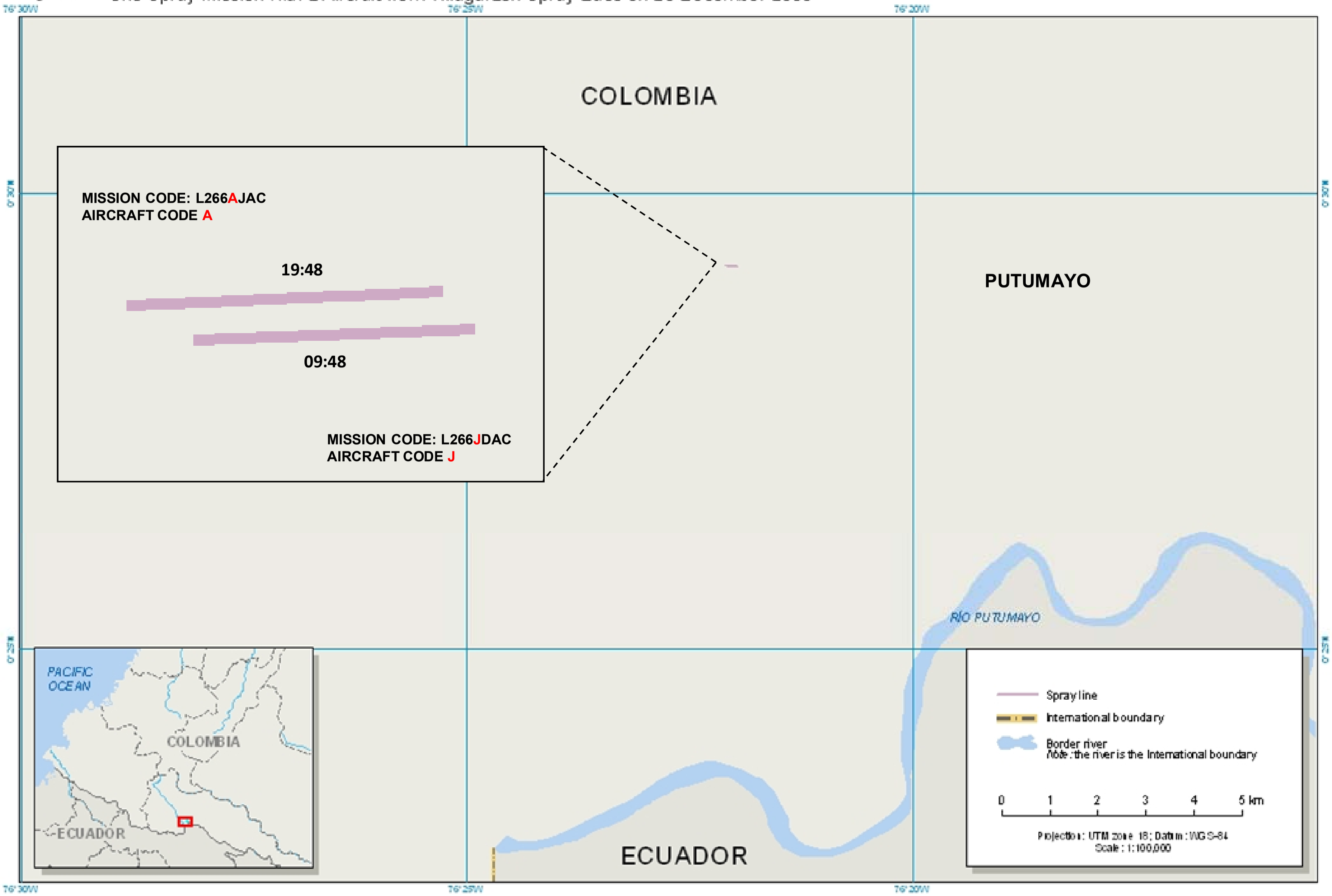
From the chart above, it may be seen that it refers to a mission carried out on 26 December 2006 on coca crops, in which 2 aircraft identified with codes J and A took part. Row 1 shows the time-lag in the start time, as follows:

- Row 1 corresponds to the aircraft with code **J**. It may be seen that the time recorded by DelNorte software was 19:48, while that on the DFS was 09:45, evidencing a time-lag of 10 hours, and the 3 minutes of the aircraft's flight to spray area and preparation for spraying.

- Row 2 corresponds to the aircraft with code **A**. It may be seen that the time recorded by DelNorte software was 09:48, and that on the DFS was 09:45, thus showing that the pilot set the offset correctly (GMT – 5:00), and therefore there was no time-lag, and the only difference is that of 3 minutes of the aircraft's flight to spray area and preparation for spraying.

Consequently, it may be seen that on the time recorded by the DelNorte software for both aircraft shown in Row 2 the offset was set correctly by the pilot and thus is consistent with the time recorded on the DFS.

Figure 9. One Spray Mission with 2 Aircraft from Villagarzon Spray Base on 26 December 2006



1/2

One Spray Mission with 2 Aircraft from Larandia Spray Base on 26 December 2006 [28]

FID	SEG	FILE_NAME	MISSION	SIDE	LINE	START_TIME	LATITUDE	LONGITUDE	ALTITUDE	DOP	FLT_TIME	FLT_LENGTH	OTE	SPEED	VOLUME	AREA	LENGTH	MONTH	SWATH	AIRCRAFT	AC_CROP
17142	7011	L266AJAC.B99	292-1	Right	281	19:48:22:30	0.48674345	-76.36858044	329	0,8900	3,9	281,1	0,700	161,200	6,700	0,857	281,586	0612	50	T-65	T-65_Coca
17209	7078	L266JDAC.B01	292-1	Right	280	9:48:09:00	0.48649831	-76.36804332	276	1,1800	3,4	250,8	1,100	165,000	6,500	0,764	251,03	0612	50	T-65	T-65_Coca

DELNORTE System Record .

COCA T65 DAILY FLIGHT SUMMARY - Villa Garzon, Putumayo

Date: 12/26/2006

LOG Name	TO TIME	AC#	PILOT	FLT TIME	MSN	GALS Sprayed	DN GALS	DN Hect.	ADJ Hect.	ADJ CAL	DN CAL	PLOT	RATING	REASONS	COORDS	DEPT
L266JDAC	0945	3065	CABRERA	0.4	E	150	150	25.66			5.83	29201			N0°29.35' W76°16.68'	PUTUMAYO
L266JDBC	1015	3065	CABRERA	0.4	E	150	149	24.97			5.98	29201			N0°29.40' W76°18.31'	PUTUMAYO
L266AJAC	0945	0270	GARCIA	0.3	E	150	152	24.46			6.20	29201			N0°29.37' W76°16.75'	PUTUMAYO
L266AJBC	1010	0270	GARCIA	0.3	E	165	167	27.26			6.13	29201			N0°29.40' W76°18.07'	PUTUMAYO
							SubTotal	102.35	0.00							
			Total time	1.4												
							Total HA	102.35								

DFS Record.

2/2

8. Spray Mission with two aircraft departing from Villagarzon Spray Base on 08 January 2007:

MISSION CODE	ACTUAL TIME DFS RECORDS	DELNORTE SOFTWARE RECORDED TIME	TIME-LAG	DURATION OF THE SPRAY MISSION
A087**D**JAC	07:15	12:35	05:20	01:00
A087**A**BAC	07:15	17:34	10:19	01:00

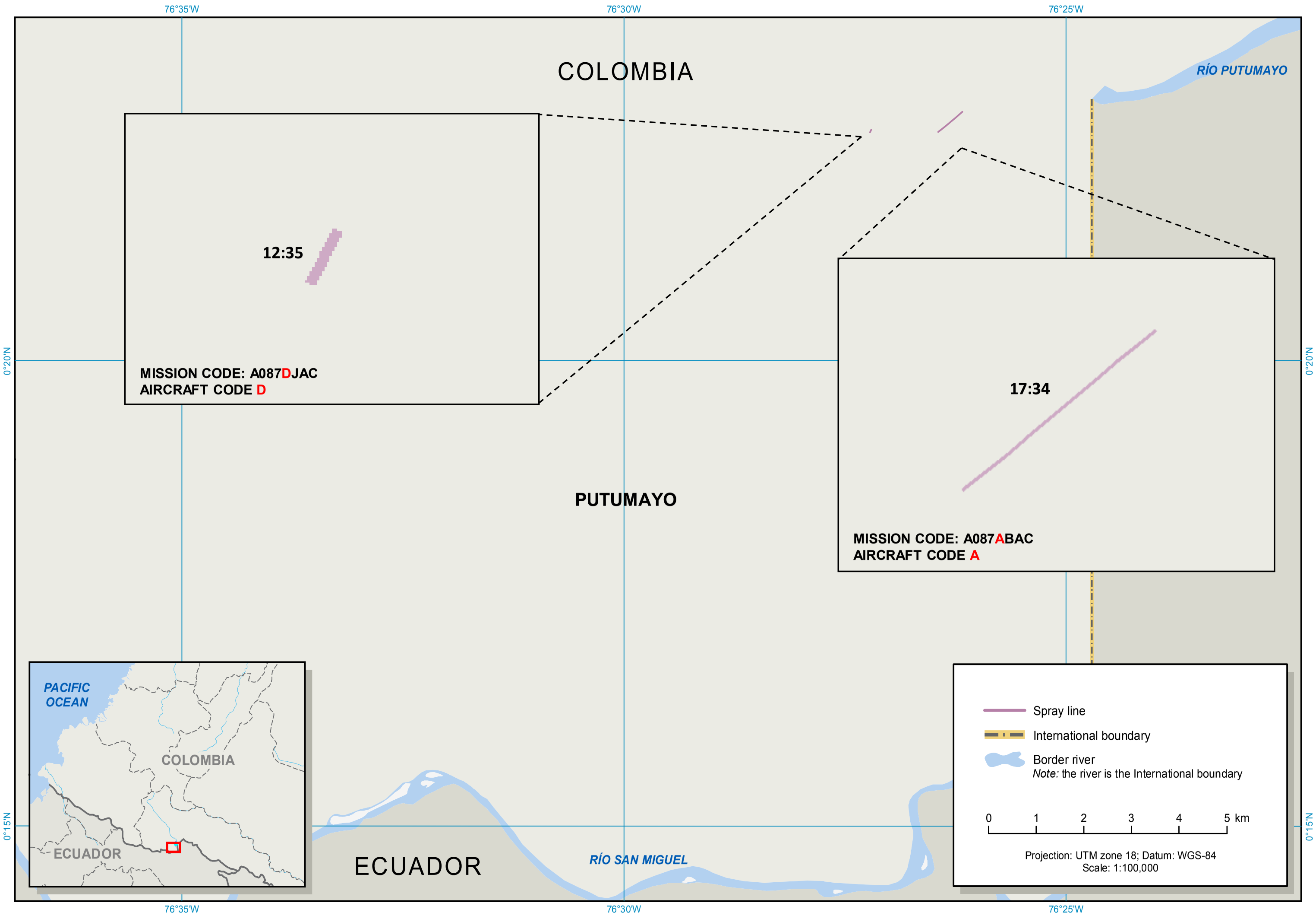
From the chart above, it may be seen that it refers to a mission carried out on 8 January 2007 on coca crops, in which 2 aircraft identified with codes A and D took part. Row 1 shows a time-lag of 5 hours in the start time and row 2 a time-lag of 10 hours, as follows:

- Row 1 corresponds to the aircraft with code **D**. It may be seen that the time recorded by DelNorte software was 12:35, while that on the DFS was 07:15, evidencing a time-lag of 5 hours, and 20 minutes of the aircraft's flight to spray area and preparation for spraying.

- Row 2 corresponds to the aircraft with code **A**. It may be seen that the time recorded by DelNorte software was 17:34, and that on the DFS was 07:15, thus showing a time-lag of 10 hours, and 19 minutes of the aircraft's flight to spray area and preparation for spraying.

Consequently, it may be seen that on the time recorded by the DelNorte software for both aircraft the offset was set incorrectly by the pilots and is thus inconsistent with the time recorded on the DFS.

Figure 10. One Spray Mission with 2 Aircraft from Villagarzon Spray base on 8 January 2007



One Spray Mission with 2 Aircraft from Villagarzon Spray Base on 8 January 2007

FID	SEG	FILE_NAME	MISSION	SIDE	LINE	START_TIME	LATITUDE	LONGITUDE	ALTITUDE	DOP	FLT_TIME	FLT_LENGTH	OTE	SPEED	VOLUME	AREA	LENGTH	MONTH	SWATH	AIRCRAFT	AC_CROP	GROUP
3543	3293	A087ABAC.B99	292-1	- - -	1	17:34:03:40	0.37427294	-76.44067857	301	1,030	8,7	644,675	4395,400	165,800	6,800	1,965	646,845	0701	50	T-65	T-65_Coca	Condor
3572	3459	A087DJAC.B99	292-7	Right	2	12:35:49:77	0.37422575	-76.45356127	303	1,100	0,8	59,634	851152,688	166,700	5,900	0,182	59,409	0701	50	T-65	T-65_Coca	Condor

DELNORTE System Record .

COCA T65 DAILY FLIGHT SUMMARY - Villa Garzon, Putumayo

Date: 08/01/2007

LOG Name	TO TIME	AC#	PILOT	FLT TIME	MSN	GALS Sprayed	DN GALS	DN Hect.	ADJ Hect.	ADJ CAL	DN CAL	PLOT	RATING	REASONS	COORDS	DEPT
A087DJAC	0715	3078		1,0	E	270	269	43,73			6,16	29207			N0°22.01' W76°27.65'	PUTUMAYO
A087DJBC	0845	3078		0,6	E	250	240	45,53			5,28	28001			N0°30.60' W76°27.78'	PUTUMAYO
A087DJCC	0930	3078		0,4	E	250	242	40,51			5,98	28001			N0°32.89' W76°29.40'	PUTUMAYO
A087DJDC	1000	3078		0,6	E	250	241	40,57			5,95	28001/03			N0°34.08' W76°29.70'	PUTUMAYO
A087DJEC	1055	3078		1,0	E	280	280	46,03			6,09	28003			N0°32.37' W76°22.56'	PUTUMAYO
A087ABAC	0715	0270		1,0	E	150	152	24,71			6,17	29207			N0°22.88' W76°26.62'	PUTUMAYO
A087ABBC	0845	0270		0,3	E	150	150	24,50			6,12	28002			N0°29.03' W76°25.67'	PUTUMAYO
A087ABCC	0915	0270		0,3	E	150	152	25,00			6,11	28002			N0°31.03' W76°26.54'	PUTUMAYO
A087ABDC	0945	0270		0,6	E	150	148	24,36			6,11	28002			N0°31.60' W76°25.28'	PUTUMAYO
A087ABEC	1040	0270		0,6	E	150	151	24,46			6,18	28002			N0°33.07' W76°25.70'	PUTUMAYO
							SubTotal	339,40	0,00							
			Total time	6,4												
							Total HA	339,40								

DFS Record.

9. Spray Mission with five aircraft departing from Larandia Spray Base, on 01 January 2007:

MISSION CODE	ACTUAL TIME DFS RECORDS	DELNORTE SOFTWARE RECORDED TIME	TIME-LAG	DURATION OF THE SPRAY MISSION
A017**K**QAC	12:04	22:25	10:21	01:24
A017**L**AAC	12:04	23:25	11:21	01:24
A017**O**PAC	12:04	17:25	05:21	01:06
A017**P**-AC	12:04	12:25	00:21	01:06
A017**F**EAC	12:04	22:25	10:21	01:24

From the chart above, it may be seen that it refers to a mission carried out on 1 January 2007 on coca crops, in which 5 aircraft identified with codes K, L, O, P and F took part. Rows 1, 2, 3 and 5 show the time-lag in the start time, as follows:

- Row 1 corresponds to the aircraft with tail number PNC 4002, code **K**. It may be seen that the time recorded by DelNorte software was 22:25, while that on the DFS was 12:04, evidencing a time-lag of plus 10 hours, and the 21 minutes of the aircraft's flight to spray area and preparation for spraying.

- Row 2 corresponds to the aircraft with tail number PNC 4003, code **L**. It may be seen that the time recorded by DelNorte was 23:25, while that on the DFS was 12:04, evidencing a time-lag of plus 11 hours, and the 21 minutes of the aircraft's flight to spray area and preparation for spraying.

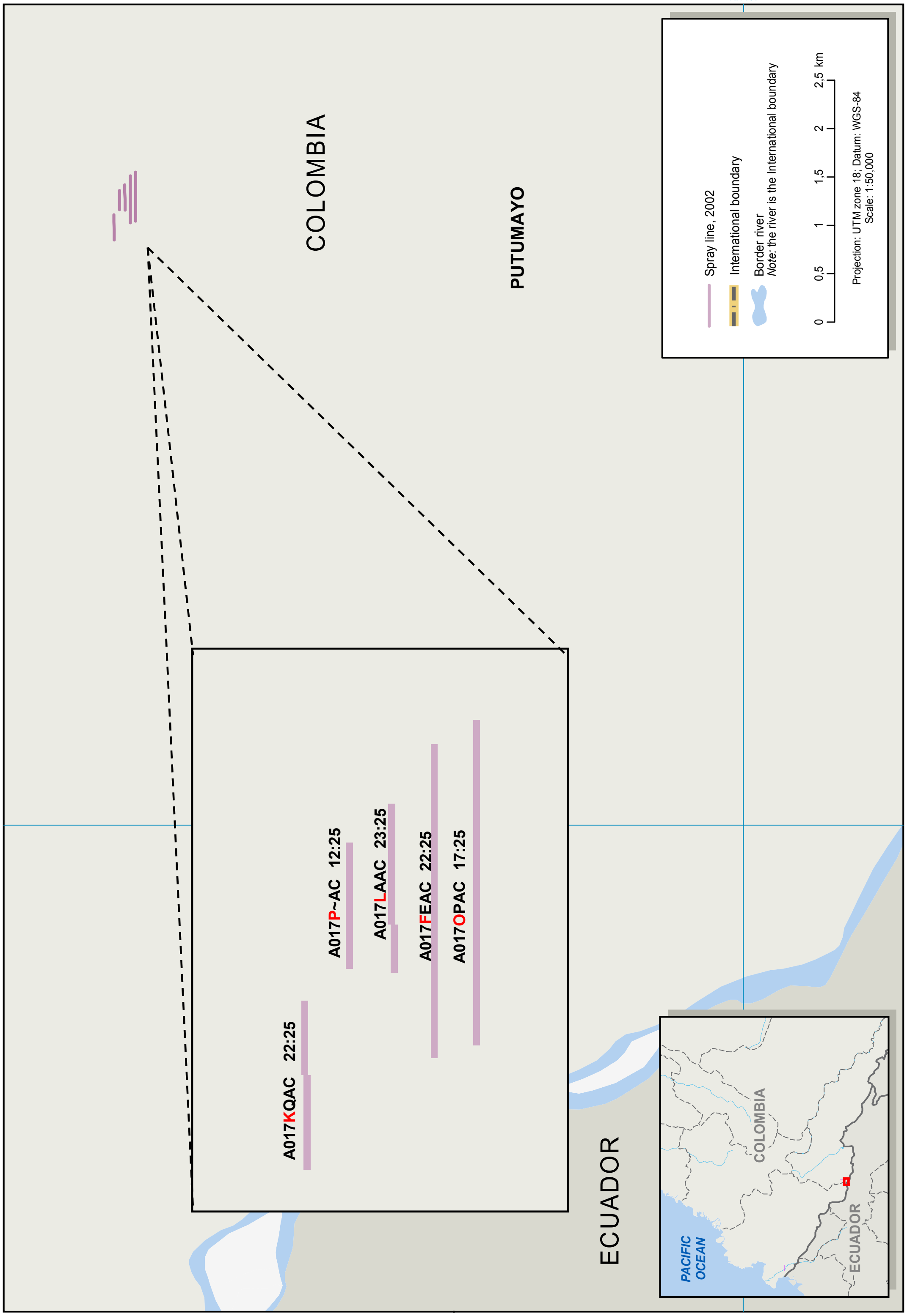
- Row 3 corresponds to the aircraft with tail number PNC 4007, code **O**. It may be seen that the time recorded by DelNorte software was 17:25, while that on the DFS was 12:04, evidencing a time-lag of plus 5 hours, and the 21 minutes of the aircraft's flight to spray area and preparation for spraying.

- Row 4 corresponds to the aircraft with tail number PNC 4008, code **P**. It may be seen that the time recorded by DelNorte software was 12:25, and that on the DFS was 12:04, thus showing that the pilot set the offset correctly (GMT – 5:00), and therefore there was no time-lag, but only the difference of the 21 minutes of the aircraft's flight to spray area and preparation for spraying.

- Row 5 corresponds to the aircraft with tail number PNC 4011, code **F**. It may be seen that the time recorded by DelNorte was 22:25, while that on the DFS was 12:04, evidencing a time-lag of plus 10 hours, and the 21 minutes of the aircraft's flight to spray area and preparation for spraying.

Consequently, it may be seen that on the time recorded by the DelNorte software for the aircraft shown in Row 4, the offset was set correctly by the pilot and is thus consistent with the time recorded on the DFS.

Figure 11. One Spray Mission with 5 Aircraft from Larandia Spray base on 8 Junary 2007



1/2

One Spray Mission with 5 Aircraft from Larandia Spray Base on 1 January 2007

FID	SEG	FILE_NAME	MISSION	SIDE	LINE	START_TIME	LATITUDE	LONGITUDE	ALTITUDE	DOP	FLT_TIME	FLT_LENGTH	OTE	SPEED	VOLUME	AREA	LENGTH	MONTH	SWATH	AIRCRAFT	AC_CROP	GROUP
3680	69	A017FEAC.B99	288-5	Right	191	22:25:46:50	0.38725751	-77.02307591	366	0,890	6,25	489,727	17,000	175,300	6,200	2,538	489,961	0701	85	AT802	AT802_Coca	Lobo
3900	671	A017KQAC.B99	288-5	Right	188	22:25:47:40	0.38869957	-77.02668482	375	0,890	3,4	263,381	14,100	173,300	6,000	1,365	263,569	0701	85	AT802	AT802_Coca	Lobo
4010	876	A017LAAC.B99	288-5	Right	190	23:25:46:10	0.38773404	-77.02391805	372	0,890	3,5	262,521	16,700	167,800	6,000	1,360	262,933	0701	85	AT802	AT802_Coca	Lobo
4118	1093	A017OPAC.B99	288-5	Right	192	17:25:48:00	0.38677844	-77.02273513	371	0,890	6,5	508,104	17,300	174,900	6,300	2,633	508,11	0701	85	AT802	AT802_Coca	Lobo
4220	1311	A017P-AC.B99	288-5	Right	189	12:25:45:90	0.38819609	-77.02446177	377	0,890	2,6	198,192	16,300	170,500	5,900	1,027	198,367	0701	85	AT802	AT802_Coca	Lobo

DELNORTE System Record .

DAILY FLIGHT SUMMARY - LARANDIA

AT-802

Date: 01/01/2007

LOG Name	TO	AC#	PILOT	FLT	MSN	GALS	DN	DN	ADJ	ADJ	DN	PLOT	REASONS	COORDS	DEPT
	TIME			TIME		Sprayed	GALS	Hect.	Hect.	CAL	CAL				
A017KQAC	1204	4002		1,4	E	476	476,28	66,54			7,16	28805		N 00° 22.89' - W 77° 01.49'	Narino/Putumayo
A017KQBC	1403	4002		1,6	E	289	288,63	43,08			6,70	26701,28904		N 00° 27.59' - W 76° 50.90'	Putumayo
A017LAAC	1204	4003		1,4	E	500	490,77	86,04			5,70	28805		N 00° 23.26' - W 77° 03.55'	Narino/Putumayo
A017LABC	1403	4003		1,4	E	300	296,74	49,49			6,00	26701,28904		N 00° 29.72' - W 76° 50.96'	Putumayo
A017OPAC	1204	4007		1,1	E	515	514,65	84,36			6,10	28805		N 00° 22.50' - W 77° 04.86'	Narino/Putumayo
A017OPBC	1403	4007		1,1	E	296	296,29	49,64			5,97	26701,28904		N 00° 29.17' - W 76° 51.01'	Putumayo
A017P-AC	1204	4008		1,1	E	560	559,92	90,95			6,16	28805		N 00° 22.87' - W 77° 04.61'	Narino/Putumayo
A017P-BC	1403	4008		2,1	E	281			45,03	6,24		26701,28904	*	N 00° 41.82' - W 76° 38.33'	Putumayo
A017FEAC	1204	4011		1,4	E	669	668,23	108,48			6,16	28805		N 00° 22.67' - W 77° 04.17'	Narino/Putumayo
A017FEBC	1403	4011		2,1	E	474	473,03	75,54			6,26	26701,28904		N 00° 26.69' - W 76° 52.02'	Putumayo
							ADJ HA	45,03							
			Total FLT Time	14,7			Total HA	699,15							

Log missed count the gals and hects.

Pilots and maintenance have been notified about the low/high calibration.

AC-Abort due to crew availability
AD-Abort due to FOD
AF-Abort due to foreign government
AG-Abort due to armament systems
AH-Abort due to hostile fire
AM-Abort due to mechanical reasons
AU-Abort due to U.S. Govt.
AW-Abort due to weather
AX-Abort due to other (requires explaination)

DFS Record.

10. Analysis of a single aircraft (Code K) on separate missions during 2006

Below is an example in which a follow-up of the same aircraft (tail number PNC4011 Code F), shows a time-lag of 10 hours in several missions during the year 2006:

MISSION CODE	ACTUAL TIME DFS RECORDS	DELNORTE SOFTWARE RECORDED TIME	TIME-LAG
C056**K**0BC	13:13	23:43	10:30
E036**K**PAC	11:13	22:22	11:09
L256**K**AAC	10:32	20:56	10:24

The chart above shows records for the Code-K aircraft, of missions conducted on 5 March 2006, 3 May 2006, and 25 December 2006, on coca crops. All the Rows the plus 10-hour time-lag in the start time, as follows:

- Row 1 shows that on 5 March 2006, DelNorte software recorded the start time for that aircraft as 23:43, while that on the DFS was 13:13, evidencing a time-lag of plus 10 hours, and the 30 minutes of the aircraft's flight to spray area and preparation for spraying.
- Row 2 shows that on 3 May 2006, DelNorte software recorded the start time for that aircraft as 22:22, while that on the DFS was 11:13, evidencing a time-lag of plus 10 hours, and 01:13 minutes of the aircraft's flight to spray area and preparation for spraying.
- Row 3 shows that on 25 December 2006, DelNorte software recorded the start time for that aircraft as 20:56, while that on the DFS was 10:32, evidencing a time-lag of plus 10 hours, and the 24 minutes of the aircraft's flight to spray area and preparation for spraying.

Consequently, it may be seen that on the time recorded by the DelNorte software for the referred-to aircraft, on separate missions, the offset was not set correctly by the pilots, and thus maintains a 10-hour difference with regard to the time recorded on the DFS.

Figure 12. Analysis of a single aircraft (Code K) on two separate missions during 2006

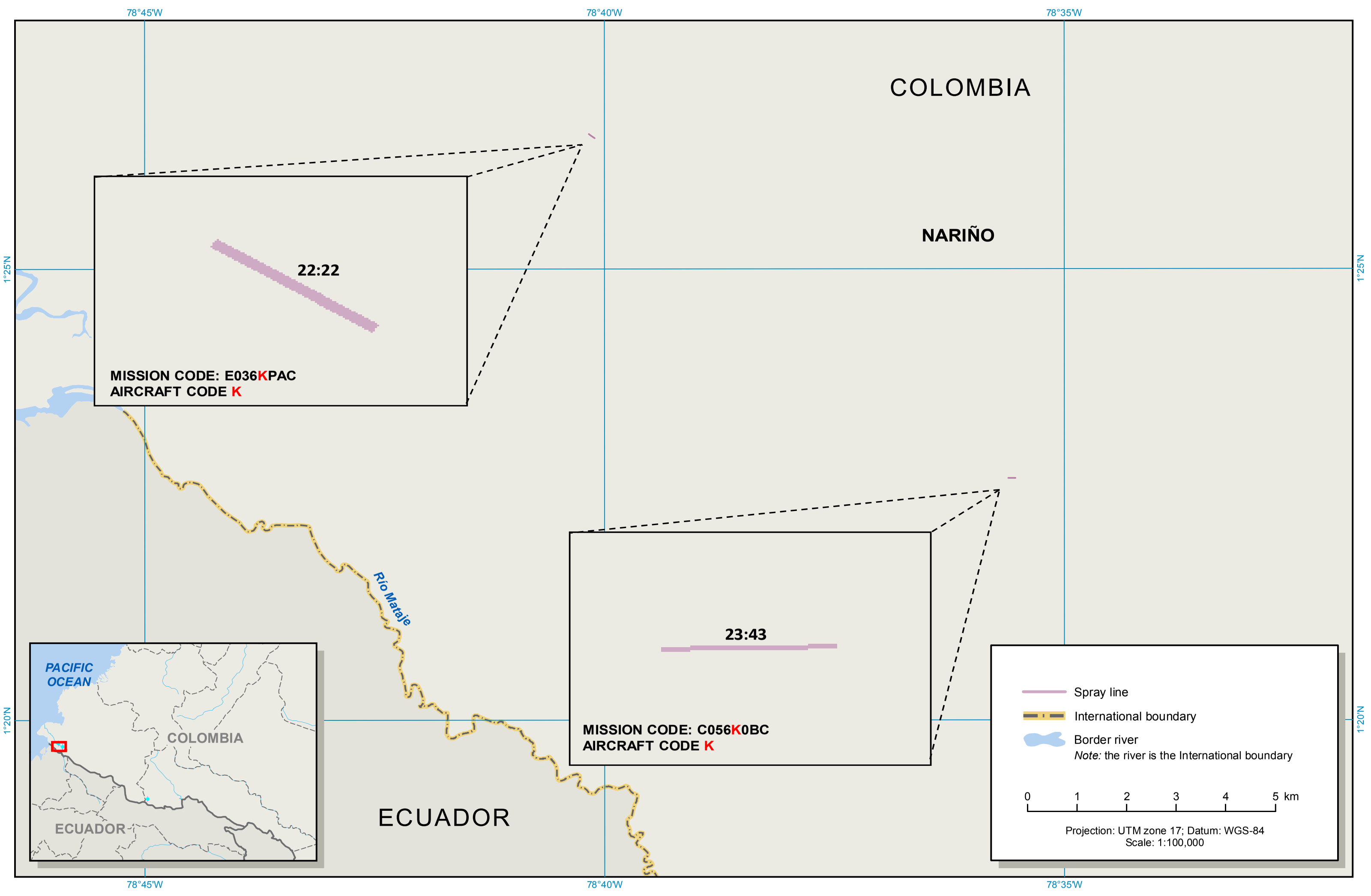
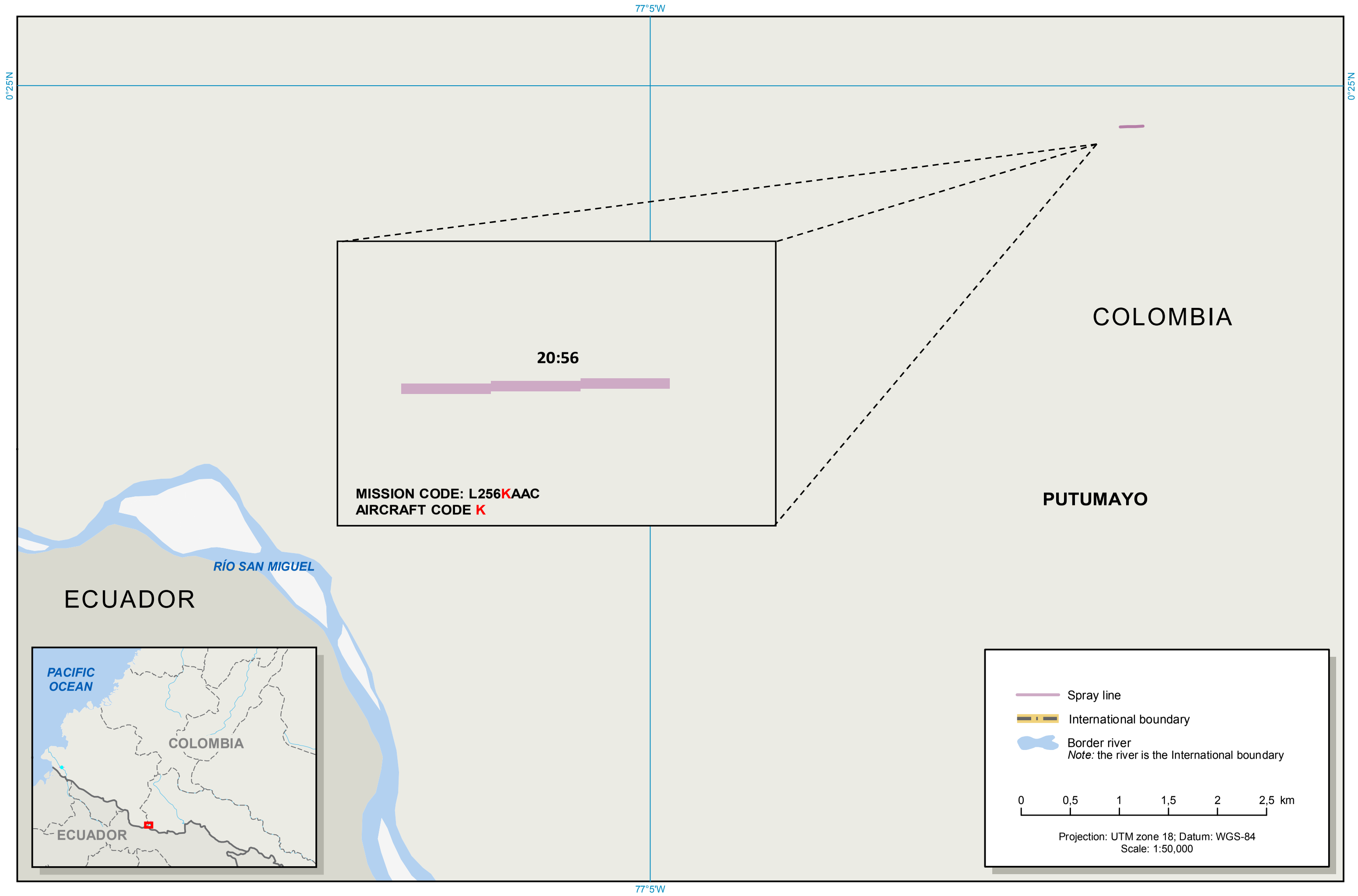


Figure 13. Analysis of a single aircraft (Code K) on a mission during 2006



CR NOTE: PAGE 39 BLANK IN THE ORIGINAL

II. VERIFICATION OF WIND CONDITIONS (BEEPER)

Prior to the start of spray missions, a reconnaissance aircraft flies over the areas targeted for eradication and its pilot verifies if weather conditions are appropriate to authorize the beginning of the operations.

During the reconnaissance flight, the pilot determines if wind conditions are appropriate. He releases a discharge of smoke –known as Beeper– (Photograph 1) and how it behaves once it is in contact with the wind is observed. If the smoke moves only slightly, indicative of mild winds, spray operations are authorized; otherwise, they are cancelled.

Photograph 1: Smoke trail, to validate wind conditions.

Photograph taken in Tumaco (Nariño Province), showing validation of wind conditions present at Plot targeted for eradication.

This procedure is repeated by the pilots during the spray missions in order to confirm that wind conditions as observed by the reconnaissance pilot remain so (photograph 2). Risk of drift is thus reduced to minimal.

Foto 2: Smoke trail and spray, seen from below the aircraft.

Same as previous, taken from below, clearly shows the difference between trail left by spray and that of smoke.

CR NOTE: PAGE 42 BLANK IN THE ORIGINAL

III. SPRAYING MISSION CANCELLATION DUE TO WEATHER

Before each spraying mission begins, a reconnaissance aircraft flies over the selected areas for the eradication of illicit crops, and its pilot verifies if weather conditions such as rain, wind and cloud cover are in compliance with the operational parameters.

If weather conditions are not appropriate, the mission is cancelled. The fact that it was not possible to comply with spraying tasks due to weather reasons is recorded on the Spray Mission Record (some samples are included below).

Records are kept for all non-spray (cancelled) missions, and they are at the Court's disposal. They show that Colombia has been careful not to spray under bad weather conditions. With regard to the relevant period in the present case, the following Spray Mission Records are available:

2001: Caquetá-Putumayo: 15 records.
2002: Caquetá-Putumayo: 22 records.
2003: Nariño-Cauca: 136 records.
2004: Caquetá-Putumayo: 48 records.
2004: Nariño-Cauca: 39 records.
2005: Nariño-Cauca: 12 records.
2006: Caquetá-Putumayo: 17 records.
2006: Nariño-Cauca: 54 records.

A chart showing the number of ops days cancelled due to weather between 2000 and 2010 is also included below.

SPRAYING OPS DAYS CANCELLED DUE TO WEATHER 2000-2010

YEAR	BASE LOCATION	DAYS OF SPRAYING OPS	SPRAYING OPS DAYS CANCELLED DUE TO WEATHER
2010	LARANDIA (CAQUETA)	319	65
	TUMACO (NARIÑO)	255	133
Total 2010		**574**	**198**
2009	LARANDIA (CAQUETA)	33	14
	TUMACO (NARIÑO)	281	155
Total 2009		**314**	**169**
2008	LARANDIA (CAQUETA)	120	40
	TUMACO (NARIÑO)	300	129
	VILLAGARZON (PUTUMAYO)	90	28
Total 2008		**510**	**197**
2007	LARANDIA (CAQUETA)	137	57
	TUMACO (NARIÑO)	223	86
	VILLAGARZON (PUTUMAYO)	14	1
Total 2007		**374**	**144**
2006	LARANDIA (CAQUETA)	105	35
	TUMACO (NARIÑO)	209	70
	VILLAGARZON (PUTUMAYO)	104	24
Total 2006		**418**	**129**
2005	LARANDIA (CAQUETA)	172	48
	TUMACO (NARIÑO)	165	60
	CHACHAGUI (NARIÑO)	29	28
Total 2005		**366**	**136**
2004	LARANDIA (CAQUETA)	247	117
	TUMACO (NARIÑO)	131	58
	VILLAGARZON (PUTUMAYO)	57	19
Total 2004		**435**	**194**
2003	LARANDIA (CAQUETA)	11	5
	TUMACO (NARIÑO)	215	114
	VILLAGARZON (PUTUMAYO)	79	36
	CHACHAGUI (NARIÑO)	14	7
Total 2003		**319**	**162**
2002	LARANDIA (CAQUETA)	250	81
	TUMACO (NARIÑO)	102	46
	VILLAGARZON (PUTUMAYO)	187	26
Total 2002		**539**	**153**
2001	LARANDIA (CAQUETA)	228	74
	SOLANO (CAQUETA)	32	13
	TUMACO (NARIÑO)	54	14
	VILLAGARZON (PUTUMAYO)	48	11
Total 2001		**362**	**112**
2000	LARANDIA (CAQUETA)	285	60
	SOLANO (CAQUETA)	12	4
	TUMACO (NARIÑO)	27	5
Total 2000		**324**	**69**

ANTI- NARCOTICS DIRECTION NATIONAL POLICE
ILLICIT CROP ERADICATION AREA
SPRAY AIR BASE – VILLA GARZON-PUTUMAYO

MINUTE NO. 027/ - NON-SPRAYING OF COCA ILLICIT CROPS IN THE JURISDICTION OF THE PROVINCE OF PUTUMAYO

In Villagarzón, on January 12, 2007, staff participating in the Eradication of Illicit Coca Crops, Major VALERO TORRES WILLIAM, Spraying Operation Commander, and Mr. CAMILO GUERRERO BETANCOURT, representative of the Public Ministry, met at the administrative premises of the Spray Air Base of Villagarzón in order to put on record that no spraying operations were conducted due to BAD WEATHER CONDITIONS IN THE ZONE.

There being no other matters to deal with, this Minute is read and signed for all those who took part in it.

[Signed]

Mr. CAMILO GUERRERO BETANCOURT
Regional Ombudsman Villagarzón

[Signed]
Major VALERO TORRES WILLIAM
Commander Spraying Operation

E-mail: areci.diran@policia.gov.co
Avenida El Dorado Entrada 6 Base Aérea de Bogotá Telefax 4397433

ANTI- NARCOTICS DIRECTION NATIONAL POLICE
ILLICIT CROP ERADICATION AREA
AERIAL SPRAYING BASE – POPAYAN

MINUTE NO. 017/ - NON-SPRAYING OF ILLICIT OPIUM-POPPY CROPS IN THE PROVINCES OF CAUCA AND NARIÑO

In Popayán, Cauca, on April 2, 2003, Capt. Carlos Arturo Téllez, ARECI Spraying Coordinator and Operation Commander; Capt Germán Pineda, Turbo Thrush Pilot, Mrs. Emma Vernaza-Niño, Delegated Procurator met at the administrative offices of the Popayán Air Base in order to proceed with the aerial spraying of illicit opium-poppy crops in the Departments of Cauca and Nariño. Operations could not be conducted due to bad weather conditions in the zone.

Mrs. EMMA VERNAZA-NIÑO
Delegated Procurator

[Signed]
Capt GERMÁN PINEDA
Turbo Thrush Pilot

[Signed]
Capt CARLOS ARTURO TÉLLEZ
ARECI Spraying Coordinator and Operation Commander

ANTI- NARCOTICS DIRECTION NATIONAL POLICE
ILLICIT CROP ERADICATION AREA
AERIAL SPRAYING BASE – VILLAVICENCIO

MINUTE NO. 001/ - NON-SPRAYING OF ILLICIT COCA-LEAF CROPS IN THE PROVINCE OF NARIÑO

In Tumaco, Nariño, on December 6, 2003, Capt LUIS FERNANDO ARISTIZÁBAL-TAMAÑO; Spraying Operation Commander, Vice-First Sgt GUSTAVO MEJIA-BÁEZ, ARECI Spraying Coordinator, Mr. DIEGO ARIAS-GAVIRIA, Delegated Procurator met at the administrative offices of the Tumaco Air Base in order to proceed with the aerial spraying of illicit coca-leaf crops. Operations could not be conducted due to bad weather conditions in the zone.

There being no other matters to deal with, this Minute is read and signed for all those who took part in it.

[Signed]
Mr. DIEGO ARIAS-GAVIRIA
Delegated Procurator

[Signed]
VF Sgt GUSTAVO MEJÍA-BÁEZ
ARECI Spraying Coordinator

[Signed]
LUIS FERNANDO ARISTIZÁBAL-TAMAYO
Spraying Operation Commander

ANTI- NARCOTICS DIRECTION NATIONAL POLICE
ILLICIT CROP ERADICATION AREA
SPRAY AIR BASE – LARANDIA

MINUTE NO. 066/ - NON-SPRAYING OF COCA ILLICIT CROPS IN THE JURISDICTION OF THE PROVINCES CAQUETA AND PUTUMAYO

In Larandia (Caquetá) on December 1, 2004, the staff participating in the Eradication of Illicit Coca Crops in Jurisdiction of the Departments of Caquetá and Putumayo met at the premises of the Spray Air Base of Larandia, in order to put on record that spraying of illicit crops could not be conducted due to bad weather conditions.

There being no other matters to deal with, this Minute is signed by those who took part in it.

[Signed]
Mrs. AMPARO CUELLAR-QUIMBAYA
Criminal Judicial Procurator 96 – II

[Signed]
Capt. AUGUSTO AMADOR VILLEGAS
COMMANDER LARANDIA MISSION

ANTI- NARCOTICS DIRECTION NATIONAL POLICE
ILLICIT CROP ERADICATION AREA
SPRAY AIR BASE – VILLA GARZON-PUTUMAYO

MINUTE NO. 028/ - NON-SPRAYING OF COCA ILLICIT CROPS IN THE JURISDICTION OF THE PROVINCE OF PUTUMAYO

In Villa Garzón, on December 1, 2004, staff participating in the Eradication of Illicit Coca Crops met at the administrative premises of the Spray Air Base of Villa Garzón.

NO AERIAL SPRAYING WAS CONDUCTED DUE TO: bad weather conditions in the zone.

[Signed]
Mr. CAMILO GUERRERO
Regional Ombudsman Villa Garzón

[Signed]
Major HECTOR MONTENEGRO-MONTENEGRO
Commander Spraying Operation

DIRECTORATE OF ANTI-NARCOTICS POLICE
ILLICIT CROP ERADICATION AREA
AERIAL SPRAYING BASE – TUMACO

MINUTE NO. 153/ - NON-SPRAYING OF ILLICIT COCA-LEAF CROPS IN THE JURISDICTION OF THE PROVINCE OF NARIÑO

In Tumaco, Nariño, on May 7, 2004, the air mission staff met at the administrative offices of the Tumaco, in order to proceed with the aerial spraying of illicit crops. oPerations could not be conducted due to the transfer of the Base.

There being no other matters to deal with, Record is read and signed for all those who took part in it.

Mr. CESAR JAVIER CASTRO-QUIROZ
Municipal Ombudsman
(Did not attend)

[Signed]
MY LUIS ALBERTO CARDOZO BERNAL CARDOZO
Spraying Operation Commander – Tumaco

ANTI- NARCOTICS DIRECTION NATIONAL POLICE
ILLICIT CROP ERADICATION AREA
SPRAY AIR BASE – LARANDIA

MINUTE NO. 073/ - NON-SPRAYING OF COCA ILLICIT CROPS IN THE JURISDICTION OF THE PROVINCE OF PUTUMAYO

In Larandia, Caquetá, on April 13, 2004, the air mission staff met at the administrative premises of the Spray Air Base of Larandia in order to conduct spraying of coca illicit crops. Activities could not be conducted due to BAD WEATHER CONDITIONS IN THE AREA.

There being no other matters to deal with, Minute is read and signed by those who took part in it.

[Signed]
Maj. JAVIER PERDOMO-RAMÍREZ
Commander Spraying Air Mission

[Signed]
ORESTES OÑOTE RIVERO
Criminal Judicial Procurator 97
Representative of the Public Ministry

ANTI- NARCOTICS DIRECTION NATIONAL POLICE
ILLICIT CROP ERADICATION AREA
AERIAL SPRAYING BASE – TUMACO

MINUTE NO. 108/ - NON-SPRAYING OF ILLICIT COCA-LEAF CROPS IN THE JURISDICTION OF THE PROVINCE OF NARIÑO

In Tumaco, (Nariño), on March 23, 2004, Major WILLIAM ALBERTO ORTÍZ-ISAZA, Commander Spraying Mission; Capt CARLOS ALFREDO CURREA-BARRERA, Police Pilot, Mr. DIEGO ARIAS-GAVIRIA, Delegated Procurator, met at the premises of the Spray Air Base of Tumaco in order to proceed with the aerial spraying of illicit crops. Operations could not be conducted due to bad weather conditions in the zone.

There being no other matters to deal with, this Minute is read and signed by those who took part in it.

[Signed]
Mr. DIEGO ARIAS GAVIRIA
Delegated Procurator

[Signed]
Capt CARLOS ALFREDO CURREA BARRERA
Pilot National Police

[Signed]
Maj. WILLIAM ALBERTO ORTIZ IZASA
Commander Spraying Operation Tumaco

ANTI- NARCOTICS DIRECTION NATIONAL POLICE
ILLICIT CROP ERADICATION AREA
AERIAL SPRAYING BASE – TUMACO

MINUTE NO. 067 - NON-SPRAYING OF ILLICIT COCA-LEAF CROPS IN THE JURISDICTION OF THE PROVINCE OF NARIÑO

In Tumaco, (Nariño), on March 12, 2005, staff taking part in the Eradication of Coca Illicit Crops in jurisdiction of the Department of Nariño met at the premises of the Spray Air Base of Tumaco the, to put on record that no spraying activities of illicit coca crops was conducted due to rain the work area.

There being no other matters to deal with, this Minute is read and signed by those who took part in it.

[Signed]
Mr. DIEGO ARIAS-GAVIRIA
Judicial Prosecutor 282, Criminal Affairs

[Signed]
Major LUIS ANTONIO BARRAGAN-SALGUERO
Spraying Operation Commander- Tumaco

ANTI- NARCOTICS DIRECTION NATIONAL POLICE
ILLICIT CROP ERADICATION AREA
AERIAL SPRAYING BASE – TUMACO-NARIÑO

MINUTE NO. 074/ - NON-SPRAYING OF ILLICIT COCA-LEAF CROPS IN THE JURISDICTION OF THE PROVINCE OF NARIÑO

In Tumaco, (Nariño), on March 19, 2005, the staff taking part in the Eradication of Illicit Coca-Leaf Crops met at the Spray Aerial Spraying Base of Tumaco.

NO SPRAYING ACTIVITIES WERE CONDUCTED DUE TO BAD WEATHER CONDITIONS IN THE AREA.

Representative of the Public Ministry

[Signed]
Ms. ANGELA ROSA MONTOYA-DUQUE
Regional Ombudsman – Tumaco

[Signed]
Major JAVIER PERDOMO-RAMÍREZ
Spraying Operation Commander

ANTI- NARCOTICS DIRECTION NATIONAL POLICE
ILLICIT CROP ERADICATION AREA
SPRAY AIR BASE – VILLA GARZON

MINUTE NO. 056/ - NON-SPRAYING OF COCA ILLICIT CROPS WITH GLYPHOSATE IN THE JURISDICTION OF THE PROVINCE OF PUTUMAYO

In Villagarzón, on October 3, 2006, Maj. LUIS FERNANDO ARISTIZÁBAL-TAMAYO, Commander of Spraying Operations and Mr. CAMILO GUERRERO-BETANCOURT, representative of the Public Ministry met at the premises of the Spray Air Base of Villagarzón in order put on record that spraying of illicit crops could not be conducted due to BAD WEATHER CONDITIONS.

There being no other matters to deal with, this Minute is signed by those who took part in it.

[Signed]
Mr. CAMILO GUERRERO-BETANCOURT
Regional Ombudsman

[Signed]
Maj. LUIS FERNANDO ARISTIZÁBAL-TAMAYO
Commander Spraying Operations

ANTI- NARCOTICS DIRECTION NATIONAL POLICE
ILLICIT CROP ERADICATION AREA
AERIAL SPRAYING BASE – TUMACO-NARIÑO

MINUTE NO. 113/ - NON-SPRAYING OF ILLICIT COCA-LEAF CROPS IN THE JURISDICTION OF THE PROVINCE OF NARIÑO

At the Spray Base of Tumaco, Nariño, on March 08, 2006, the Spraying Operation Commander, Mr. DIEGO ARIAS-GAVIRIA, representative of the Public Ministry and MAJ. LUIS FERNANDO ARISTIZÁBAL-TAMAYO, Commander Spray Operation met in order to put on record that it was not possible to conduct spraying activities due to bad weather conditions in the zones to be sprayed.

There being no other matters to deal with, this Minute is signed by all those who took part in it.

(Signed)
Mr. DIEGO ARIAS-GAVIRIA
Judicial Procurator 282

(Signed)
Major LUIS ANTONIO BARRAGÁN-SALGUEROL
Spraying Operation Commander – Tumaco

ANTI- NARCOTICS DIRECTION NATIONAL POLICE
ILLICIT CROP ERADICATION AREA
AERIAL SPRAYING BASE – TUMACO-NARIÑO

MINUTE NO. <u>182/</u> - NON-SPRAYING OF ILLICIT COCA-LEAF CROPS IN THE JURISDICTION OF THE PROVINCE OF NARIÑO

At the Spray Base of Tumaco, Nariño, on May 16, 2006, the Spraying Operation Commander, MAJ. LUIS FERNANDO ARISTIZÁBAL-TAMAYO and Mr. DIEGO ARIAS-GAVIRIA, representative of the Public Ministry met in order to put on record that it was not possible to conduct spraying activities due to bad weather conditions in the zones to be sprayed.

There being no other matter to deal with, this Minute is signed by all those who took part in it.

(Signed)
Mr. DIEGO ARIAS-GAVIRIA
Judicial Procurator I

(Signed)
Major LUIS ANTONIO BARRAGÁN-SALGUEROL
Spraying Operation Commander – Tumaco

ANTI- NARCOTICS DIRECTION NATIONAL POLICE
ILLICIT CROP ERADICATION AREA
SPRAY AIR BASE – VILLA GARZON-PUTUMAYO

MINUTE NO. 039/ - NON-SPRAYING OF COCA ILLICIT CROPS WITH GLYPHOSATE IN THE JURISDICTION OF THE PROVINCE OF PUTUMAYO

In Villagarzón, on September 16, 2006, Capt. EDISO ARMANDO RUBIANO-BELTRÁN, Commander of Spraying Operations and Mr. CAILO GUERRERO-BETANCOURT, representative of the Public Ministry met at the premises of the Spray Air Base of Villagarzón in order to put on record that spraying activities could not be conducted due to WEATHER FACTORS IN THE AREA TO BE SPRAYED.

There being no other matters to deal with, this Minute is signed by those who took part in it.

[Signed]
Mr. CAMILO GUERRERO-BETNCOURT
Regional Ombudsman

[Signed]
Capt. EDISON ARMANDO RUBIANO-BELTRÁN
Commander Spraying Operation

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IV. SPRAYING DATA AND WITNESS STATEMENTS CONFRONTED

ANALYSIS METHOD

Based on the description provided by each witness in his or her statement, the relevant community or communities in Ecuador where the witness lived at the time of alleged spraying were determined. As accurately as possible, given the imprecise statements of years from some witnesses, the year or years a given witness claims to have been affected by spraying were also noted.

The spray events (spray lines), from the Department of State data, for each year/witness location combination were then overlaid onto a map of the Colombia-Ecuador border region in a standard Universal Transverse Mercator Projection (zone 17 for the Río Mataje area and zone 18 for the Río San Miguel area). The map was centered near the Ecuadorian community location specified by the witness.

Using the measurement tools in ESRI's ArcGIS software, and a heads-up visual proximity assessment, the spray line closest to the specific community for the specific year was identified. More than one spray line was selected when several were near the same distance away.

Once the closest spray line to the witness's community had been determined, two distances were measured.

- First, the straight-line distance (in meters) was measured from the closest end of the closest spray line to the center of the Ecuadorian community as identified by the witness.

- A second distance was measured from the closest end of the closest spray line to the point along the Ecuadorian bank of the border river (either the Río San Miguel or the Río Mataje) that intersected the straight line in part "a" above.

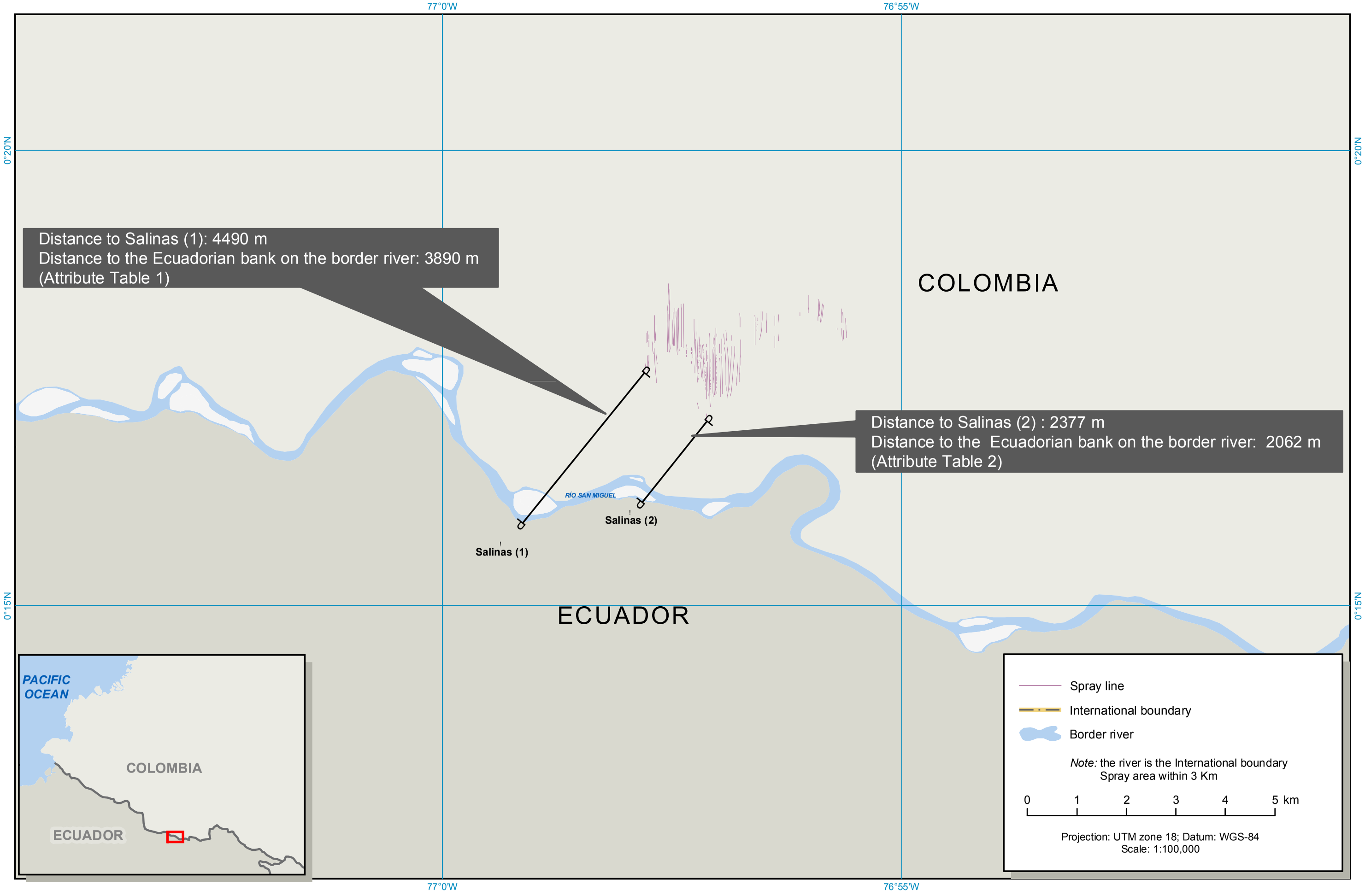
If there were additional details about the location of the witness at the time of alleged spraying, as distinct from a location at the center of the community, these details were incorporated into measurements.

- There is an additional measurement for some locations, for instance, when a statement such as "I have lived in San Francisco 2, province of Sucumbíos, *about two kilometers from the border*" is found.

- For cases where the witness claimed a house location near the river, a closest-case scenario was used to measure the distance from the closest spray line to the community directly to the river (the line would then not be along the straight line from the closest spray line to the community center as described above).

For cases where the only spray lines for the location and year being evaluated are not directly across from the community or have an interceding area of land on the Ecuador side of the border between the spray line and the general area of the community, the spray lines are not considered relevant and no measurements were made.

Figure 1 Salinas, Spray Lines in 2000 (Witnesses 1-2-3-6-7)



Salinas (1) (location from Ecuador Reply and Ecuador 1:50000 Topographic Map)

Salinas (2) (second location from Ecuador 1:50000 Topographic Map)

Salinas, 2000 (witnesses 1-2-3-6-7)

Metadata of the closest spray line

ATTRIBUTE TABLE OF THE CLOSEST SPRAY LINE TO SALINAS (2) IN 2000 (Witnesses 1-2-3-6-7)																						
OBJECTID	**LINE_ID**	**TIME**	**ALTITUDE**	**XTRACK**	**MPH**	**HEADING**	**S**	**SPRAY_RATE**	**DOP**	**SV**	**USED**	**DF**	**STNID**	**ASCIINAME**	**LENGTH**	**MONTH**	**SWATH**	**MISSION**	**AIRCRAFT**	**A_C_CROP**	**CROP**
3813	002721	12:59:06.39	1,100	-39,59	194,200	3,600	1	0	1	8	8	0	-1	I260kdac	152,977	0012	50	Coca	T-65	T-65_Coca	Coca
PARAMETERS		12:59	FEET		MILES/HOUR									26 September 2000							

ADDED ATTRIBUTES		
Spray Line Altitude over MSL (Metres)	**Ground Altitude over MSL (Metres)**	**Spray Line Altitude over Ground Level (Metres)**
335	281	54

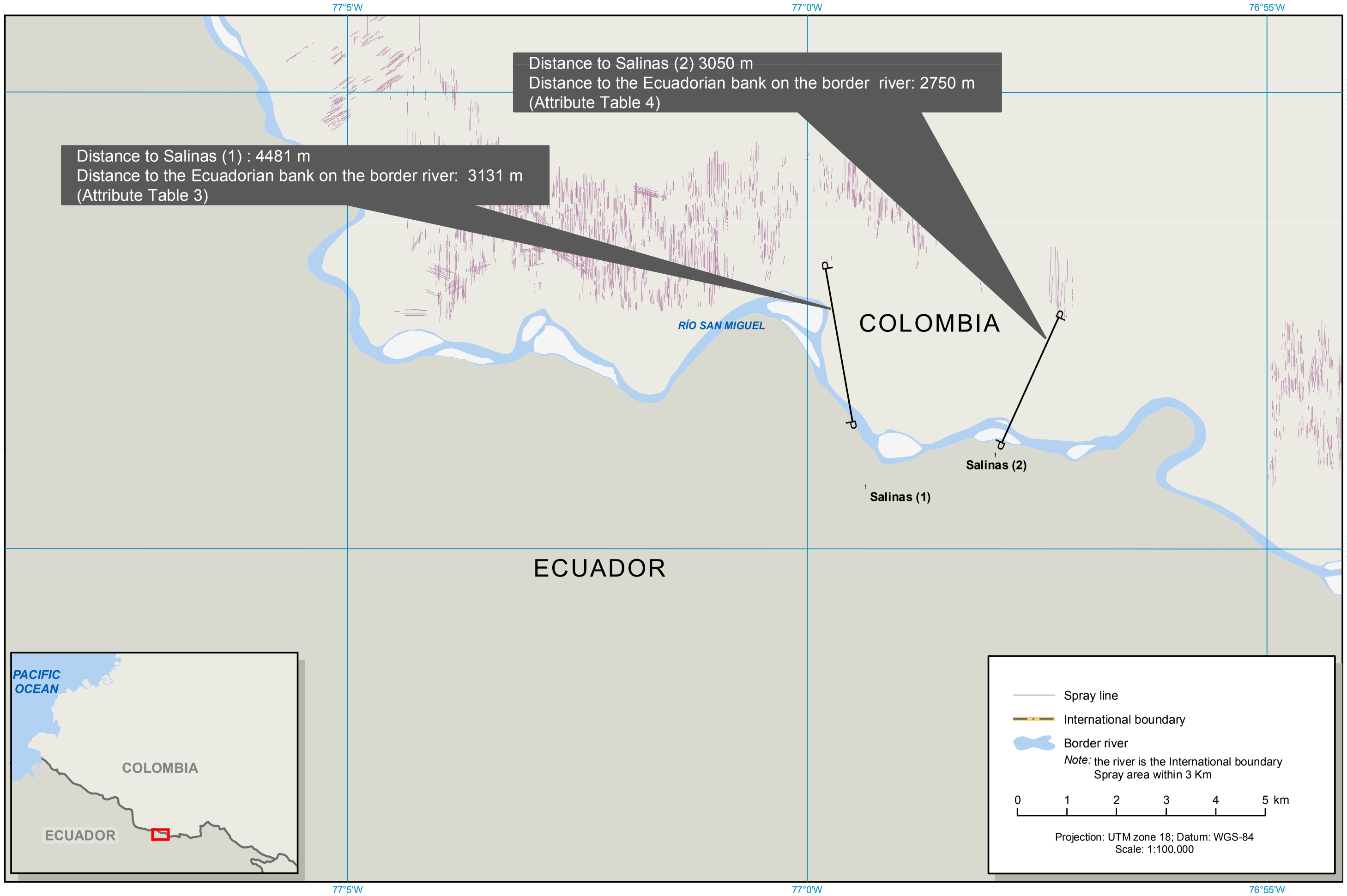
Attribute Table 1

ATTRIBUTE TABLE OF THE CLOSEST SPRAY LINE TO SALINAS (1) IN 2000 (Witnesses 1-2-3-6-7)																						
OBJECTID	**LINE_ID**	**TIME**	**ALTITUDE**	**XTRACK**	**MPH**	**HEADING**	**S**	**SPRAY_RATE**	**DOP**	**SV**	**USED**	**DF**	**STNID**	**ASCIINAME**	**LENGTH**	**MONTH**	**SWATH**	**MISSION**	**AIRCRAFT**	**A_C_CROP**	**CROP**
5422	003293	13:44:19.25	1,200	37,88	185,820	11,700	1	91,270	1,200	10	9	9	100	I310cfcc	201,637	0012	50	Coca	T-65	T-65_Coca	Coca
PARAMETERS		13:44	FEET		MILES/HOUR									31 September 2000							

ADDED ATTRIBUTES		
Spray Line Altitude over MSL (Metres)	**Ground Altitude over MSL (Metres)**	**Spray Line Altitude over Ground Level (Metres)**
365	299	66

Attribute Table 2

Figure 2 Salinas, Spray Lines in 2001 (Witnesses 1-2-3-4-5)



Salinas (1) (location from Ecuador Reply and Ecuador 1:50000 Topographic Map)

Salinas (2) (second location from Ecuador 1:50000 Topographic Map)

Salinas, 2001 (witnesses 1-2-3-4-5)

Metadata of the closest spray line

ATTRIBUTE TABLE OF THE CLOSEST SPRAY LINE TO SALINAS (1) IN 2001 (Witnesses 1-2-3-6-7)																						
OBJECTID	LINE_ID	TIME	ALTITUDE	XTRACK	MPH	HEADING	S	SPRAY_RATE	DOP	SV	USED	DF	STNID	ASCIINAME	LENGTH	MONTH	SWATH	TYPE	AIRCRAFT	LOG	SOURCETHM	AC_CROP
13644	002771	07:36:22.30	1,200	502,57	165,120	9,600	2	0	1,800	11	11	0	-1	a041j#ac	0	0101	50	Coca	T-65	a041j#ac	2001_sl_lines.sh	T-65_Coca
PARAMETERS		07:36	FEET		MILES/HOUR									04 January 2001								

ADDED ATTRIBUTES		
Spray Line Altitude over MSL (Metres)	Ground Altitude over MSL (Metres)	Spray Line Altitude over Ground Level (Metres)
365	295	70

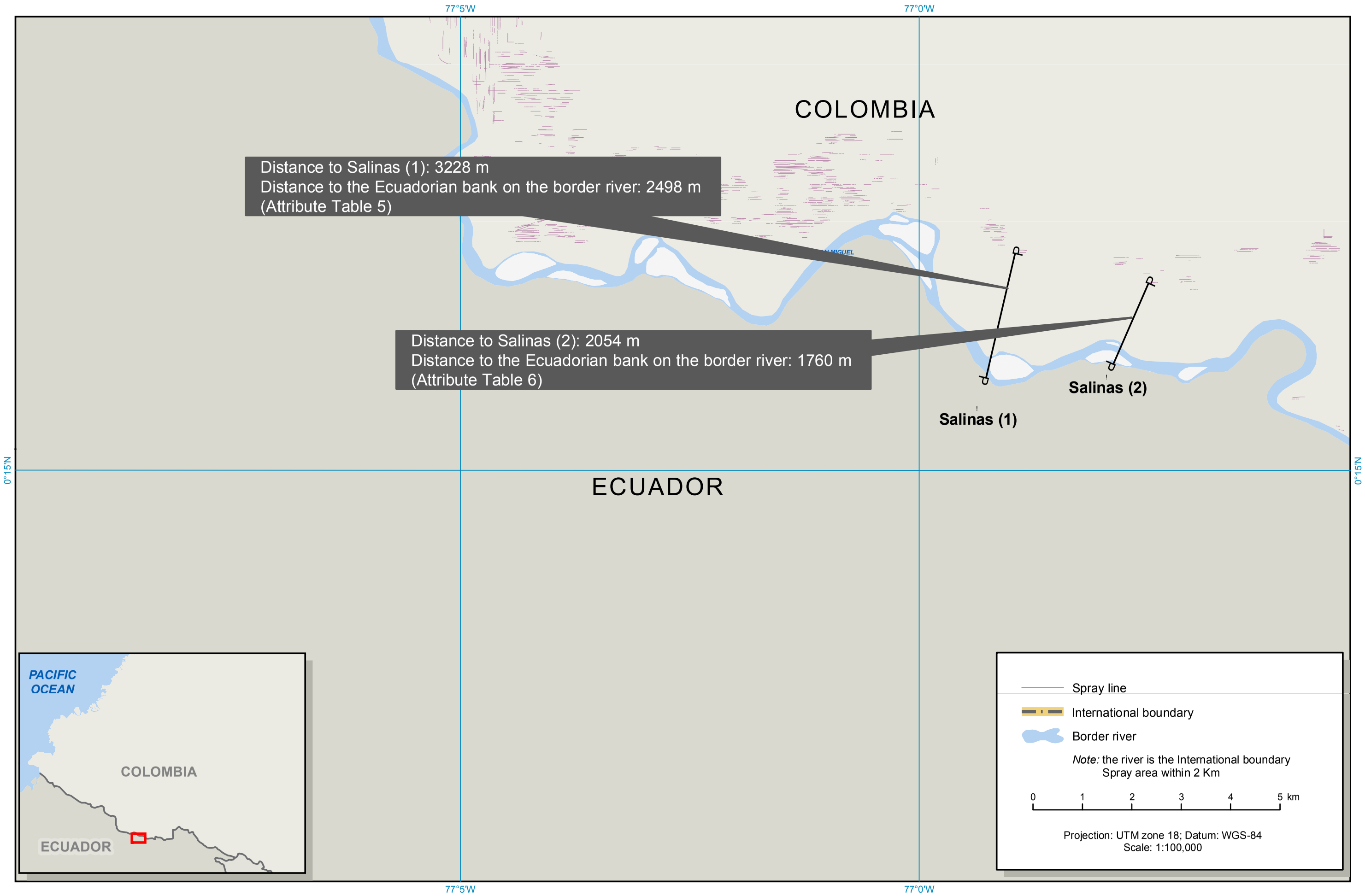
Attribute Table 3

ATTRIBUTE TABLE OF THE CLOSEST SPRAY LINE TO SALINAS (2) IN 2001 (Witnesses 1-2-3-6-7)																						
OBJECTID	LINE_ID	TIME	ALTITUDE	XTRACK	MPH	HEADING	S	SPRAY_RATE	DOP	SV	USED	DF	STNID	ASCIINAME	LENGTH	MONTH	SWATH	TYPE	AIRCRAFT	LOG	SOURCETHM	AC_CROP
14039	001711	12:18:52.05	1,200	215,84	156,040	11,700	1	0	0,900	11	9	0	-1	a051djdc	0,006	0101	50	Coca	T-65	a051djdc	2001_sl_lines.sh	T-65_Coca
PARAMETERS		12:18	FEET		MILES/HOUR									05 January 2001								

ADDED ATTRIBUTES		
Spray Line Altitude over MSL (Metres)	Ground Altitude over MSL (Metres)	Spray Line Altitude over Ground Level (Metres)
365	286	79

Attribute Table 4

Figure 3 Salinas, Spray Lines in 2002 (Witnesses 2-3)



Salinas (1) (location from Ecuador Reply and Ecuador 1:50000 Topographic Map)

Salinas (2) (second location from Ecuador 1:50000 Topographic Map)

Salinas, 2002 (witnesses 2-3)

Metadata of the closest spray line

ATTRIBUTE TABLE OF THE CLOSEST SPRAY LINE TO SALINAS (1) IN 2002 (Witnesses 2-3)																								
OBJECTID	SEG	FILE_NAME	MISSION	SIDE	LINE	START_TIME	LATITUDE	LONGITUDE	ALTITUDE	DOP	FLT_TIME	FLT_LENGTH	OTE	SPEED	VOLUME	AREA	LOG	LENGTH	MONTH	SWATH	AIRCRAFT	CROP	A_C_CROP
21443	914	I082EZBC.B99	301-2	Right	34	12:15:30:70	0.28979779	-76.98222492	1097	0,770	0,1	25,6	4,700	174,5	0	0	I082EZBC	7,8	0209	50	T-65	Coca	T-65_Coca
PARAMETERS		08 September 2002				12:15			FEET					MILES/HOUR									

ADDED ATTRIBUTES		
Spray Line Altitude over MSL (Metres)	**Ground Altitude over MSL (Metres)**	**Spray Line Altitude over Ground Level (Metres)**
333	285	48

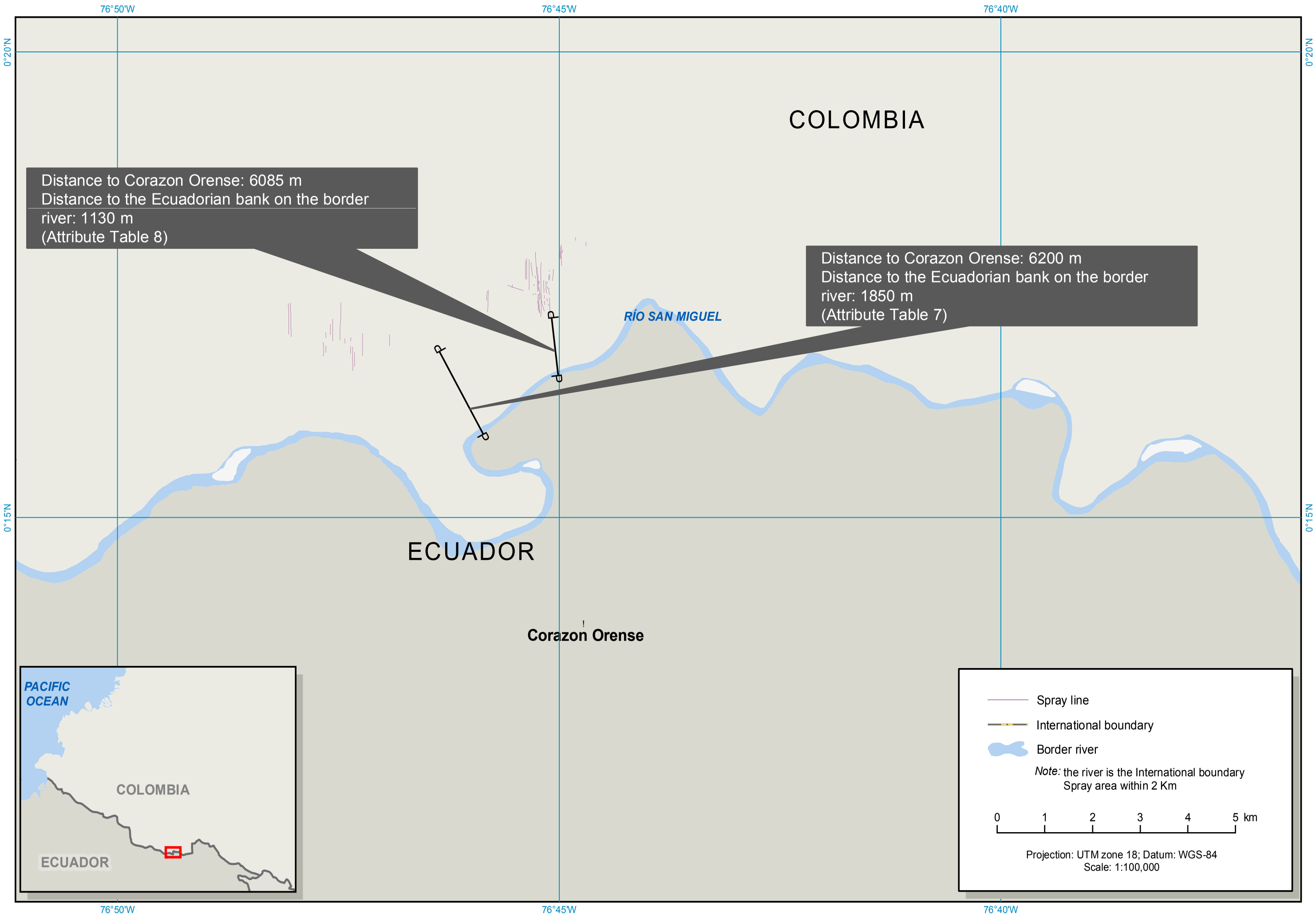
Attribute Table 5

ATTRIBUTE TABLE OF THE CLOSEST SPRAY LINE TO SALINAS (2) IN 2002 (Witnesses 2-3)																							
OBJECTID	SEG	FILE_NAME	MISSION	SIDE	LINE	START_TIME	LATITUDE	LONGITUDE	ALTITUDE	DOP	FLT_TIME	FLT_LENGTH	OTE	SPEED	VOLUME	AREA	LOG	LENGTH	MONTH	SWATH	AIRCRAFT	CROP	A_C_CROP
23513	2994	I082KBCC.B99	301-1	Right	54	18:40:28:07	0.28433029	-76.95826520	1047	0,890	0,2	51,4	10,500	152,400	0	0	I082KBCC	15,951	0209	50	T-65	Coca	T-65_Coca
PARAMETERS		08 September 2002				13:40			FEET					MILES/HOUR									

ADDED ATTRIBUTES		
Spray Line Altitude over MSL (Metres)	**Ground Altitude over MSL (Metres)**	**Spray Line Altitude over Ground Level (Metres)**
318	282	36

Attribute Table 6

Figure 4 Corazón Orense, Spray Lines in 2001 (Witness 9)



Corazón Orense, 2001 (witness 9)

Metadata of the closest spray lines

ATTRIBUTE TABLE OF THE CLOSEST SPRAY LINE TO CORAZON ORENSE IN 2001 (Witness 9)																						
OBJECTID	LINE_ID	TIME	ALTITUDE	XTRACK	MPH	HEADING	S	SPRAY_RATE	DOP	SV	USED	DF	STNID	ASCIINAME	LENGTH	MONTH	SWATH	TYPE	AIRCRAFT	LOG	SOURCETHM	AC_CROP
18412	002552	09:39:31.82	1,100	-7,49	174,200	2,600	1	75,130	0,800	12	9	10	100	a181cfac	0,001	0101	50	Coca	T-65	a181cfac	2001_sl_lines.sh	T-65_Coca
PARAMETERS		09:39	FEET		MILES/HOUR									18 January 2001								

ADDED ATTRIBUTES		
Spray Line Altitude over MSL (Metres)	Ground Altitude over MSL (Metres)	Spray Line Altitude over Ground Level (Metres)
335	273	62

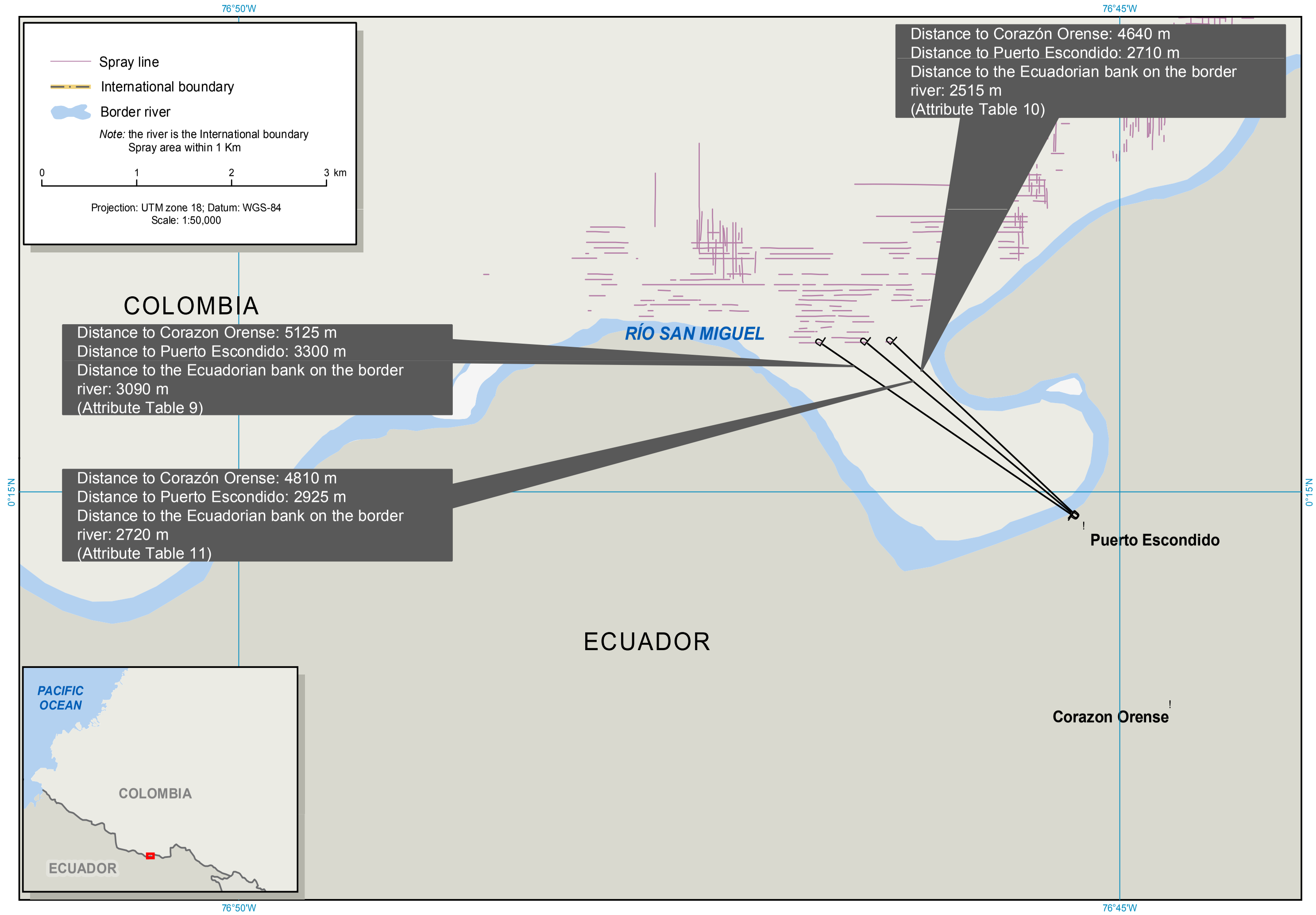
Attribute Table 7

ATTRIBUTE TABLE OF THE SECOND CLOSEST SPRAY LINE TO CORAZON ORENSE 2001 (Witness 9)																						
OBJECTID	LINE_ID	TIME	ALTITUDE	XTRACK	MPH	HEADING	S	SPRAY_RATE	DOP	SV	USED	DF	STNID	ASCIINAME	LENGTH	MONTH	SWATH	TYPE	AIRCRAFT	LOG	SOURCETHM	AC_CROP
18508	002647	12:00:17.27	1,100	-785,72	170,980	3,500	1	81,800	1,100	11	9	9	100	a181cfbc	0,004	0101	50	Coca	T-65	a181cfbc	2001_sl_lines.sh	T-65_Coca
PARAMETERS		12:00	FEET		MILES/HOUR									18 January 2001								

ADDED ATTRIBUTES		
Spray Line Altitude over MSL (Metres)	Ground Altitude over MSL (Metres)	Spray Line Altitude over Ground Level (Metres)
335	272	63

Attribute Table 8

Figure 5 Corazón Orense – Puerto Escondido, Spray Lines in 2002 (Witnesses 8-9-20-21-22-23)



Corazón Orense – Puerto Escondido, 2002 (witnesses 8-9-20-21-22-23)

Metadata of the closest spray line

ATTRIBUTE TABLE OF THE CLOSEST SPRAY LINE TO CORAZON ORENSE - PUERTO ESCONDIDO IN 2002 (Witnesses 8-9-20-21-22-23)																						
OBJECTID	SEG	FILE_NAME	MISSION	SIDE	LINE	START_TIME	LATITUDE	LONGITUDE	ALTITUDE	DOP	FLT_TIME	FLT_LENGTH	OTE	SPEED	VOLUME	AREA	LOG	LENGTH	MONTH	SWATH	AIRCRAFT	CROP	A_C_CROP
1084	399	J102Q7AC.B99	302-1	Right	150	17:48:43:57	0.26335588	-76.78027357	1061	0,890	2,4	761,1	16,100	219,900	2,600	0	J102Q7AC	232,761	0210	85	OV-10	Coca	OV-10_Coca
PARAMETERS		10 October 2002				12:48			FEET					MILES/HOUR									

ADDED ATTRIBUTES		
Spray Line Altitude over MSL (Metres)	Ground Altitude over MSL (Metres)	Spray Line Altitude over Ground Level (Metres)
323	280	43

Attribute Table 9

ATTRIBUTE TABLE OF THE SECOND CLOSEST SPRAY LINE TO CORAZON ORENSE - PUERTO ESCONDIDO IN 2002 (Witnesses 8-9-20-21-22-23)																						
OBJECTID	SEG	FILE_NAME	MISSION	SIDE	LINE	START_TIME	LATITUDE	LONGITUDE	ALTITUDE	DOP	FLT_TIME	FLT_LENGTH	OTE	SPEED	VOLUME	AREA	LOG	LENGTH	MONTH	SWATH	AIRCRAFT	CROP	A_C_CROP
1086	401	J102Q7AC.B99	302-1	Right	150	17:48:52:74	0.26343991	-76.77209578	1028	0,890	0,6	211	10,200	224,800	2,300	0	J102Q7AC	64,493	0210	85	OV-10	Coca	OV-10_Coca
PARAMETERS		10 October 2002				12:48			FEET					MILES/HOUR									

ADDED ATTRIBUTES		
Spray Line Altitude over MSL (Metres)	Ground Altitude over MSL (Metres)	Spray Line Altitude over Ground Level (Metres)
313	265	48

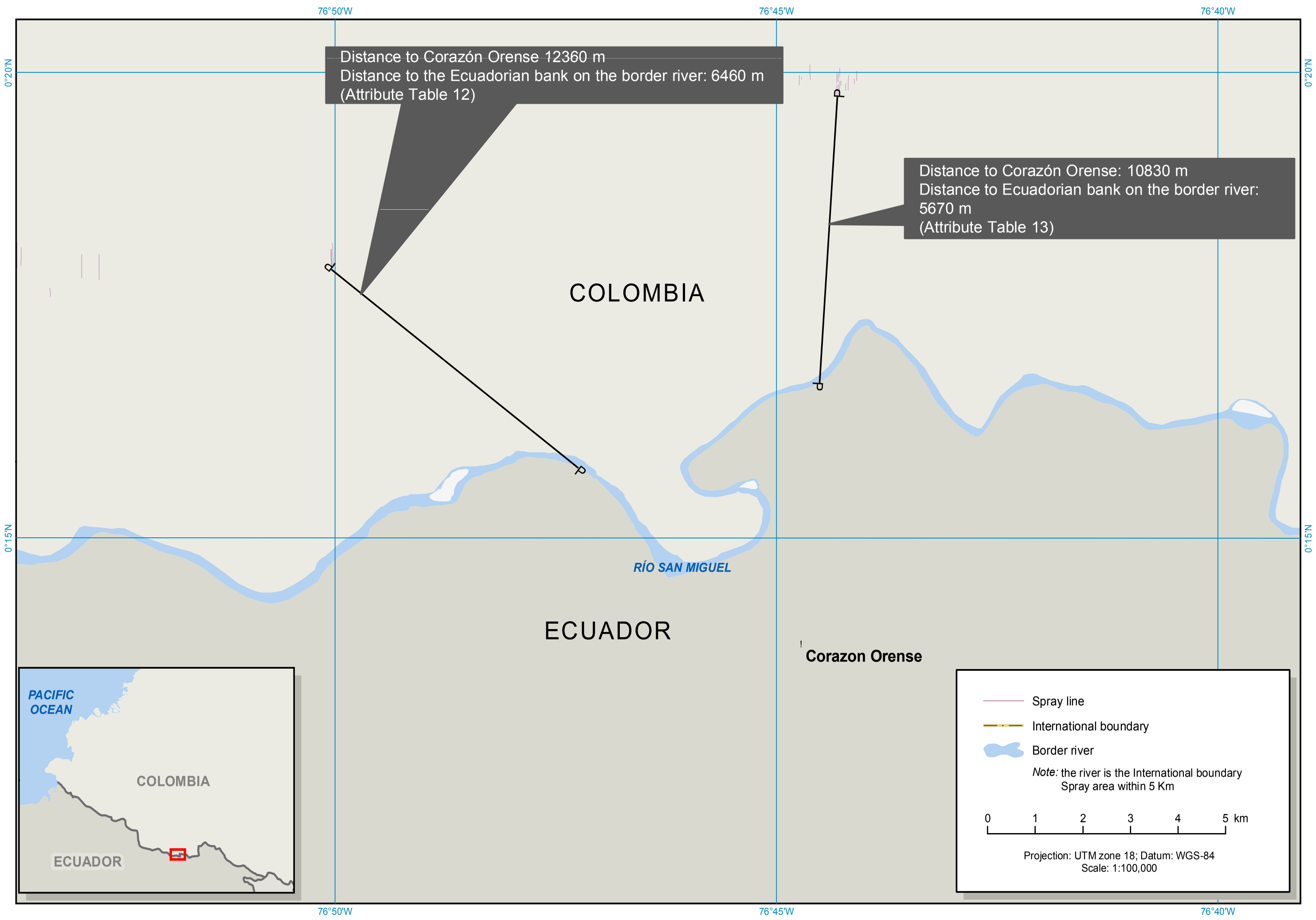
Attribute Table 10

ATTRIBUTE TABLE OF THE THIRD CLOSEST SPRAY LINE TO CORAZON ORENSE - PUERTO ESCONDIDO IN 2002 (Witnesses 8-9-20-21-22-23)																						
OBJECTID	SEG	FILE_NAME	MISSION	SIDE	LINE	START_TIME	LATITUDE	LONGITUDE	ALTITUDE	DOP	FLT_TIME	FLT_LENGTH	OTE	SPEED	VOLUME	AREA	LOG	LENGTH	MONTH	SWATH	AIRCRAFT	CROP	A_C_CROP
1085	400	J102Q7AC.B99	302-1	Right	150	17:48:48:47	0.26340366	-76.77592492	1041	0,890	2,2	726	1,5	223	2,600	0	J102Q7AC	220,454	0210	85	OV-10	Coca	OV-10_Coca
PARAMETERS		10 October 2002				12:48			FEET					MILES/HOUR									

ADDED ATTRIBUTES		
Spray Line Altitude over MSL (Metres)	Ground Altitude over MSL (Metres)	Spray Line Altitude over Ground Level (Metres)
316	274	42

Attribute Table 11

Figure 6 Corazón Orense, Spray Lines in 2003 (Witness 8)



Corazón Orense, 2003 (witness 8)

Metadata of the closest spray line

ATTRIBUTE TABLE OF THE CLOSEST SPRAY LINE TO CORAZON ORENSE IN 2003 (Witness 8)																								
OBJECTID	SEG	FILE_NAME	MISSION	SIDE	LINE	START_TIME	LATITUDE	LONGITUDE	ALTITUDE	DOP	FLT_TIME	FLT_LENGTH	OTE	SPEED	VOLUME	AREA	LOG	LENGTH	MONTH	SWATH	AIRCRAFT	CROP	A_C_CROP	
12273	694	E233ADAC.B99	289-1	Right	607	13:36:35:47	0.30162120	-76.83405338	1082	0,770	5,4	1316,9	11,700	166,600	2,5	3,023	E233ADAC	402,029	0305	50	T-65	Coca	T-65_Coca	
PARAMETERS		23 May 2003				13:36			FEET					MILES/HOUR										

ADDED ATTRIBUTES		
Spray Line Altitude over MSL (Metres)	Ground Altitude over MSL (Metres)	Spray Line Altitude over Ground Level (Metres)
328	288	40

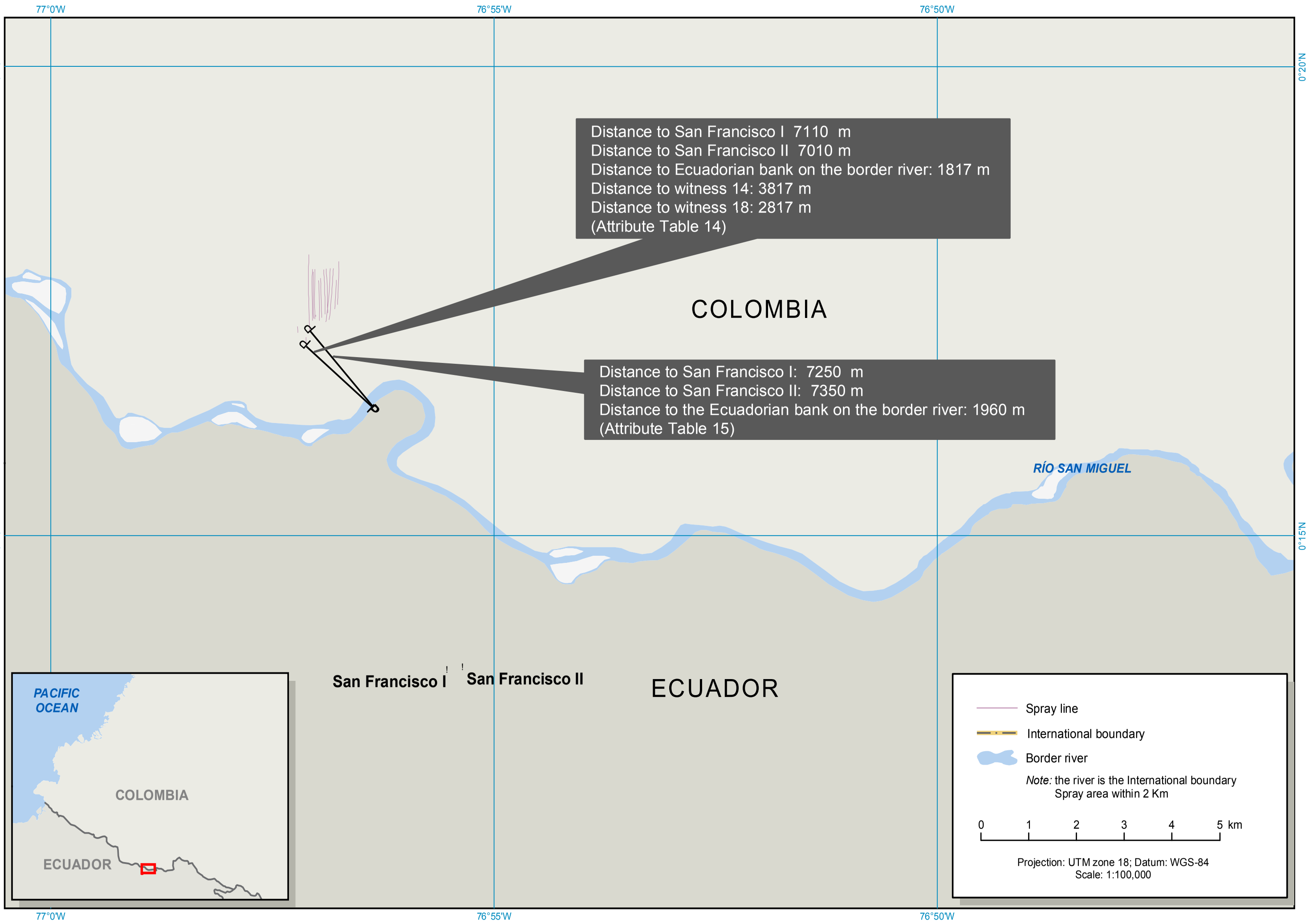
Attribute Table 12

ATTRIBUTE TABLE OF THE SECOND CLOSEST SPRAY LINE TO CORAZON ORENSE IN 2003 (Witness 8)																							
OBJECTID	SEG	FILE_NAME	MISSION	SIDE	LINE	START_TIME	LATITUDE	LONGITUDE	ALTITUDE	DOP	FLT_TIME	FLT_LENGTH	OTE	SPEED	VOLUME	AREA	LOG	LENGTH	MONTH	SWATH	AIRCRAFT	CROP	A_C_CROP
2993	286	G093ABBC.B99	290-1	Right	347	11:18:06:50	0.32928509	-76.73853981	1060	0,630	0,2	50,2	5	171,200	0	0,1153	G093ABBC	15,386	0307	50	T-65	Coca	T-65_Coca
PARAMETERS		09 July 2003				11:18			FEET					MILES/HOUR									

ADDED ATTRIBUTES		
Spray Line Altitude over MSL (Metres)	Ground Altitude over MSL (Metres)	Spray Line Altitude over Ground Level (Metres)
322	276	46

Attribute Table 13

Figure 7 San Francisco I – II, Spray Lines in 2000 (Witnesses 14-18-19)



San Francisco I – II, 2000 (witnesses 14-18-19)

Metadata of the closest spray line

ATTRIBUTE TABLE OF THE CLOSEST SPRAY LINE TO SAN FRANCISCO I Y II IN 2000 (Witnesses 14-18-19)																					
OBJECTID	LINE_ID	TIME	ALTITUDE	XTRACK	MPH	HEADING	S	SPRAY_RATE	DOP	SV	USED	DF	STNID	ASCIINAME	LENGTH	MONTH	SWATH	MISSION	AIRCRAFT	A_C_CROP	CROP
3813	002721	12:59:06.39	1,100	-39,59	194,200	3,600	1	0	1	8	8	0	-1	l260kdac	152,977	0012	50	Coca	T-65	T-65_Coca	Coca
PARAMETERS		12:59	FEET		MILES/HOUR									26 September 2000							

ADDED ATTRIBUTES		
Spray Line Altitude over MSL (Metres)	Ground Altitude over MSL (Metres)	Spray Line Altitude over Ground Level (Metres)
335	281	54

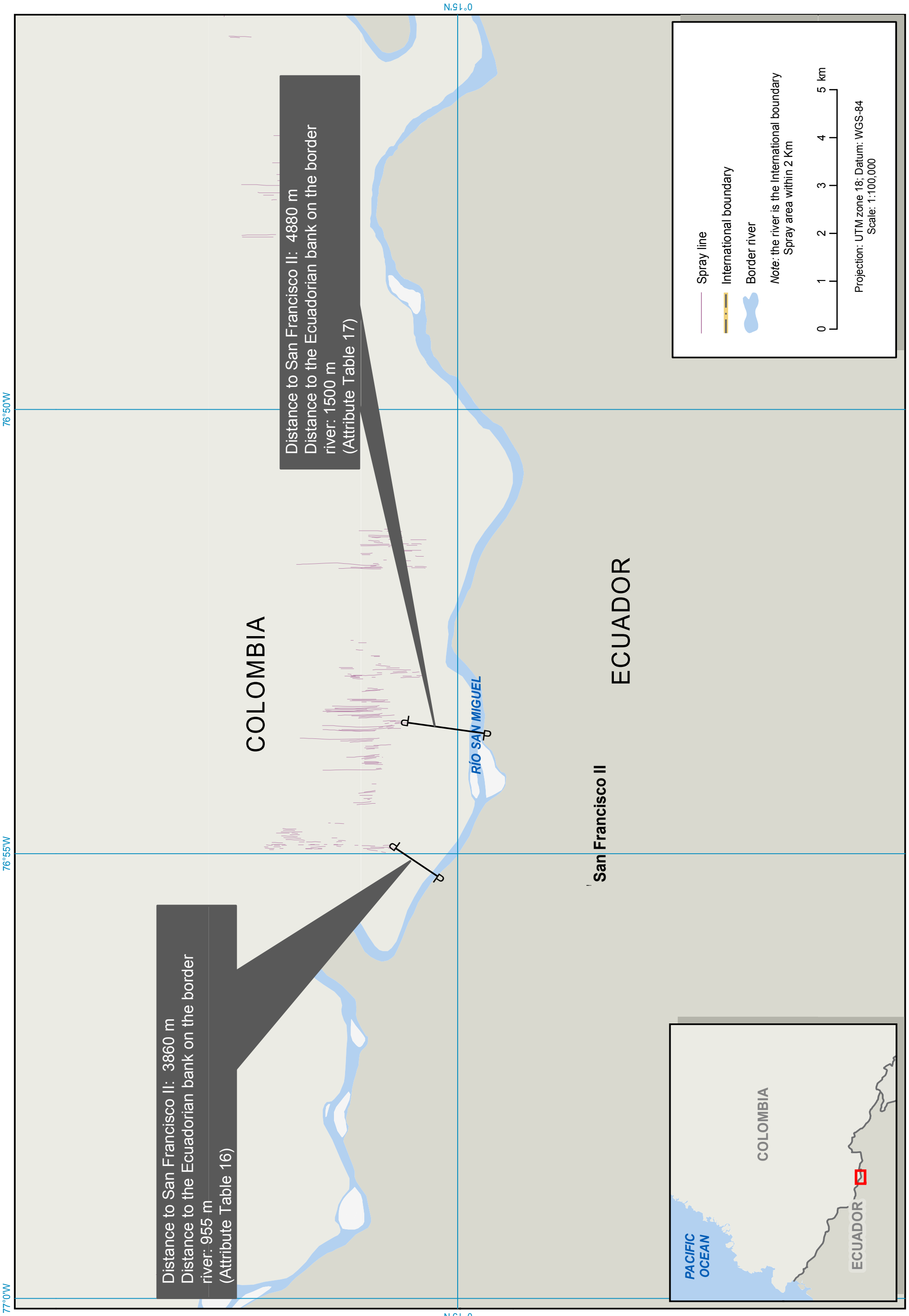
Attribute Table 14

ATTRIBUTE TABLE OF THE SECOND CLOSEST SPRAY LINE TO SAN FRANCISCO I Y II IN 2000 (Witnesses 14-18-19)																					
OBJECTID	LINE_ID	TIME	ALTITUDE	XTRACK	MPH	HEADING	S	SPRAY_RATE	DOP	SV	USED	DF	STNID	ASCIINAME	LENGTH	MONTH	SWATH	MISSION	AIRCRAFT	A_C_CROP	CROP
3360	002748	12:58:57.00	1,100	-81,45	177,280	3,560	1	0	0,900	12	9	12	100	l260cfac	1491,877	0012	50	Coca	T-65	T-65_Coca	Coca
PARAMETERS		12:58	FEET		MILES/HOUR									26 September 2000							

ADDED ATTRIBUTES		
Spray Line Altitude over MSL (Metres)	Ground Altitude over MSL (Metres)	Spray Line Altitude over Ground Level (Metres)
335	282	53

Attribute Table 15

Figure 8 San Francisco II, Spray Lines in 2001 (Witness11)



San Francisco II, 2001 (Witness 11)

Metadata of the closest spray line

ATTRIBUTE TABLE OF THE CLOSEST SPRAY LINE TO SAN FRANCISCO II IN 2001 (Witness 11)																						
FID	LINE_ID	TIME	ALTITUDE	XTRACK	MPH	HEADING	S	SPRAY_RATE	DOP	SV	USED	DF	STNID	ASCIINAME	LENGTH	MONTH	SWATH	TYPE	AIRCRAFT	LOG	SOURCETHM	AC_CROP
8959	003527	13:24:17.48	1,000	-9,94	186,270	1,800	1	10,660	1,100	8	8	0	-1	a271kbac	0,001	0101	50	Coca	T-65	a271kbac	2001_sl_lines.sh	T-65_Coca
PARAMETERS		13:24	FEET		MILES/HOUR									27 January 2001								

ADDED ATTRIBUTES		
Spray Line Altitude over MSL (Metres)	Ground Altitude over MSL (Metres)	Spray Line Altitude over Ground Level (Metres)
304	274	30

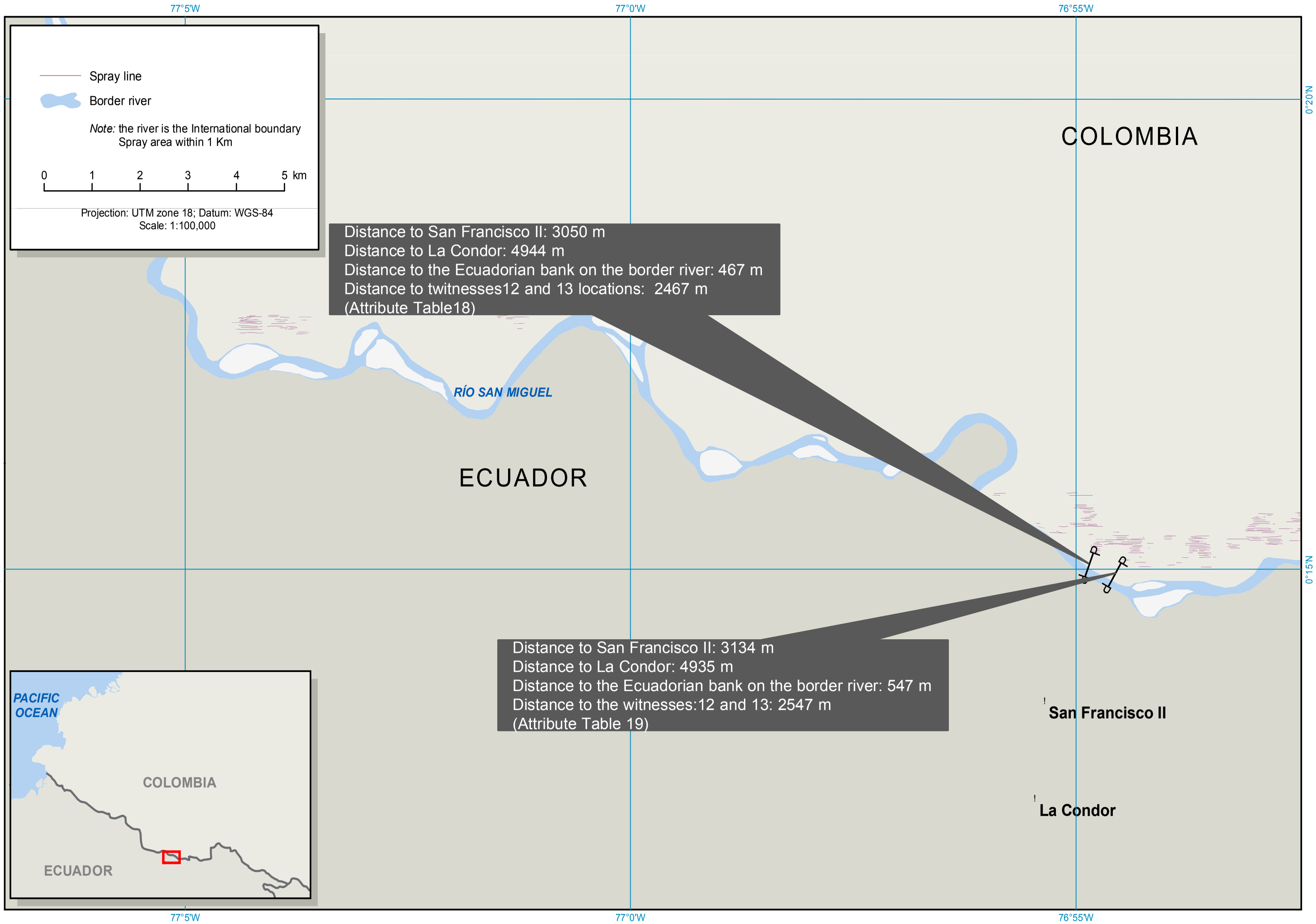
Attribute Table 16

ATTRIBUTE TABLE OF THE SECOND CLOSEST SPRAY LINE TO SAN FRANCISCO II IN 2001 (Witness 11)																						
FID	LINE_ID	TIME	ALTITUDE	XTRACK	MPH	HEADING	S	SPRAY_RATE	DOP	SV	USED	DF	STNID	ASCIINAME	LENGTH	MONTH	SWATH	TYPE	AIRCRAFT	LOG	SOURCETHM	AC_CROP
8254	001979	12:52:41.20	1,200	137,11	163,280	1,730	2	0,000	1,700	10	10	0	-1	a241jddc	0,002	0101	50	Coca	T-65	a241jddc	2001_sl_lines.sh	T-65_Coca
PARAMETERS		12:52	FEET		MILES/HOUR									24 January 2001								

ADDED ATTRIBUTES		
Spray Line Altitude over MSL (Metres)	Ground Altitude over MSL (Metres)	Spray Line Altitude over Ground Level (Metres)
365	287	78

Attribute Table 17

Figure 9 San Francisco II y La Cóndor, Spray Lines in 2002 (Witnesses 12-13-17)



San Francisco II and La Condor, 2002 (Witnesses 12 - 13)

Metadata of the closest spray line

ATTRIBUTE TABLE OF THE CLOSEST SPRAY LINE TO SAN FRANCISCO II IN 2002 (Witnesses 12-13)

OBJECTID	SEG	FILE_NAME	MISSION	SIDE	LINE	START_TIME	LATITUDE	LONGITUDE	ALTITUDE	DOP	FLT_TIME	FLT_LENGTH	OTE	SPEED	VOLUME	AREA	LOG	LENGTH	MONTH	SWATH	AIRCRAFT	CROP	A_C_CROP
15724	528	I222A#DC.B99	301-1	Right	168	10:59:30:80	0.25294071	-76.91334732	1068	0,890	0,1	20	19,900	136,100	0	0	I222A#CC	6,077	0209	50	T-65	Coca	T-65_Coca
PARAMETERS		22 September 2002				10:59			FEET					MILES/HOUR									

ADDED ATTRIBUTES		
Spray Line Altitude over MSL (Metres)	Ground Altitude over MSL (Metres)	Spray Line Altitude over Ground Level (Metres)
324	279	45

Attribute Table 18

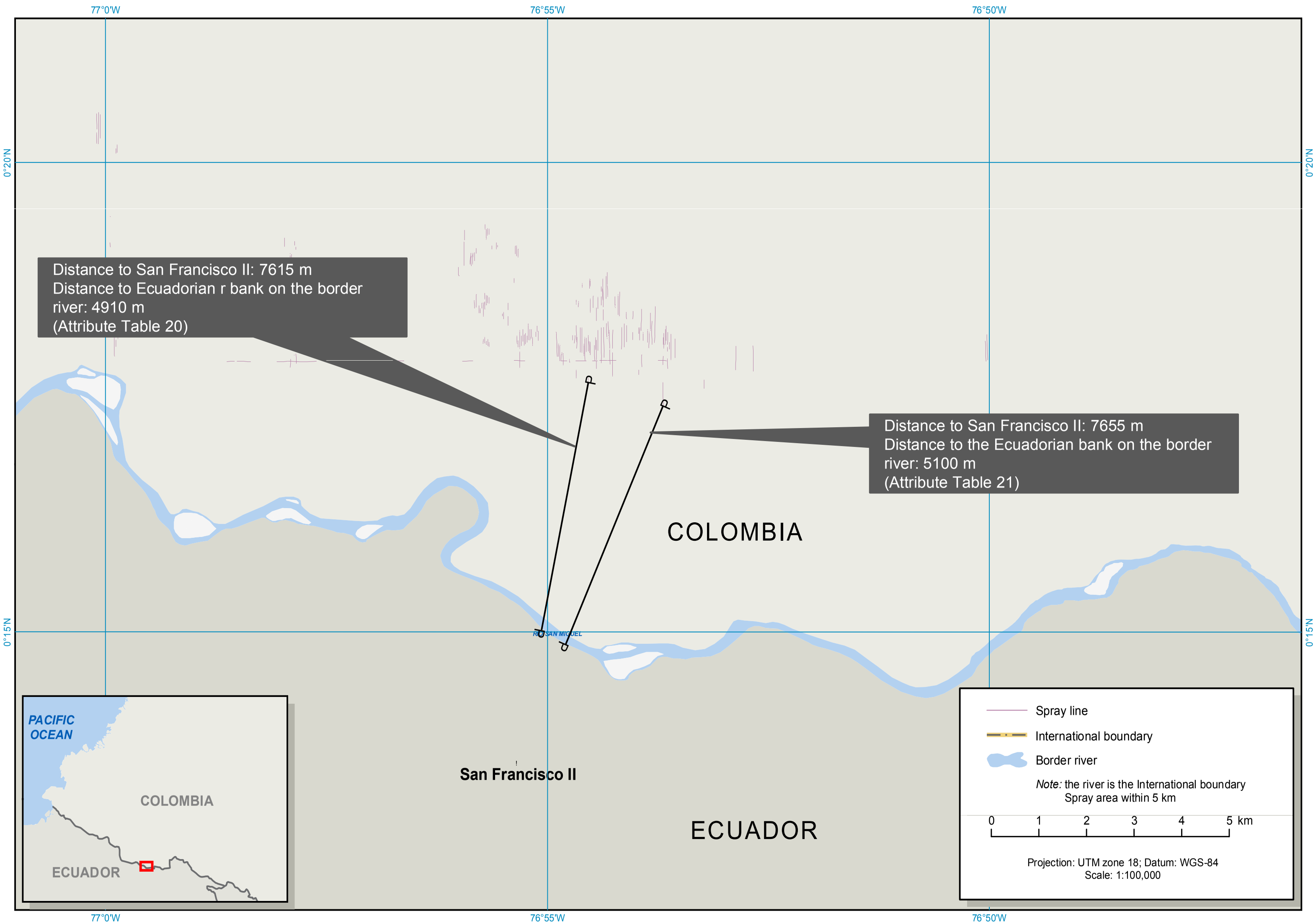
ATTRIBUTE TABLE OF THE SECOND CLOSEST SPRAY LINE TO SAN FRANCISCO II IN 2002 (Witnesses 12-13)

OBJECTID	SEG	FILE_NAME	MISSION	SIDE	LINE	START_TIME	LATITUDE	LONGITUDE	ALTITUDE	DOP	FLT_TIME	FLT_LENGTH	OTE	SPEED	VOLUME	AREA	LOG	LENGTH	MONTH	SWATH	AIRCRAFT	CROP	A_C_CROP
15758	562	I222A#DC.B99	301-1	Right	174	11:05:10:20	0.25123216	-76.90809108	1062	0,770	0,1	21	0,100	143,300	0	0	I222A#CC	6,399	0209	50	T-65	Coca	T-65_Coca
PARAMETERS		22 September 2002				11:05			FEET					MILES/HOUR									

ADDED ATTRIBUTES		
Spray Line Altitude over MSL (Metres)	Ground Altitude over MSL (Metres)	Spray Line Altitude over Ground Level (Metres)
322	279	43

Attribute Table 19

Figure 10 San Francisco II, Spray Lines in 2003 (Witnesses11-17)



San Francisco II, 2003 (Witness 11)

Metadata of the closest spray line

ATTRIBUTE TABLE OF THE CLOSEST SPRAY LINE TO SAN FRANCISCO II IN 2003 (Witness 11)																							
OBJECTID	SEG	FILE_NAME	MISSION	SIDE	LINE	START_TIME	LATITUDE	LONGITUDE	ALTITUDE	DOP	FLT_TIME	FLT_LENGTH	OTE	SPEED	VOLUME	AREA	LOG	LENGTH	MONTH	SWATH	AIRCRAFT	CROP	A_C_CROP
2701	730	G103JJDC.B99	289-1	Right	333	14:04:35:80	0.29445543	-76.90890373	1173	0,770	0,1	26,1	33	178,300	2,5	0,060	G103JJDC	7,959	0307	50	T-65	Coca	T-65_Coca
PARAMETERS		10 July 2003				14:04			FEET					MILES/HOUR									

ADDED ATTRIBUTES		
Spray Line Altitude over MSL (Metres)	Ground Altitude over MSL (Metres)	Spray Line Altitude over Ground Level (Metres)
356	293	63

Attribute Table 20

ATTRIBUTE TABLE OF THE SECOND CLOSEST SPRAY LINE TO SAN FRANCISCO II IN 2003 (Witness 11)																							
OBJECTID	SEG	FILE_NAME	MISSION	SIDE	LINE	START_TIME	LATITUDE	LONGITUDE	ALTITUDE	DOP	FLT_TIME	FLT_LENGTH	OTE	SPEED	VOLUME	AREA	LOG	LENGTH	MONTH	SWATH	AIRCRAFT	CROP	A_C_CROP
1412	291	G143CJAC.B99	289-1	Right	385	10:02:15:30	0.29426431	-76.89484179	1135	0,770	6,1	1504,2	27,500	168,100	2,500	3,453	G143CJAC	458,599	0307	50	T-65	Coca	T-65_Coca
PARAMETERS		14 July 2003				10:02			FEET					MILES/HOUR									

ADDED ATTRIBUTES		
Spray Line Altitude over MSL (Metres)	Ground Altitude over MSL (Metres)	Spray Line Altitude over Ground Level (Metres)
345	296	49

Attribute Table 21

Figure 11 Reserva Cofàn Bermejo, Spray Lines in 2000 (Witnesses 26-27-29-31)

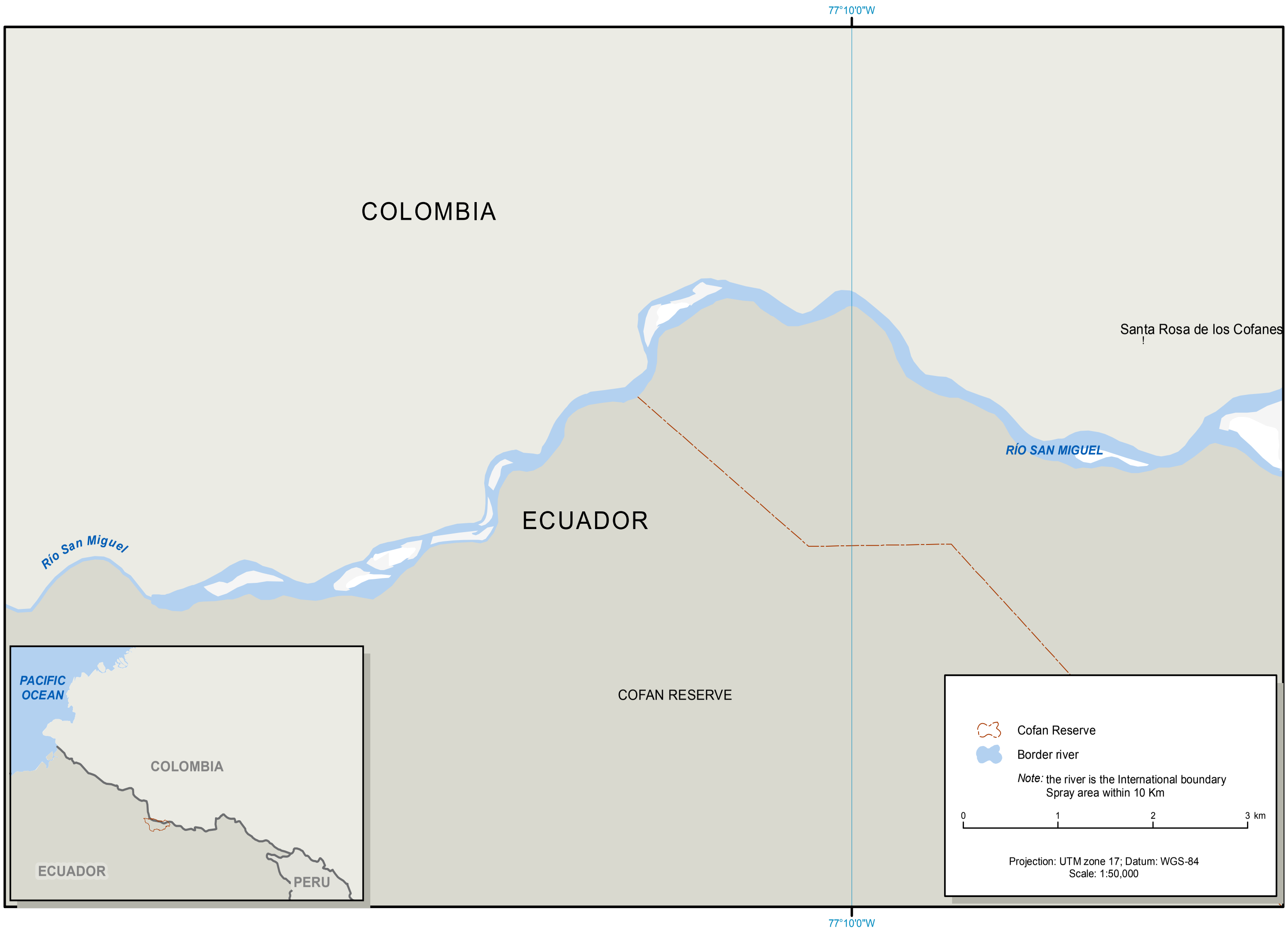


Figure 12 Reserva Cofàn Bermejo, Spray Lines in 2001 (Witnesses 26-27-29-31)

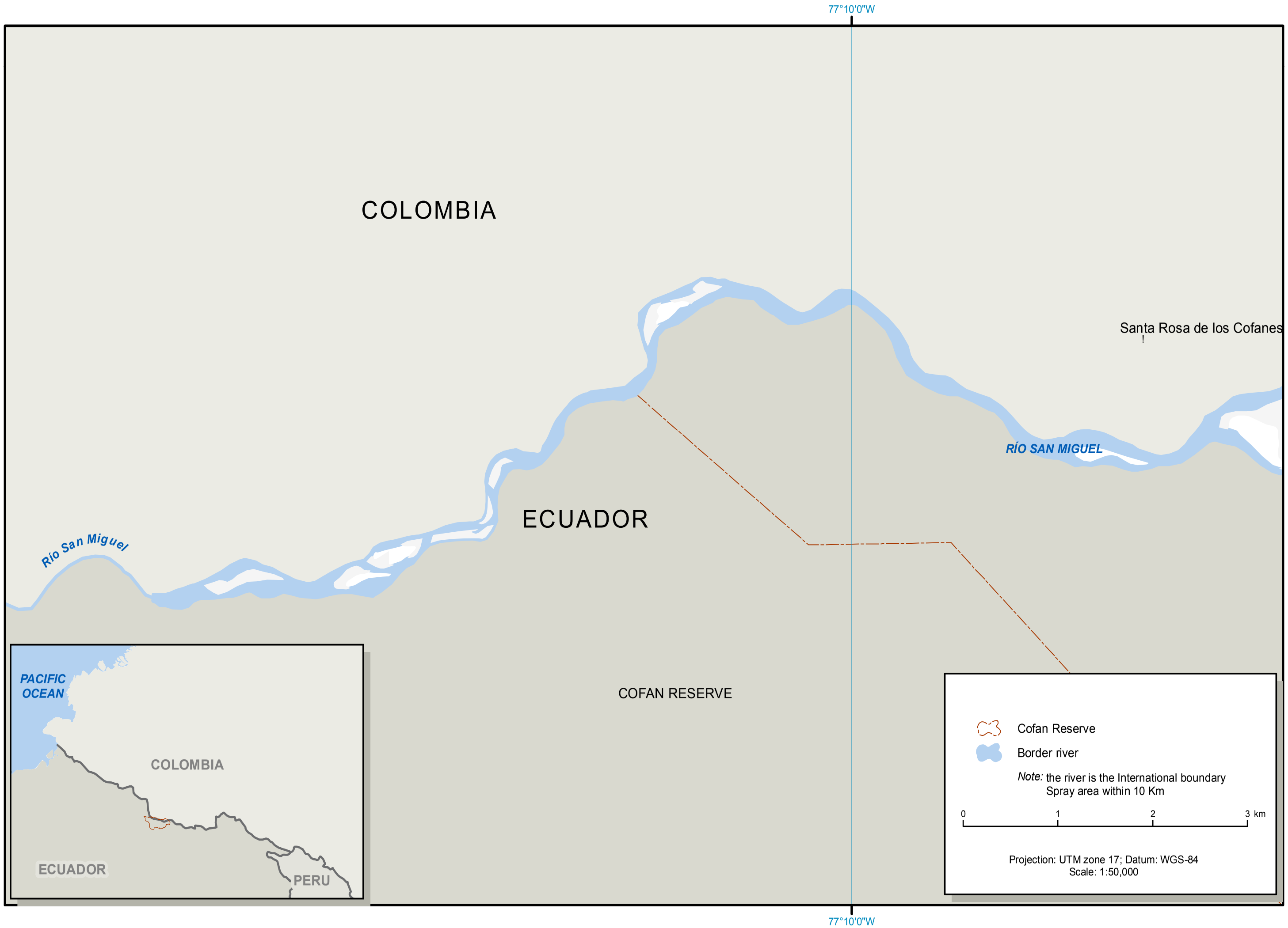
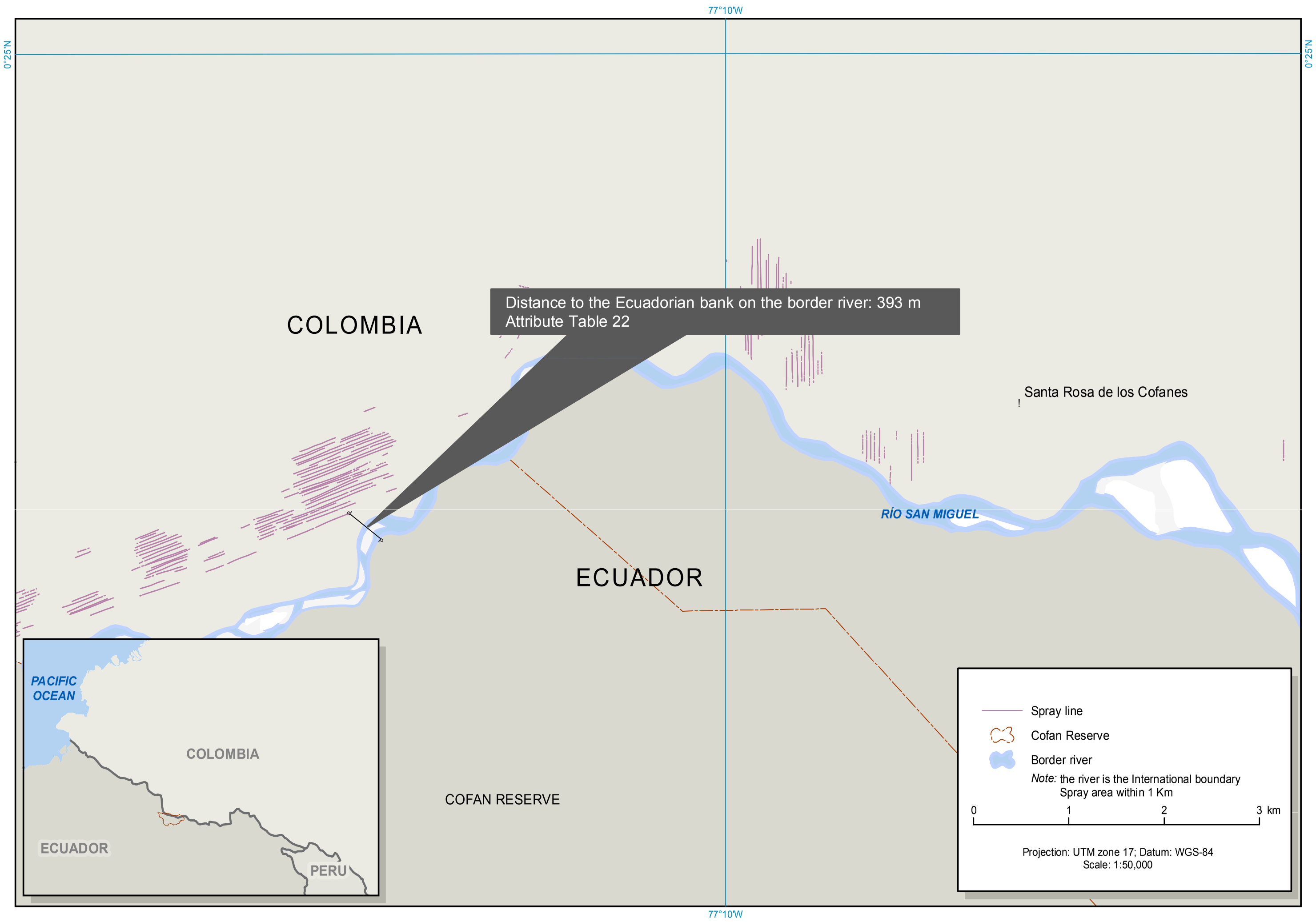


Figure 13 Cofán Bermejo Reserve, Spray Lines in 2002 (Witnesses 26-27-29-31)



Cofán Bermejo Reserve, 2002 (Witnesses 26-27-29-31)

Metadata of the closest spray lines

METADATO SEGUNDA LINEA DE ASPERSION MAS CERCANA COFAN BERMEJO 2002 (Witnesses 26-27-29-31)																							
OBJECTID	SEG	FILE_NAME	MISSION	SIDE	LINE	START_TIME	LATITUDE	LONGITUDE	ALTITUDE	DOP	FLT_TIME	FLT_LENGTH	OTE	SPEED	VOLUME	AREA	LOG	LENGTH	MONTH	SWATH	AIRCRAFT	CROP	A_C_CROP
15196	358	I262A1BC.B99	287-3	Right	64	12:12:06:60	0.37580771	-77.20217690	1392	0,890	0,1	20,9	3,700	142,200	2,600	0	I262A1BC	6,363	0209	50	T-65	Coca	T-65_Coca
PARAMETERS		26 SEPTEMBER 2002				12:12			FEET					MILES/HOUR									

ADDED ATTRIBUTES		
Spray Line Altitude over MSL (Metres)	Ground Altitude over MSL (Metres)	Spray Line Altitude over Ground Level (Metres)
423	362	61

Attribute Table 22

Figure 14 Cofán Bermejo Reserve, Spray Lines in 2003 (Witnesses 26-27-29-31)

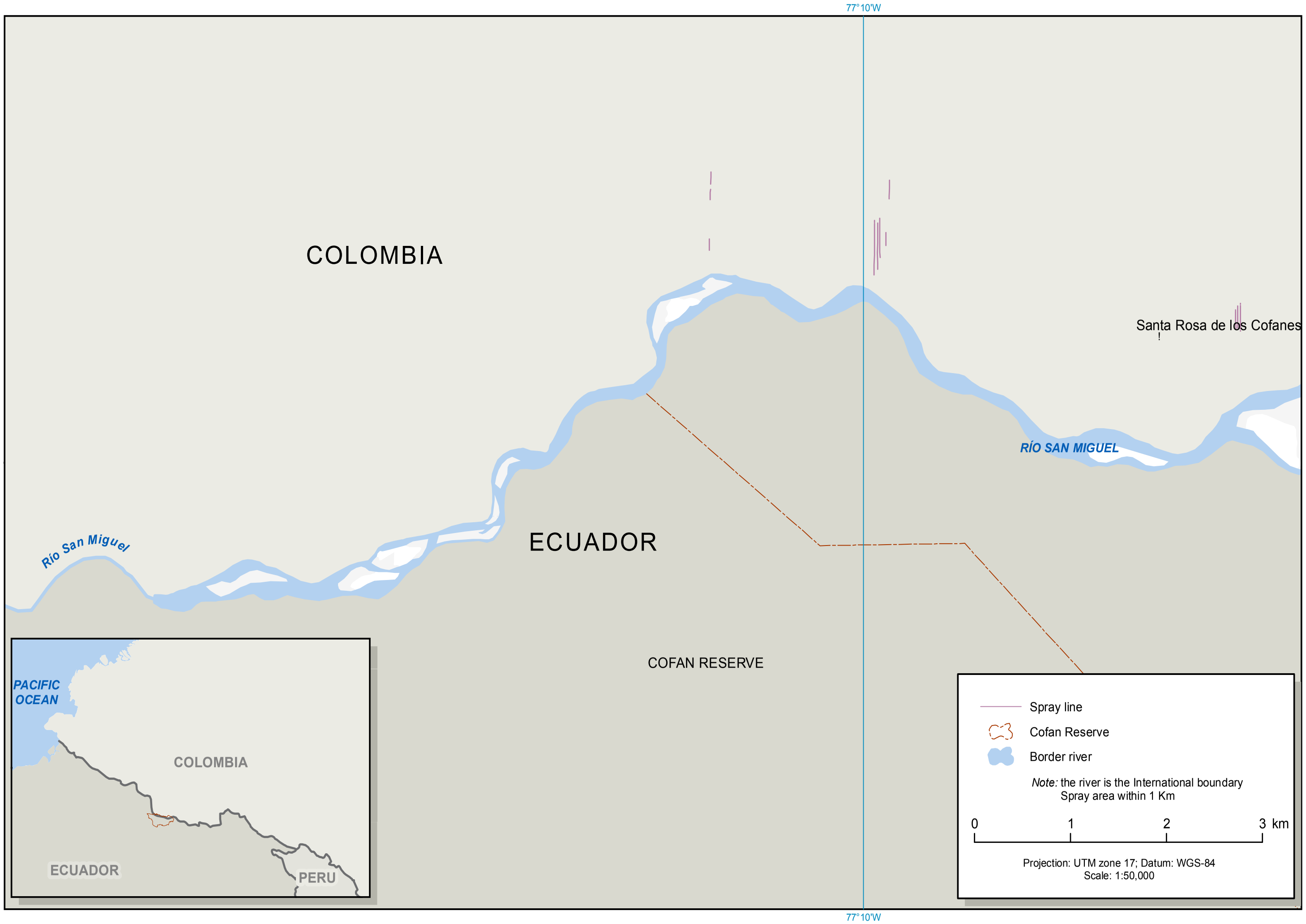
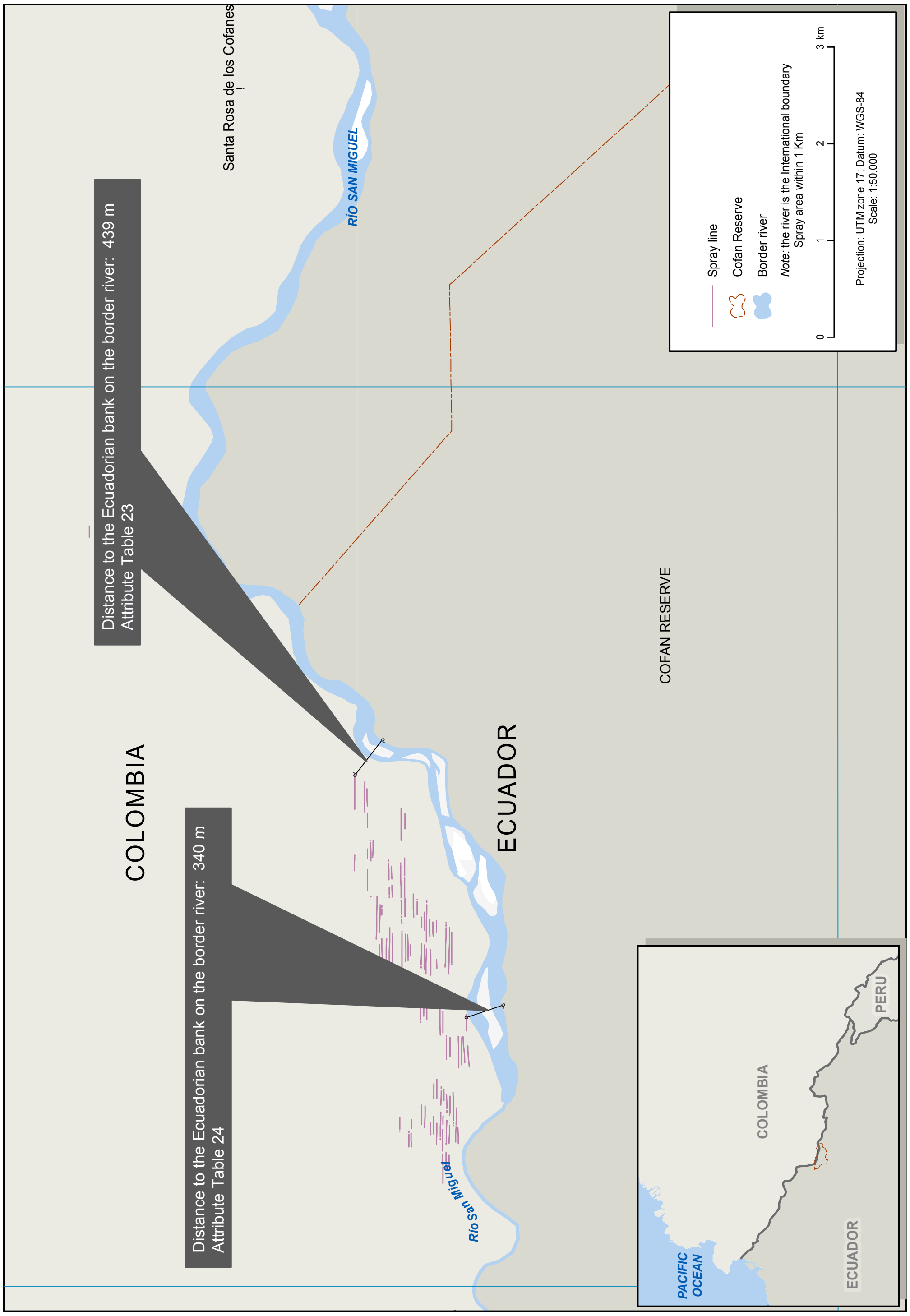


Figure 15 Cofán Bermejo, Spray Lines in 2004 (Witnesses 26-27-29-31)



Cofan Bermejo, 2004 (Witnesses 26-27-29-31)

Metadata of the closest spray lines

ATRIBUTE TABLE OF THE CLOSEST SPRAY LINE TO COFAN BERMEJO IN 2004 (Witnesses 26-27-29-31)																						
OBJECTID	SEG	FILE_NAME	MISSION	SIDE	LINE	START_TIME	LATITUDE	LONGITUDE	ALTITUDE	DOP	FLT_TIME	FLT_LENGTH	OTE	SPEED	VOLUME	AREA	LENGTH	MONTH	SWATH	AIRCRAFT	AC_CROP	CROP
947	4399	L244A1AC.B01	287-1	Right	51	8:27:20:30	0.37561924	-77.20586656	1322	0,77	4,7	1116,1	4,400	161,900	2,5	2,562	341,92	0412	50	T-65	T-65_Coca	Coca
PARAMETERS		24 December 2004				08:27			FEET					MILES/HOUR								

ADDED ATTRIBUTES		
Spray Line Altitude over MSL (Metres)	Ground Altitude over MSL (Metres)	Spray Line Altitude over Ground Level (Metres)
403	380	23

Attribute Table 23

ATTRIBUTE TABLE OF THE SECOND CLOSEST SPRAY LINE TO COFAN BERMEJO IN 2004 (Witnesses 26-27-29-31)																						
OBJECTID	SEG	FILE_NAME	MISSION	SIDE	LINE	START_TIME	LATITUDE	LONGITUDE	ALTITUDE	DOP	FLT_TIME	FLT_LENGTH	OTE	SPEED	VOLUME	AREA	LENGTH	MONTH	SWATH	AIRCRAFT	AC_CROP	CROP
817	4264	L244A1AC.B01	287-1	Right	15	7:55:48:70	0.36581905	-77.22639118	1409	0,8	2,1	484,9	53	157,400	2,2	1,113	148,078	0412	50	T-65	T-65_Coca	Coca
PARAMETERS		24 DECEMBER 2004				07:55			FEET					MILES/HOUR								

ADDED ATTRIBUTES		
Spray Line Altitude over MSL (Metres)	Ground Altitude over MSL (Metres)	Spray Line Altitude over Ground Level (Metres)
429	396	33

Attribute Table 24

Figure 16 Cofán Bermejo Reserve, Spray Lines in 2005 (Witnesses 26-27-29-31)

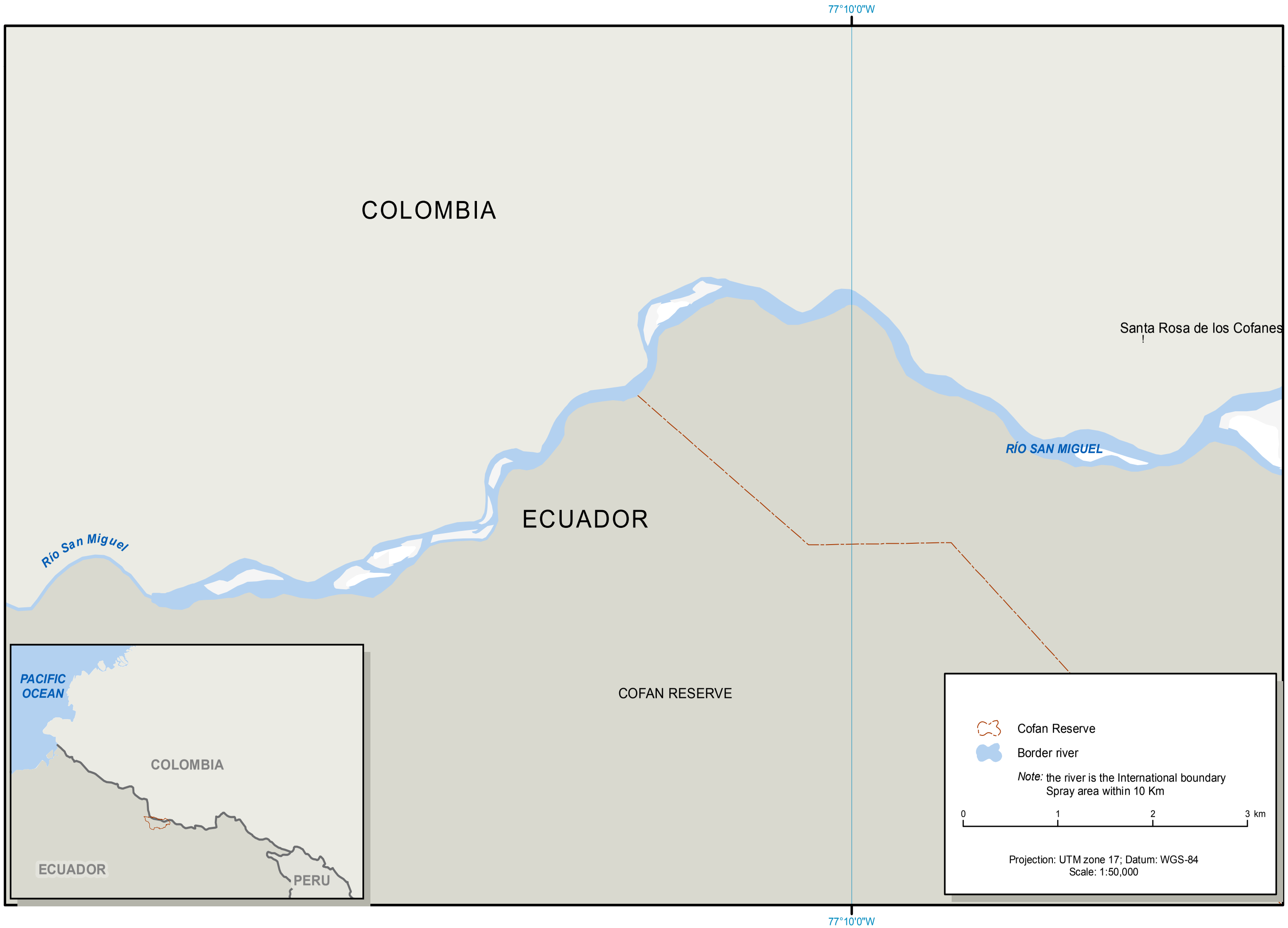
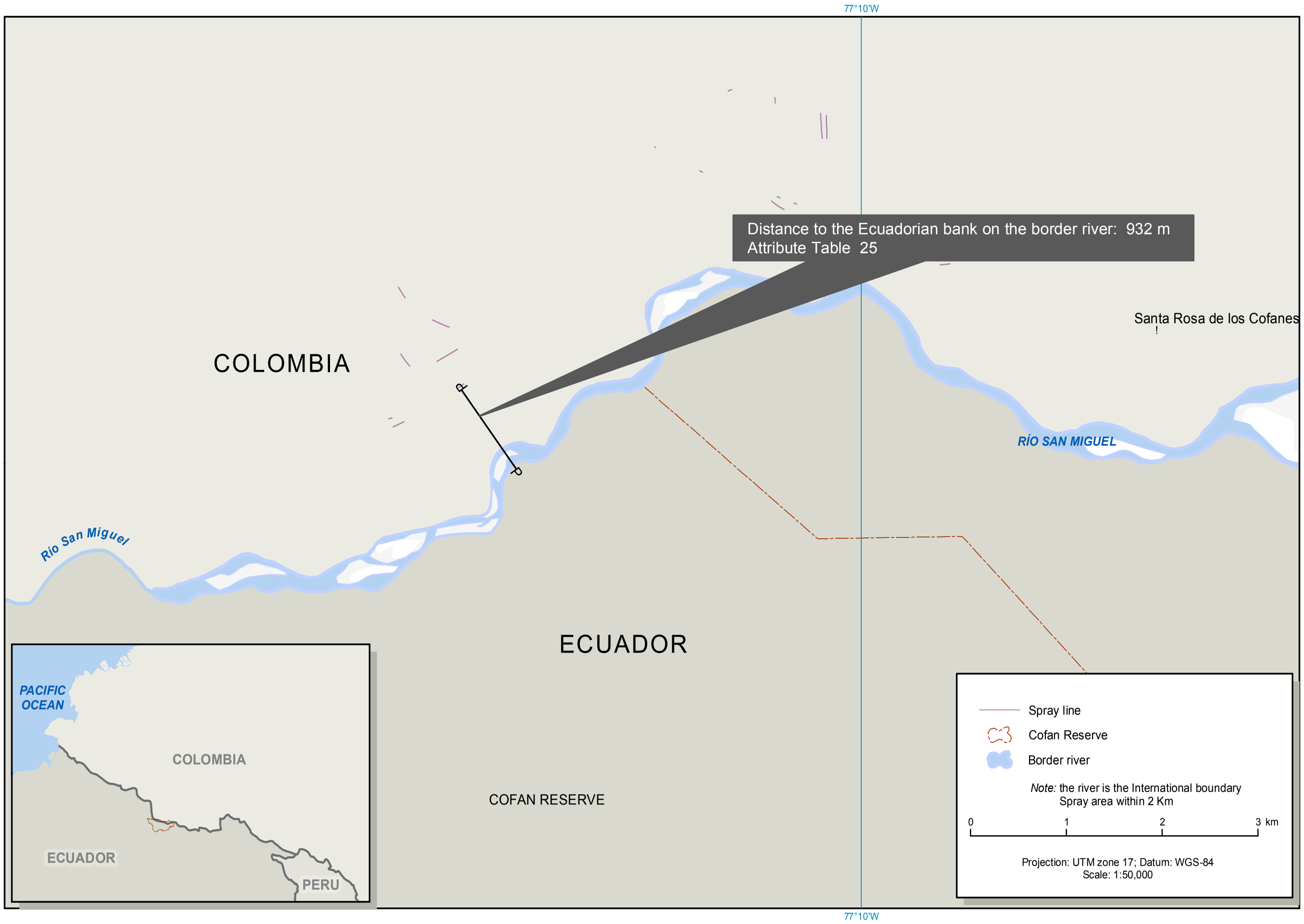


Figure 17 Cofán Bermejo, Spray Lines in 2006 (Witnesses 26-27-29-31)

Figure 18 Cofán Bermejo Reserve, Spray Lines in 2007 (Witnesses 26-27-29-31)



Cofan Bermejo, 2007 (Witnesses 26-27-29-31)

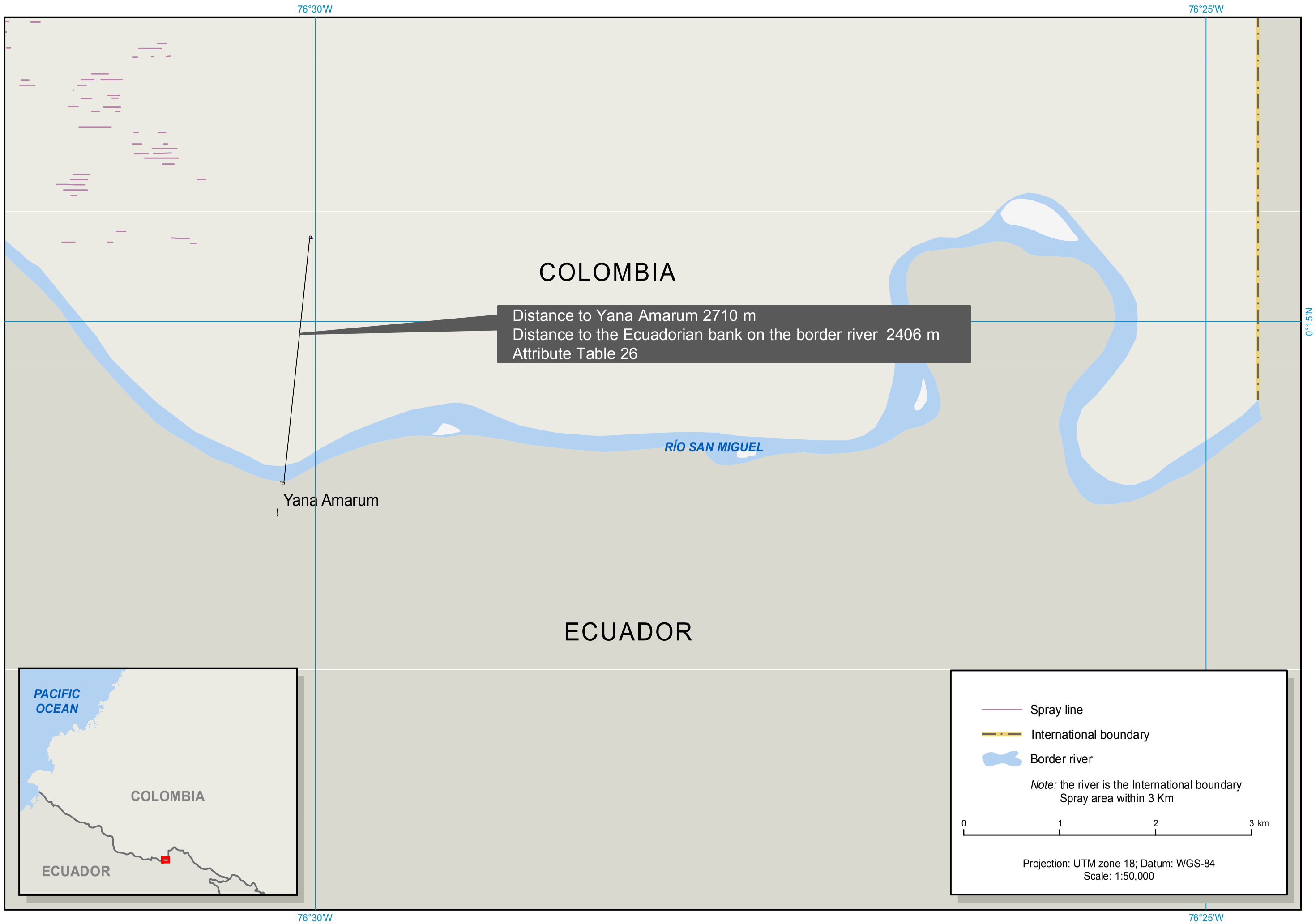
Metadata of the closest spray lines

METADATO LINEA DE ASPERSION MAS CERCANA COFAN BERMEJO 2007 (Witnesses 26-27-29-31)																							
FID	SEG	FILE_NAME	MISSION	SIDE	LINE	START_TIME	LATITUDE	LONGITUDE	ALTITUDE	DOP	FLT_TIME	FLT_LENGTH	OTE	SPEED	VOLUME	AREA	LENGTH	MONTH	SWATH	AIRCRAFT	AC_CROP	GROUP
70	4257	A147&VAC.B99	287-3	- - -	1	21:17:48:99	0.38050949	-77.20436179	416	1,100	0,76	64,023	4195,700	188,400	5,900	0,332	64,048	0701	85	AT802	AT802_Coca	Lobo
PARAMETERS		14 JANUARY 2007				11:17			METERS					MILES/HOUR								

ADDED ATTRIBUTES	
Ground Altitude over MSL (Metres)	Spray Line Altitude over
367	49

Attribute Table 25

Figure 19 Yana Amarum, Spray Lines in 2002 (Witness 28)



Yana Amarum, 2002 (Witness 28)

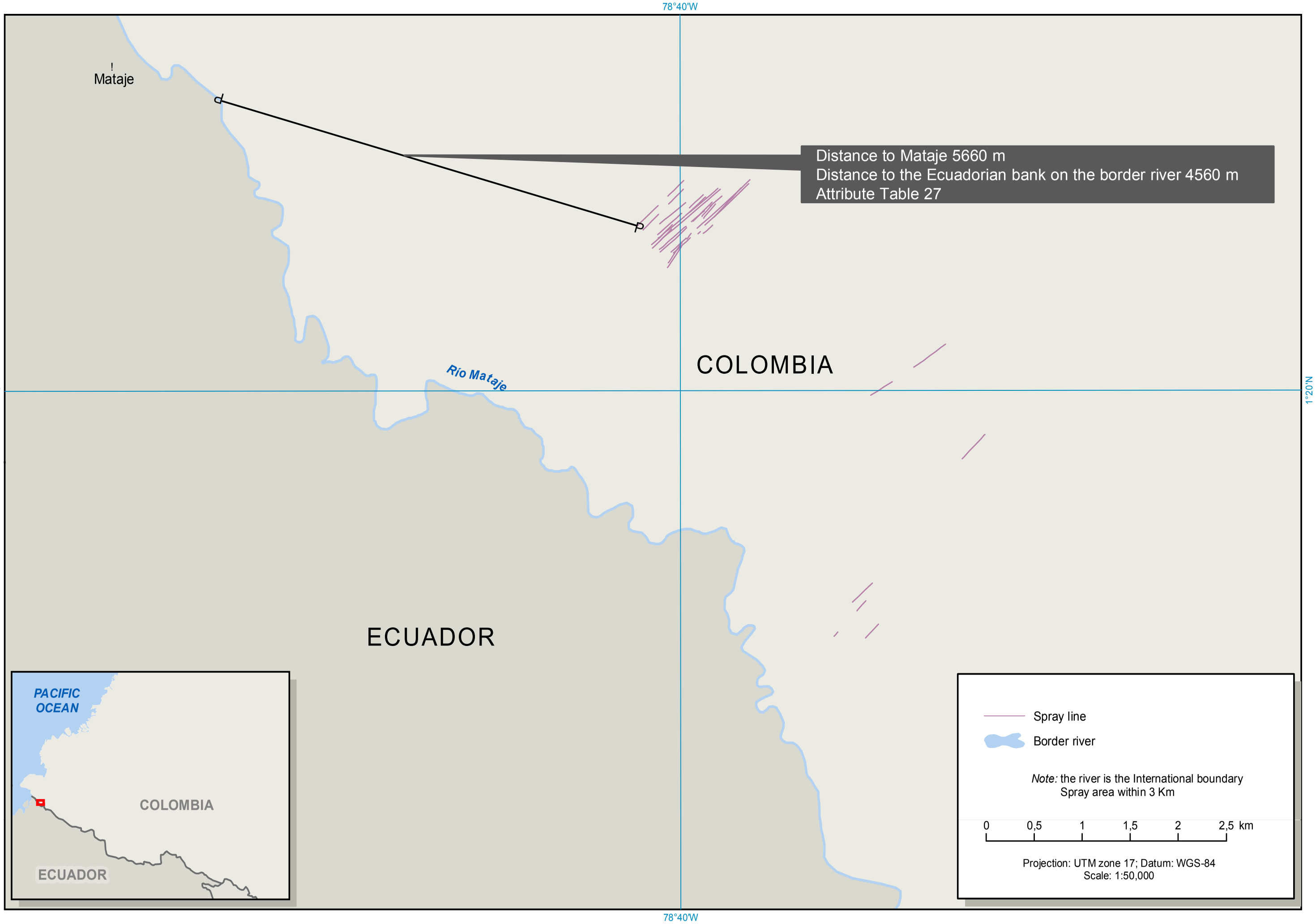
Metadata of the closest spray lines

METADATO LINEA DE ASPERSION MAS CERCANA YANA AMARUM 2002 (Witness 28)																						
OBJECTID	SEG	FILE_NAME	MISSION	SIDE	LINE	START_TIME	LATITUDE	LONGITUDE	ALTITUDE	DOP	FLT_TIME	FLT_LENGTH	OTE	SPEED	VOLUME	AREA	LOG	LENGTH	MONTH	SWATH	AIRCRAFT	CROP	A_C_CROP
1638	51	J032YSCC.B99	303-1	Right	163	18:06:45:90	0.25738970	-76.50050188	1007	0,890	0,4	118,6	1,800	202,200	2,700	0	J032YSCC	36,163	0210	85	OV-10	Coca	OV-10_Coca
PARAMETERS		03 DE OCTUBRE 2002				13:06			FEET					MILES/HOUR									

ADDED ATTRIBUTES		
Spray Line Altitude over MSL (Metres)	Ground Altitude over MSL (Metres)	Spray Line Altitude over Ground Level (Metres)
306	266	40

Attribute Table 26

Figure 20 Mataje , Spray Lines in 2000 (Witnesses 30-32-33-34-36-37-38-39)



Mataje, 2000 (Witnesses) 30-32-33-34-36-37-38-39

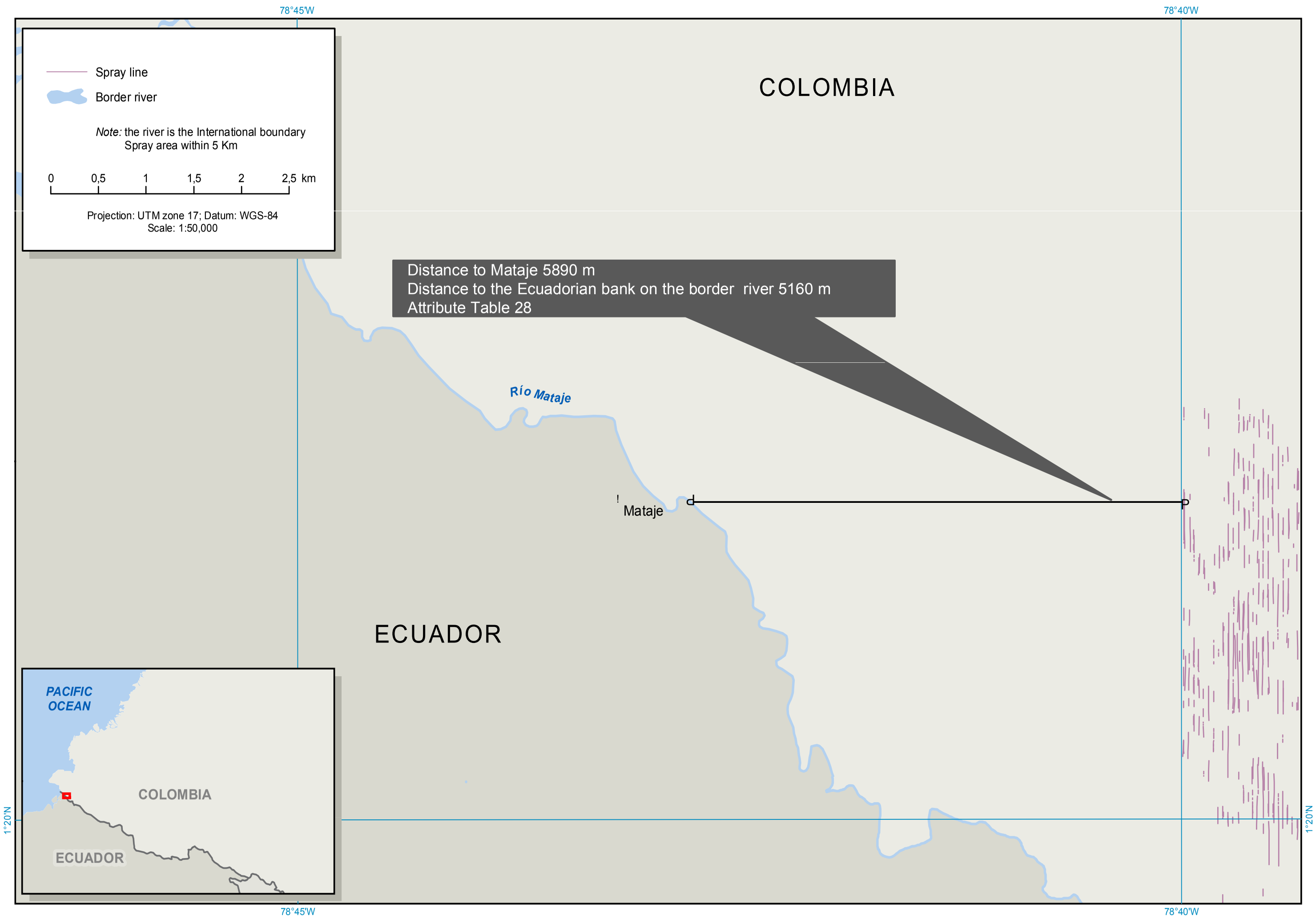
Metadata of the closest spray lines

ATTRIBUTE TABLE OF THE CLOSEST SPRAY LINE TO MATAJE IN 2000 (Witnesses 30-32-33-34-36-37-38-39)																					
OBJECTID	LINE_ID	TIME	ALTITUDE	XTRACK	MPH	HEADING	S	SPRAY_RATE	DOP	SV	USED	DF	STNID	ASCIINAME	LENGTH	MONTH	SWATH	MISSION	AIRCRAFT	A_C_CROP	CROP
932	002835	11:39:53.24	497,500	-249,73	151,900	46,400	1	62,390	0,800	10	9	0	-1	i140djac	296,179	0009	50	Coca	T-65	T-65_Coca	Coca
PARAMETERS		11:39	FEET		MILES/HOUR									14 September 2000							

ADDED ATTRIBUTES		
Spray Line Altitude over MSL (Metres)	Ground Altitude over MSL (Metres)	Spray Line Altitude over Ground Level (Metres)
151	97	54

Attribute Table 27

Figure 21 Mataje, Spray Lines in 2002 (Witness 32)



Mataje, 2002 (Witness 32)

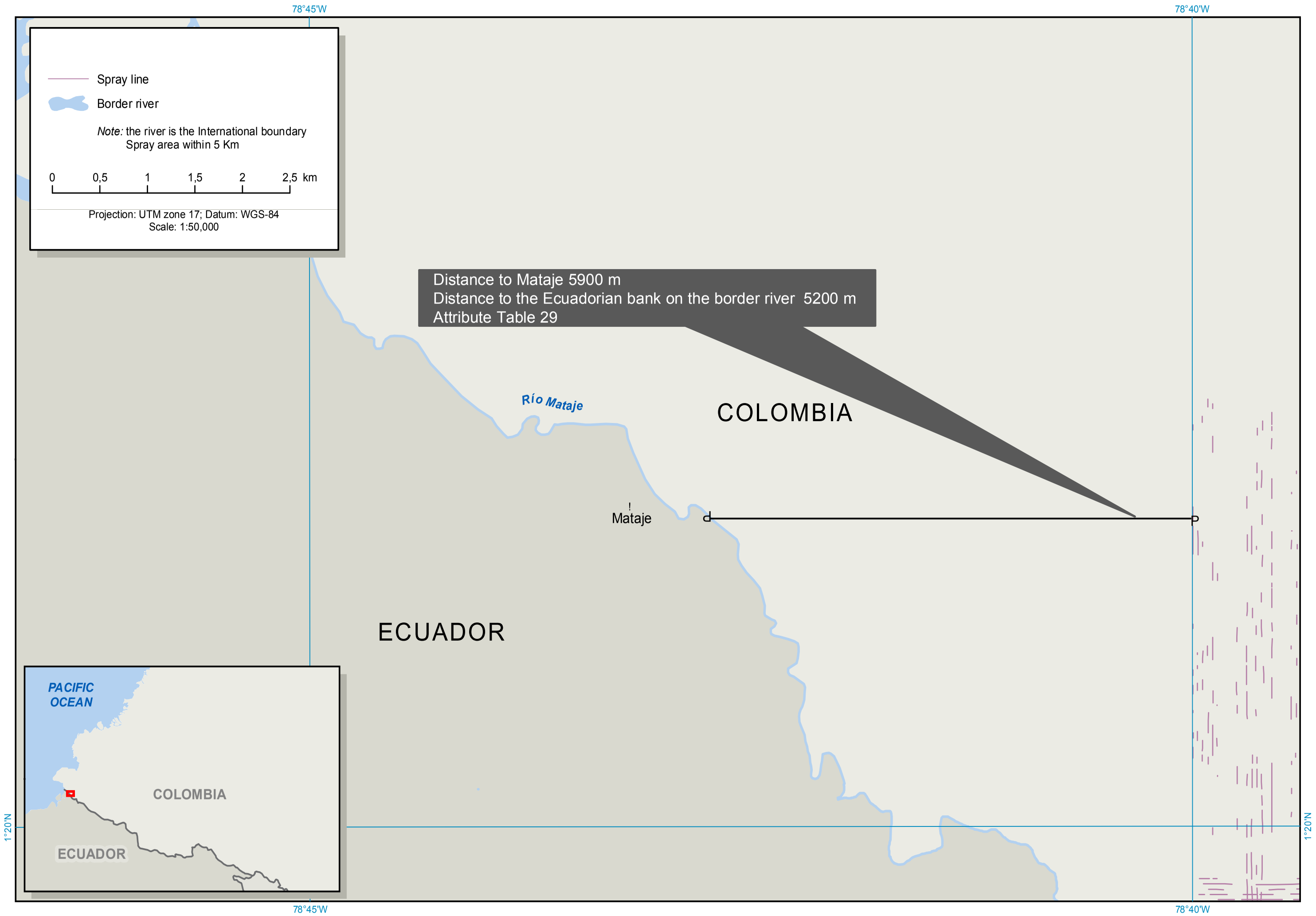
Metadata of the closest spray line

METADATO LINEA DE ASPERSION MAS CERCANA MATAJE 2002 (Witness 32)																							
OBJECTID	SEG	FILE_NAME	MISSION	SIDE	LINE	START_TIME	LATITUDE	LONGITUDE	ALTITUDE	DOP	FLT_TIME	FLT_LENGTH	OTE	SPEED	VOLUME	AREA	LOG	LENGTH	MONTH	SWATH	AIRCRAFT	CROP	A_C_CROP
2905	240	B202U$CC.B99	93-3	- - -	1	18:46:34:68	1.36273717	-78.66644455	391	0	5,3	1639,6	19,100	208,900	2,5	0	B202U$CC	500,347	0202	85	OV-10	Coca	OV-10_Coca
PARAMETERS		20 DE FEBRERO 2002				13:46			METERS					MILES/HOUR									

ADDED ATTRIBUTES		
Spray Line Altitude over MSL (Metres)	Ground Altitude over MSL (Metres)	Spray Line Altitude over Ground Level (Metres)
119	87	32

Attribute Table 28

Figure 22 Mataje, Spray Lines in 2003 (Witness 32)



Mataje, 2003 (Witness 32)

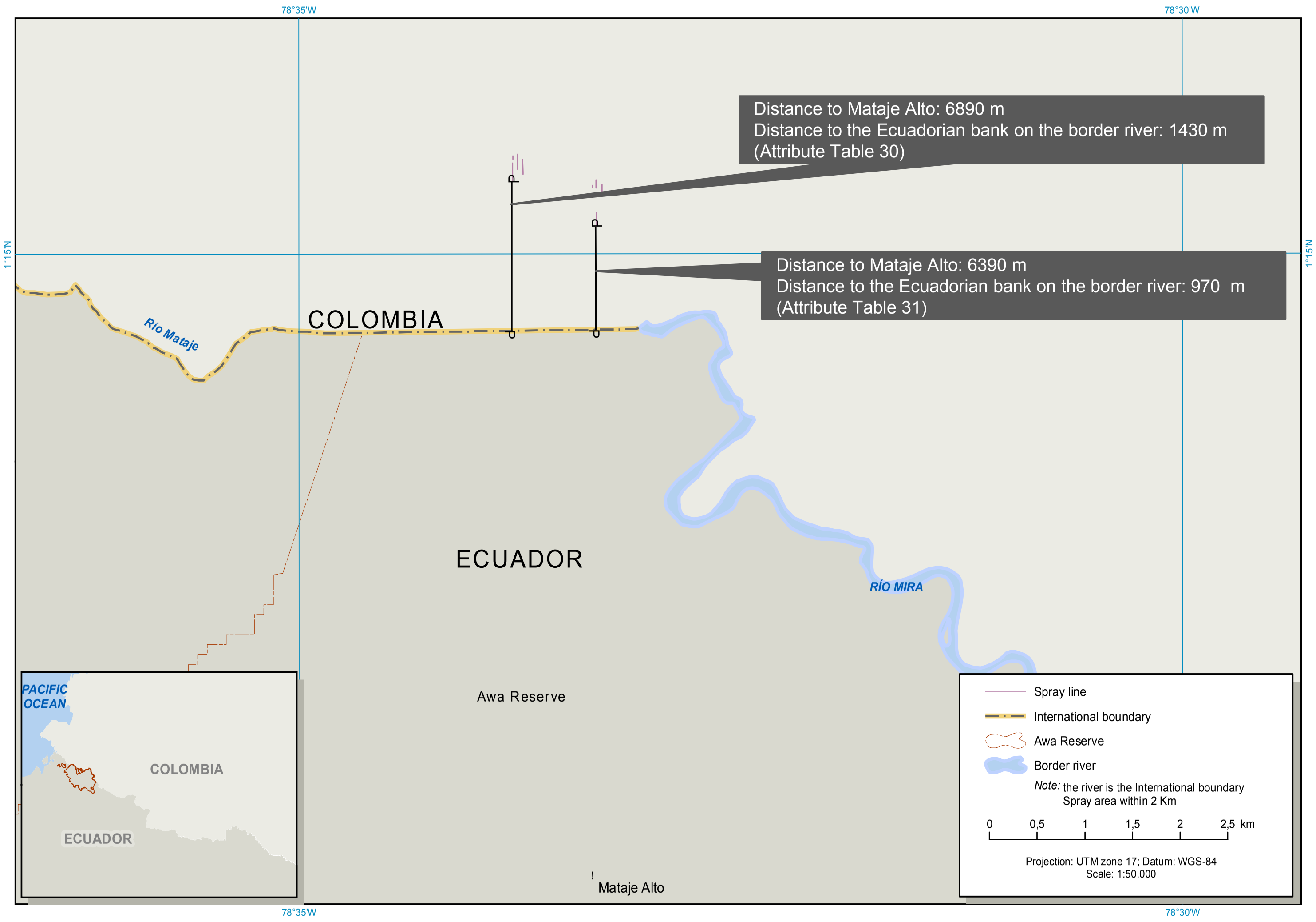
Metadata of the closest spray line

METADATO LINEA DE ASPERSION MAS CERCANA MATAJE 2003 (Witness 32)																						
OBJECTID	SEG	FILE_NAME	MISSION	SIDE	LINE	START_TIME	LATITUDE	LONGITUDE	ALTITUDE	DOP	FLT_TIME	FLT_LENGTH	OTE	SPEED	VOLUME	AREA	LOG	LENGTH	MONTH	SWATH	AIRCRAFT	CROP	A_C_CROP
16457	928	A20325BC.B99	93-1	- - -	1	15:06:19:15	1.36189819	-78.66664757	409	0,890	1,85	453,2	1,400	167,000	2,600	0,549	A20325BC	138,853	0301	85	AT802	Coca	AT802_Coca
PARAMETERS		20 DE ENERO 2003				15:06			FEET					MILES/HOUR									

ADDED ATTRIBUTES		
Spray Line Altitude over MSL (Metres)	Ground Altitude over MSL (Metres)	Spray Line Altitude over Ground Level (Metres)
124	89	35

Attribute Table 29

Figure 23 Awa - Mataje Alto, Spray Lines in 2002 (Witnesses 40-41)



Mataje Alto, 2002 (Witnesses 40 - 41)

Metadata of the closest spray lines

ATTRIBUTE TABLE OF THE CLOSEST SPRAY LINE TO MATAJE ALTO IN 2002 (Witness 41)																							
FID	SEG	FILE_NAME	MISSION	SIDE	LINE	START_TIME	LATITUDE	LONGITUDE	ALTITUDE	DOP	FLT_TIME	FLT_LENGTH	OTE	SPEED	VOLUME	AREA	LOG	LENGTH	MONTH	SWATH	AIRCRAFT	CROP	A_C_CROP
5051	66	E142Q4AC	99-2	Right	45		1.25808638	-78.56322520	693	0,770	0	0	21,900	208,300	2,800	0	E142Q4AC	173,351	0205	85	OV-10	Coca	OV-10_Coca
PARAMETERS		14 May 2002				NO REGISTRA			FEET					MILES/HOUR									

ADDED ATTRIBUTES		
Spray Line Altitude over MSL (Metres)	Ground Altitude over MSL (Metres)	Spray Line Altitude over Ground Level (Metres)
211	171	40

Attribute Table 30

ATTRIBUTE TABLE OF THE SECOND CLOSEST SPRAY LINE TO MATAJE ALTO IN 2002 (Witness 41)																							
FID	SEG	FILE_NAME	MISSION	SIDE	LINE	START_TIME	LATITUDE	LONGITUDE	ALTITUDE	DOP	FLT_TIME	FLT_LENGTH	OTE	SPEED	VOLUME	AREA	LOG	LENGTH	MONTH	SWATH	AIRCRAFT	CROP	A_C_CROP
5085	101	E142SGAC	99-2	Right	62		1.25364475	-78.55533995	723	0,770	0	0	31,700	197,100	2,500	0	E142SGAC	123,629	0205	85	OV-10	Coca	OV-10_Coca
PARAMETERS		14 May 2002				NO REGISTRA			FEET					MILES/HOUR									

ADDED ATTRIBUTES		
Spray Line Altitude over MSL (Metres)	Ground Altitude over MSL (Metres)	Spray Line Altitude over Ground Level (Metres)
220	183	37

Attribute Table 31

Figure 24 Puerto Mestanza, Spray Lines in 2004 (Witness 10)

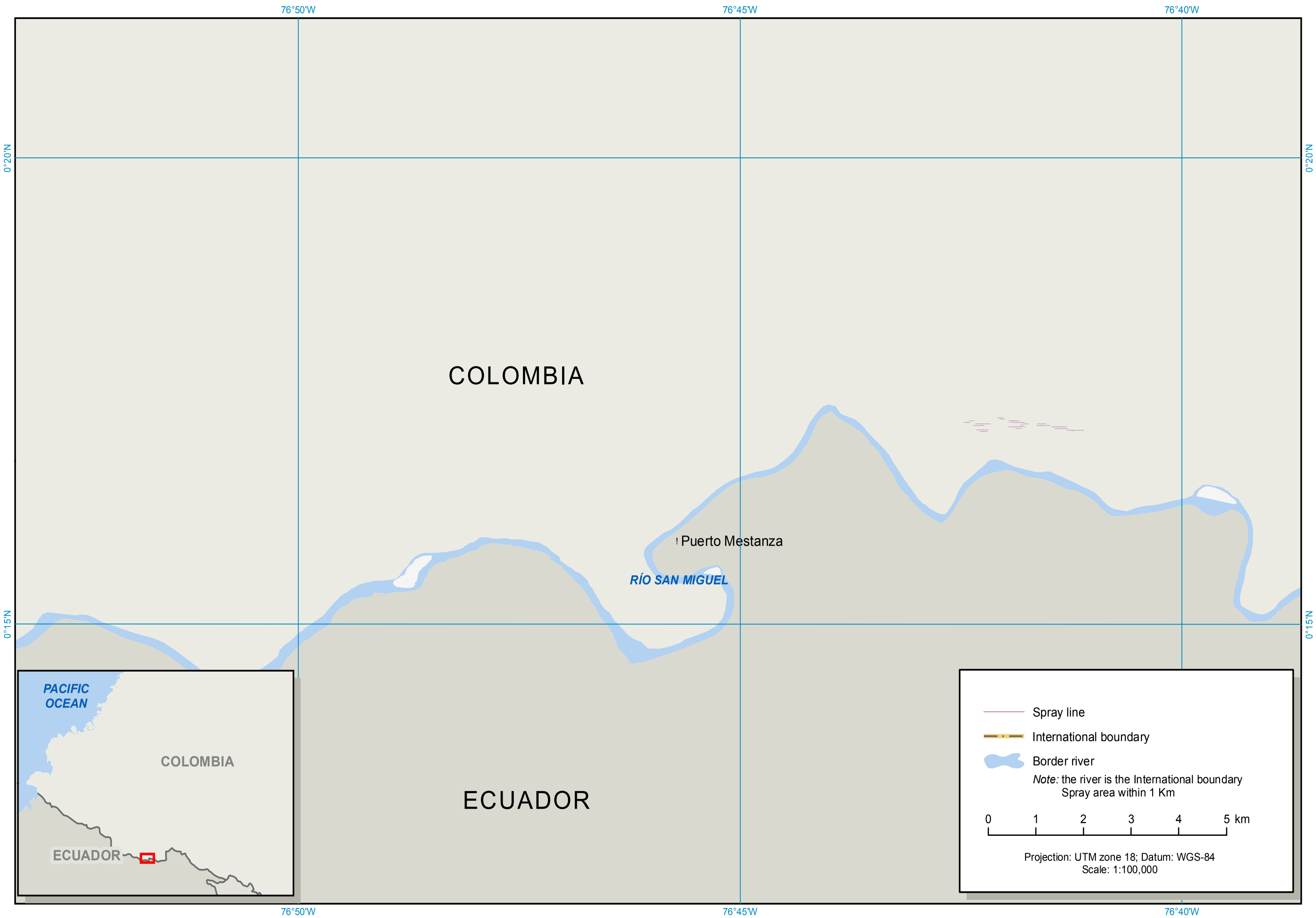
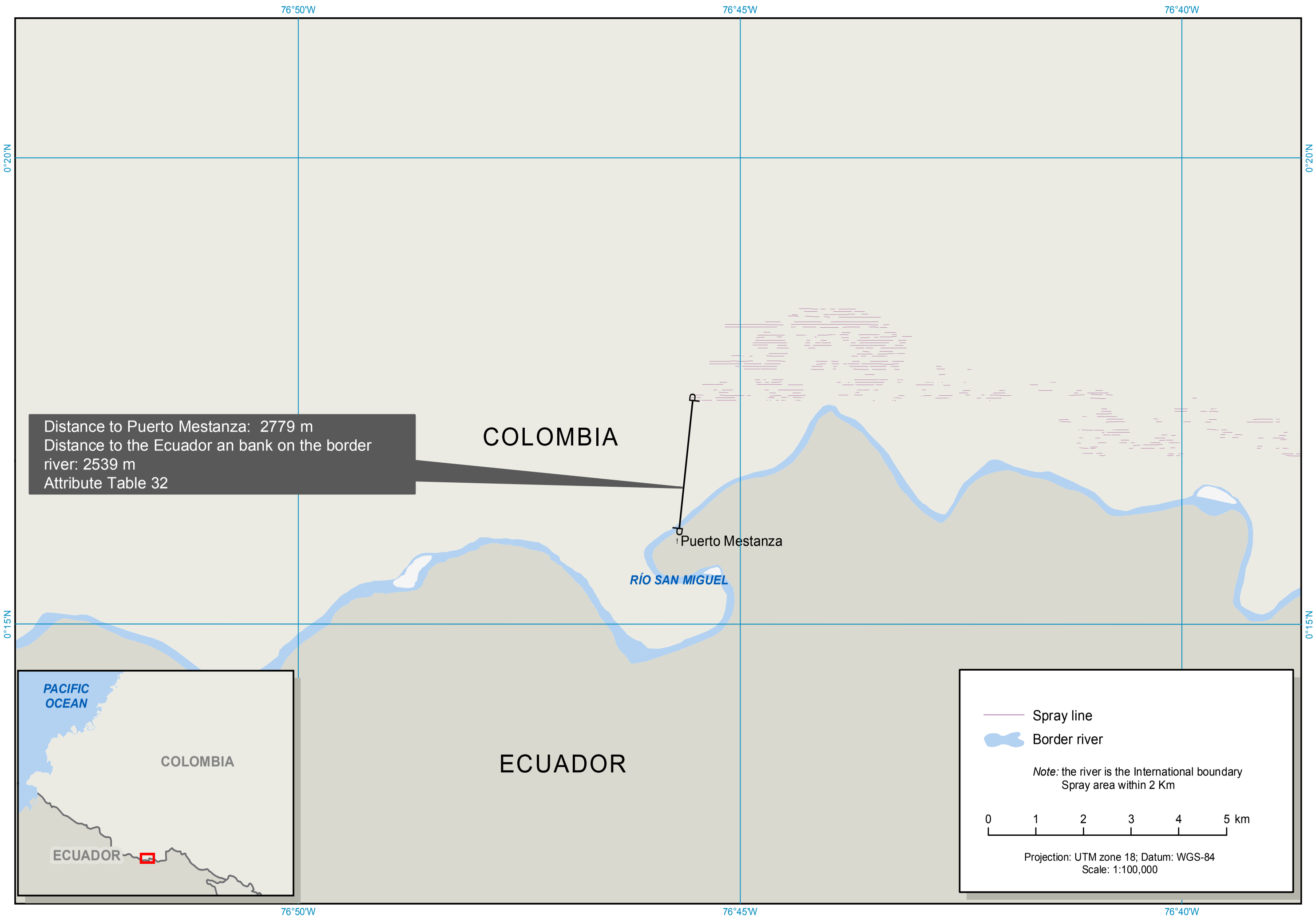


Figure 25 Puerto Mestanza, Spray Lines in 2005 (Witness 10)



Puerto Mestanza, 2005 (Witness 10)

Metadata of the closest spray lines

METADATO LINEA DE ASPERSION MAS CERCANA PUERTO MESTANZA 2005 (Witness 10)																					
OBJECTID	SEG	FILE_NAME	MISSION	SIDE	LINE	START_TIME	LATITUDE	LONGITUDE	ALTITUDE	DOP	FLT_TIME	FLT_LENGTH	OTE	SPEED	VOLUME	AREA	LENGTH	MONTH	SWATH	AIRCRAFT	AC_CROP
3295	1238	J135VMAC.B99	303-1	Right	22	8:43:14:20	0.28998635	-76.75882764	322	0,890	1,2	109,7	0,800	204,500	6,300	0,568	109,577	0510	85	OV-10	OV-10_Coca
PARAMETERS		13 OCTOBER 2005				08:43			METRES					MILES/HOUR							

ADDED ATTRIBUTES	
Ground Altitude over MSL (Metres)	Spray Line Altitude over Ground Level (Metres)
276	46

Attribute Table 32

Annex 19

INSTITUTE OF HYDROLOGY, METEOROLOGY AND ENVIRONMENTAL STUDIES (IDEAM), *CLIMATE CHARACTERIZATION OF THE NARIÑO AND PUTUMAYO BORDER ZONE WITH ECUADOR*, 7 DECEMBER 2011

REPUBLIC OF COLOMBIA

IDEAM
Institute of Hydrology,
Meteorology,
and Environmental Studies

IDEAM 07/12/2011

Ms.
SONIA PEREIRA PORTILLA
Ambassador
Ministry of Foreign Affairs
sonia.pereira@cancilleria.gov.co

Dear Ms. Pereira:

I am hereby enclosing a hard copy of the document CLIMATE CHARACTERIZATION OF THE NARIÑO AND PUTUMAYO BORDER ZONE WITH ECUADOR, prepared by officials from the Under Division of Meteorology of this Institute, meteorologists: Franklin Ruiz Murcia, Henry Benavides Ballesteros, Gloria Leon Aristizabal, Gonzalo Hurtado Moreno, and Ernesto Rangel Mantilla

We hope this information is of use for the purposes. Please do not hesitate to contact us if you need any clarification or explanation on it.

Sincerely,

[Signed]
RODRIGO JOSE LOZANO P.
General Director

Carrera 10 No. 20 – 30 Piso 6º. Bogotá D.C. –
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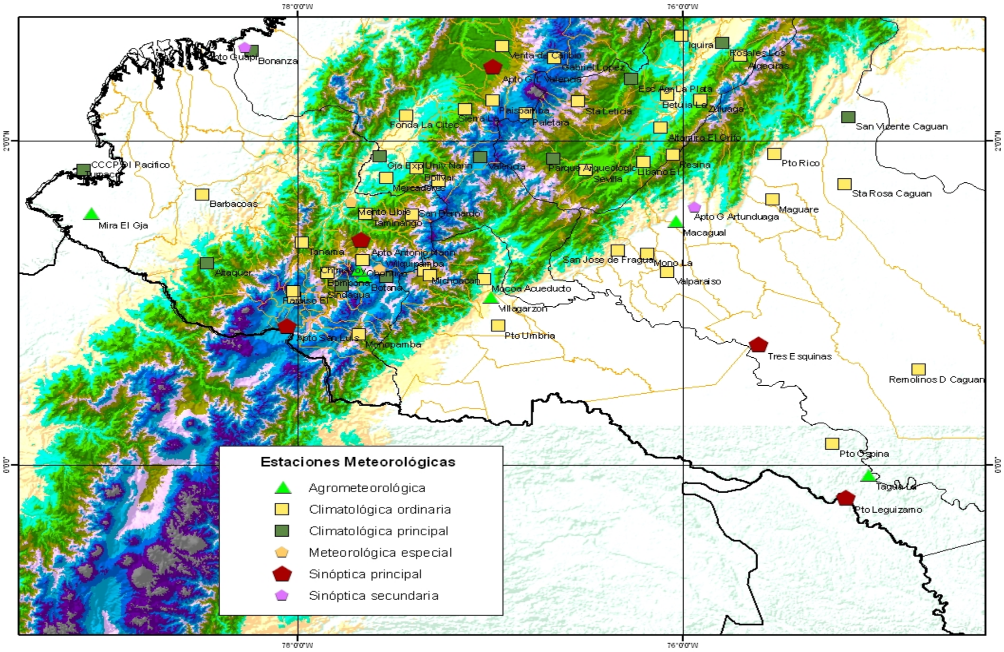
CLIMATE CHARACTERIZATION OF THE NARIÑO AND PUTUMAYO BORDER ZONE WITH ECUADOR

1. Information used

For this analysis we used the information obtained from meteorological stations operated by the IDEAM, located in proximity to the border with Ecuador, which has information on wind, temperature and humidity, whose identification data and geographical location are shown in Table 1 and map 1, respectively.

NAME	Municipality	LATITUDE Degrees (°) Minutes (‘)	WEST LONGITUDE Degrees (°) Minutes (‘)	ELEVATION (msl)
Pacific Pollution Control Center - CCCP	Tumaco	01° 48’ N	78° 46’ W	1 m
La Tagua	Leguízamo	00° 04’ S	74° 40’ W	153 m
Puerto Leguízamo	Leguízamo	00° 19’ S	74° 46’ W	147 m

Table 1. Identification data weather stations



Weather stations: agrometeorological; ordinary climatologic; main climatologic; special weathermain synoptic, secondary synoptic

Map No. 1. Location of meteorological stations on the COLOMBIA - ECUADOR border zone

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2.1 Trend of precipitation, temperature and humidity in Putumayo and Nariño

2.1 Puerto Leguízamo (Putumayo)

Information from the Puerto Leguizamo meteorological station was used for this analysis (Geographical coordinates: 00° S, 74° 46' W, elevation: 147 m)

2.1.1 Trend of precipitation
The Putumayo area is mostly flat to undulating with warm humid climate (tropical rainforest). Mean annual rainfall is around 3000 mm. It is a monomodal system, that is, it presents a dry period (or less rain) between December and January and a rainy season from February to November. Higher rainfall months are May, June and July and lower rainfall is in December and January.

2.1.2 Trend of the Mean daily air temperature during the year (see Figure No. 1A)

In general, the minimum daily air temperature is in the morning–just before sunrise– reaching the highest values between 12 and 15 hours and at night (19 hours) it records an intermediate value regarding those observed in the aforementioned hours.

MONTH/HOUR	7	13	19
JANUARY	23.7	30.3	26.8
FEBRUARY	23.6	30.2	26.8
MARCH	23.6	29.0	25.8
APRIL	26.3	28.5	25.5
MAY	23.5	28.0	25.1
JUNE	22.9	27.5	24.8
JULY	22.5	27.5	24.6
AUGUST	22.8	28.6	25.1
SEPTEMBER	23.3	29.4	25.7
OCTOBER	23.7	29.8	25.8
NOVEMBER	24.0	30.1	26.1
DECEMBER	23.9	30.0	26.4

Daily Trend of Puerto Leguizamo temperature (Jan to Dec)

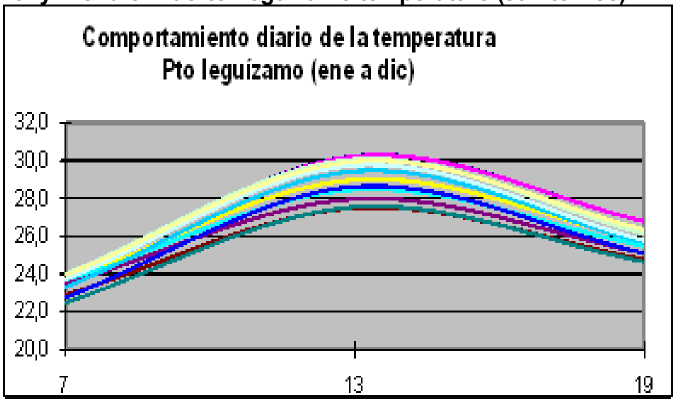

Figure No. 1A. Daily Trend (07, 13, 19 hours) of the air temperature in Puerto Leguízamo

The daily Trend of air temperature measurements taken at 07, 13 and 19 hours, Meand over a period of 30 years, is shown in Figure No 1 - A and its accompanying table. Each color represents a month. Overall it can be seen that:

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- At 07 am, the Mean temperature values vary between 22.5° C in July and 24.0° C in November.

- At 13 hours (1 pm) the Mean temperature ranges from 27.5° C in June and July to 30.3° C in January.

- At 19 hours (7 pm) the Mean temperature varies between 24.6° C in July and 26.8° C in January

Conclusions

The Mean daily temperature in Puerto Leguizamo varies between 22.5° C at 07 am and 30.3° C at 13 hours, a range within which it remains for the rest of the year. It is important to note that these values correspond to measurements taken at 2 meters above the surface of the land in accordance with standards set by the World Meteorological Organization and adopted by the IDEAM. To estimate the temperature of air at higher altitudes it should be noted that it decreases at a rate of 0.65° C per 100 m of displacement in height. For example, a temperature of 30.3° C obtained in surface at 100 meters elevation will reach a value of (30.3-0.65) = 29.4° C.

2.1.4 Trend of the relative humidity throughout the year in Puerto Leguizamo (Putumayo) (see Figure No 1B)

The trend of the Mean monthly relative humidity of the air, the result of averaging the daily observations at 07, 13 and 19 hours (7 am, 1 pm and 7 pm) for a period of 30 years, is shown in Figure 1B.

This Figure and table below allow concluding that the Mean monthly humidity values vary during the year, between 81% and 89%. Thus, the dry months or less rainy season (December to February) have relative humidity between 81 and 84% and the rainy season (March to November), between 85% and 89%.

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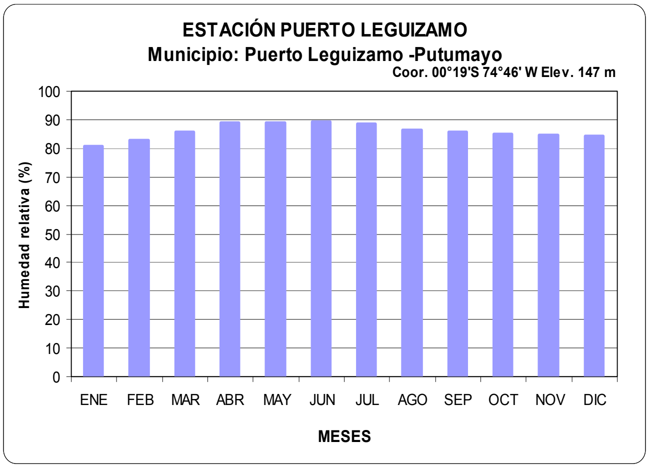
MONTH	Relative Humidity (%)
JAN	81
FEB	83
MAR	86
APR	**89**
MAY	**89**
JUN	**89**
JUL	**89**
AUG	86
SEPT	86
OCT	85
NOV	85
DEC	84

PUERTO LEGUIZAMO STATION
Municipality: Puerto Leguizamo - Putumayo



MONTHS
JAN FEB MAR APR MAY JUN JUL AUG SEPT OCT NOV DEC

Figure No 1B. Monthly Mean air humidity trend in Puerto Leguízamo

2.2 Municipality: Tumaco (Nariño)
For this analysis we used the weather station information of Pollution Control Center for the Pacific-CCCP, whose geographical coordinates are 1° 48' N, 78° 46' W, elevation: 1 msl.

2.2.1 Trend of precipitation

The Tumaco area is mostly flat to undulating, with predominantly warm humid climates (tropical rainforest) and warm very humid. Mean annual rainfall is around 3200 mm and it has a monomodal system, that is, a dry period (or less rains) and a rainy season, throughout the year. The first semester is rainy and during the second semester the driest months or of less rain are recorded, particularly in September, October and November.

2.2.2 Daily air temperature trend during the year (See Figure No 2A)

In general, the minimum daily air temperature is in the morning–just before sunrise– reaching the highest values between 12 and 15 hours and at night (19 hours) it records an intermediate value regarding those observed in the hours mentioned above (07 and 13 HLC).

The daily trend of the air temperature is shown in Figure 2A, based on measurements made at 07, 13 and 19 hours.

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MONTH/HOUR	07	13	19
JANUARY	24.3	27.6	25.7
FEBRUARY	24.4	27.7	25.7
MARCH	24.7	28.2	26.3
APRIL	24.8	28.4	26.4
MAY	24.9	27.8	26.3
JUNE	24.6	27.8	26.0
JULY	24.4	27.7	25.8
AUGUST	24.4	27.8	25.6
SEPTEMBER	24.4	27.2	25.5
OCTOBER	24.5	27.6	25.6
NOVEMBER	24.5	27.5	25.2
DECEMBER	24.3	27.4	25.2

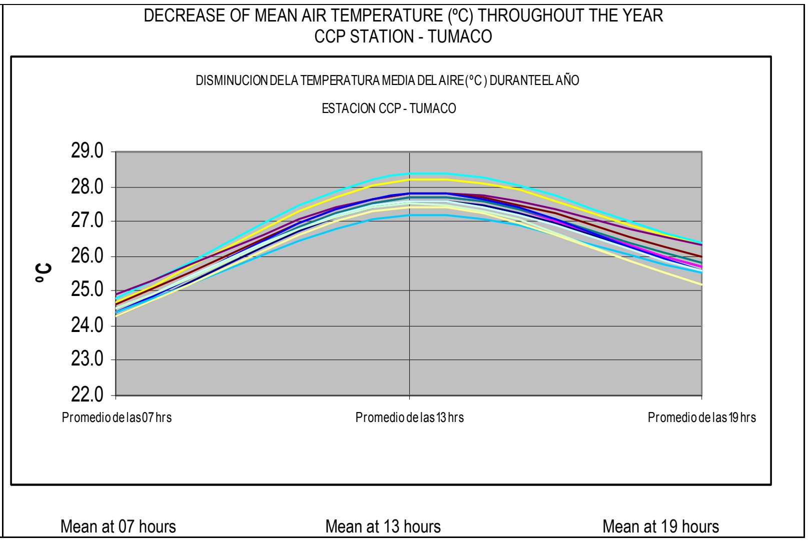

Figure No 2A. Daily trend (07, 13, 19 hours) of the air temperature in Tumaco

In analyzing Figure 2A and table below, it can be observed that:

- At 07 am, the Mean temperature values vary between 24.3° C in January and December and 24.9° C in May

- At 13 hours (1 pm) the Mean temperature ranges from 27.2° C in September to 28.4° C in April.

- At 19 hours (7 pm) the Mean temperature range from 25.2° C in November and December and 26.4° C in April.

- Conclusion: the Mean daily temperature during the year in Tumaco varies between 24.3° C (July and December at 7 am) and 28.4° C at 13 hours (April, 1 pm). During the rest of the time, the Mean temperature ranges between these values. To be sure, these values correspond to measurements taken at 2 meters above the surface of the land. For higher altitudes it should be noted that air temperature decreases at a rate of 0.65° C per 100 m of displacement in height. For example, the value of 28.4° C measured at the surface, corresponds to (28.4° C-0.65° C) = 27.8° C, at 100 meters above the ground.

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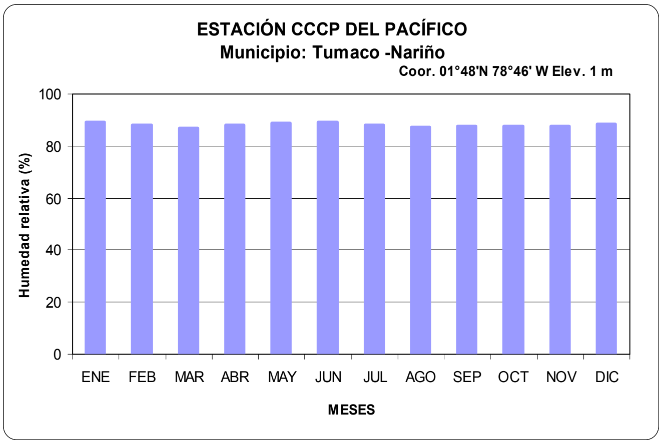
2.1.4 Trend of humidity during the year in Tumaco (Nariño) (see Figure No 2B)

The monthly performance of the relative air humidity, the result of averaging the daily observations at 07, 13 and 19 hours (7 am, 1 pm and 7 pm) for a period of 30 years, is shown in Figure No. 2B.

This Figure and table below allow concluding that the Mean monthly relative humidity varies from 87% in March and August, to 89% in January, May and June. The rest of the year the monthly Mean relative humidity is 88%.

MONTH	Relative humidity (%)
JAN	89
FEB	88
MAR	87
APR	88
MAY	89
JUN	89
JUL	88
AUG	87
SEP	88
OCT	88
NOV	88
DEC	88

PUERTO LEGUIZAMO STATION
Municipality: Puerto Leguizamo - Putumayo



MONTHS
JAN FEB MAR APR MAY JUN JUL AUG SEPT OCT NOV DEC

Figure No 2B. Monthly Mean trend of humidity in Tumaco

2. 3 Climate Classification in the provinces of Nariño y Putumayo

Lang's climate classification is based on annual Mean trend of precipitation and air temperature. To this end, Lang's index is calculated (I = P/T) where P is the amount of annual precipitation (mm) and T (° C) Mean annual temperature. According to the index value, the following climates are as follows:

INDEX	TYPE OF WEATHER	INDEX	TYPE OF WEATHER
0-20	Desert	60-100	Semi humid
20-40	Arid	100-160	Humid
40-60	Semiarid	Greater than 160	Super humid

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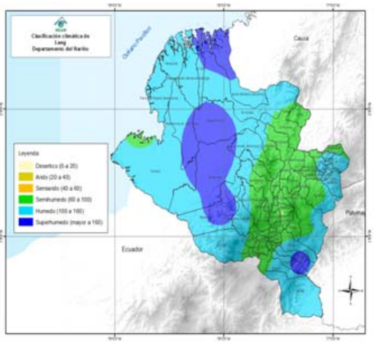
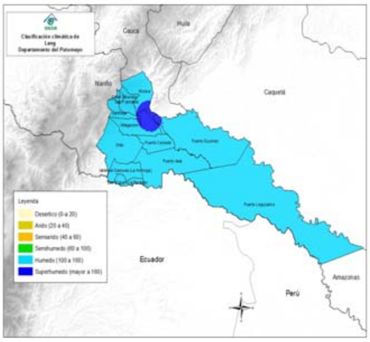
The following maps show the resulting climate type for the provinces of Nariño and Putumayo, according to the Lang climate classification:



Map No 2 Province of Nariño



Map No 3. Province of Putumayo

It can be observed that in the province of Nariño (Map 2) there are three types of climate: semi humid (green), humid (light blue) and super humid (dark blue). Along the border of the Nariño province with Ecuador, the climate is humid (light blue) and semi humid (green), the latter on a small southeast area.

In the province of Putumayo and across its border with Ecuador, the climate is humid (Map 3, light blue).

4. Wind trend

The data of wind speed measured at meteorological stations located in the Colombian border zone with Ecuador is shown in Table No. 2

Station-Municipality-Province	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
EL MIRA –Tumaco (Nariño)	1.3	1.1.	1.1	1.1	1.0	1.1	1.2	1.3	1.2	1.2	1.2	1.2
APTO. SAN LUIS-Ipiales (Nariño)	1,1	1,1	1,2	1,2	1,3	1,7	2	2,1	1,8	1,5	1,2	1,1
LA TAGUA- Pto Leguizamo (Putumayo)	1,8	1,8	1,8	1,9	1,7	1,7	1,9	1,6	1,6	1,7	1,9	2,1
Puerto Leguízamo (Putumayo)	2	1,6	1,4	1,5	1,6	1,5	1,5	1,5	1,6	1,4	1,5	1,6

Table No 2: Mean monthly wind speed (m/s)

The analysis of the above table allows revealing that the Mean monthly wind speeds throughout the year range from 1.0 m/s and 2.0 m/s, low values that confirm that the regions studied are in the doldrums.

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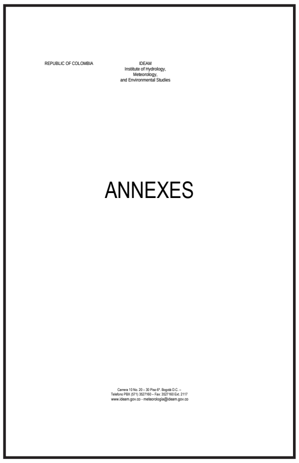
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ANNEXES

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ANNEX No. 1
WIND FIELDS

Equatorial climates correspond to the doldrums, between latitude 5° S and 10° N, where the trade winds coming from the high subtropical weaken and the trade winds of the northeast and southeast meet, in a strip around the globe known as the ITCZ (Intertropical Confluence Zone), an area where throughout the year equatorial low pressure dominates. The main characteristics of these winds and their relationship to the pressure field are described by many authors, including Riehl (1979), Krishnamurti (1979) and Hastenrath (1996).

The trade winds may be observed in conjunction with recent data obtained from satellites and other sources, such as the U.S. NCAR/NOAA Reanalysis Project (Kalnay, Kanamitsu and Kistler, 1996) and may be represented in the monthly Mean wind fields shown in Figure 1 of the Annex. The northeast trade winds are characterized by wind vectors over the Caribbean, while the southeastern dominate the Pacific regions and exceed the equator in June-November acquiring a southwesterly direction, that is, they head to the northeast. This wind system stands out in the flat and sea areas, since on mountain areas and close to these terrains the fluvial conditions have a strong influence on the trend of the wind speed and direction, leading away from the general circulation system, as occurs in the Andean border region between Ecuador and Colombia and as shown in Table 2. On the equatorial and continental zone the calm weather or doldrums (the length of the arrows that is proportional to the magnitude of the wind) is shown in Figure 1. These values of wind speed can also be evaluated in Figure 2 of the Annex. Based on the foregoing and in accordance with the analysis made in the wind fields shown in Figures 1 and 2, it can be concluded that the Mean surface winds are in the order of 1 m/s on the border area and do not acquire significant high values, which can be confirmed by the records in the Colombian stations at ground level, with values ranging from 1 to 2 m/s, as shown in item 4 of the document on climate characterization.

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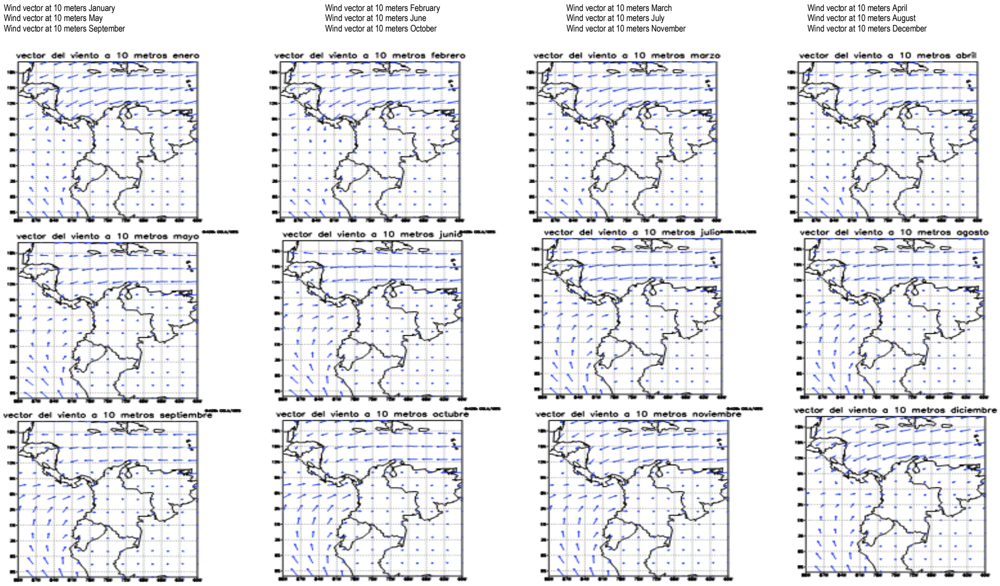

Figure 1. Mean monthly wind maps (vectors or arrows) for Colombia, Ecuador and neighboring areas, based on data from the NCAR/NOAA Reanalysis Project of the U.S.

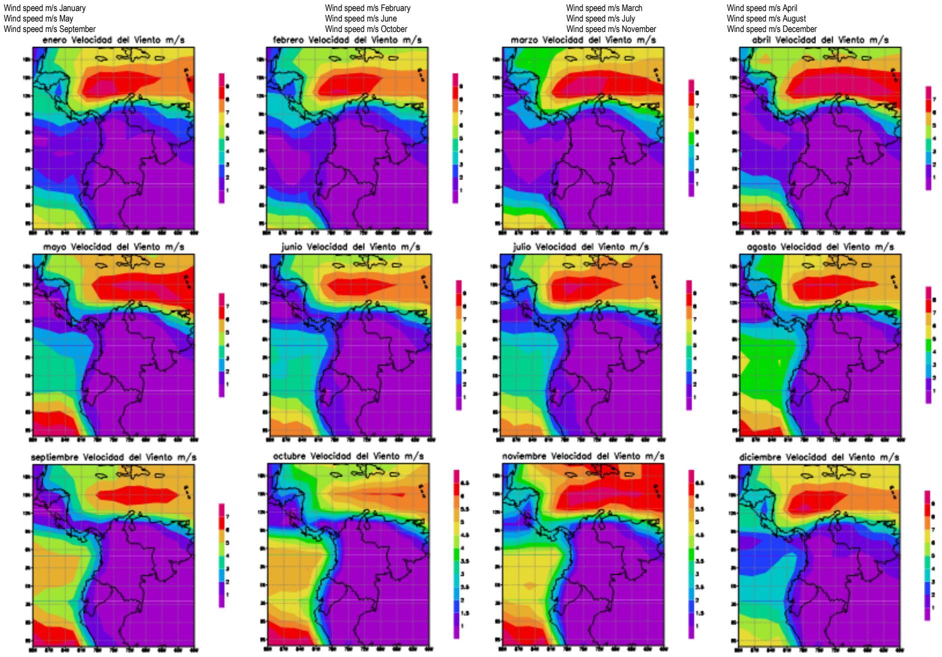

Figure 2. Maps of monthly Mean wind speed for Colombia, Ecuador and neighboring areas, based on data from the NCAR/NOAA Reanalysis Project of the U.S.

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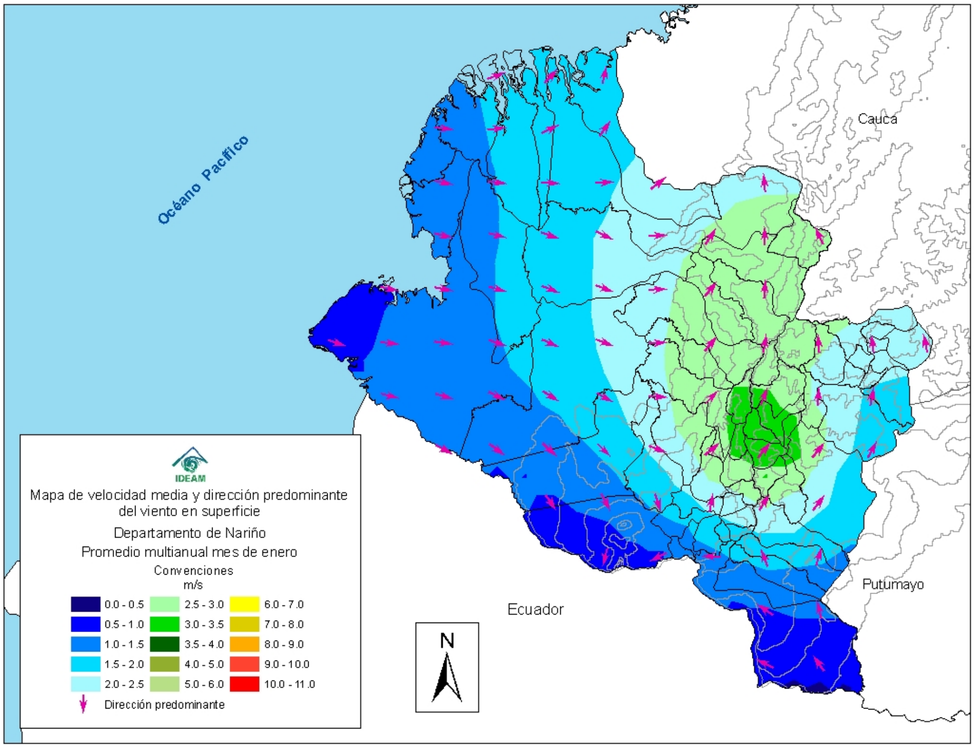
ANNEX 2A
MONTHLY MEAN WIND MAPS FOR THE PROVINCE OF NARIÑO AND BORDER WITH ECUADOR



Map of the Mean speed and predominant surface wind
Province of Nariño
Multi-annual Mean – January
Convention m/s
↓Predominant direction

For the month of January, the vectors indicate the wind direction. Along the border of Nariño with Ecuador in western and central sectors, the wind comes from the West, that is, it goes from the ocean to the west of the country. At the eastern end of the border, the wind comes from Ecuador and goes into Colombian territory. Speeds range from 0.5 m/s to the west, central and east (dark blue) and 1.5 m/s in the rest of the border (light blue).
Overall, the trajectory of the wind follows a path parallel to the border and in some cases, separates from it and enters into the province of Nariño, in the northeastern border area.

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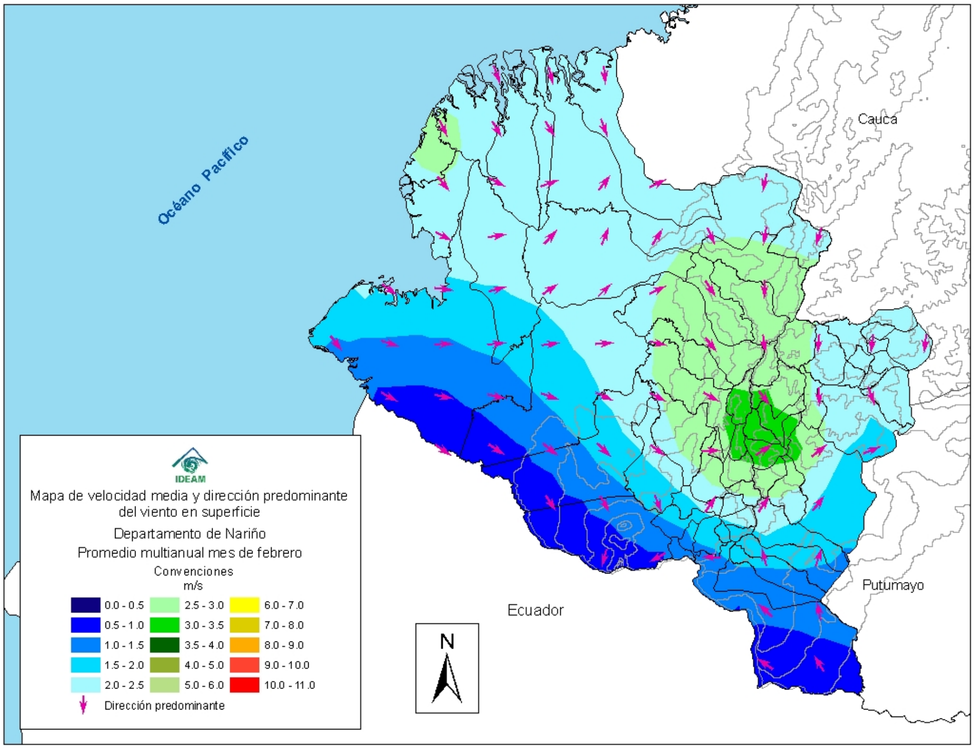

Map of the Mean speed and predominant surface wind
Province of Nariño
Multi-annual Mean – February
Convention m/s
↓Predominant direction

By February the wind blows parallel to the borderline from the West to the East on the western and central sectors. At the eastern end, the wind comes from Ecuador and enters Colombian territory. In a small area located in the central-east the wind takes the direction toward Ecuador, but its speed is less than 0.5 m/s.
Speeds range from 0.5 m/s (dark blue) and 1.5 m/s (light blue).

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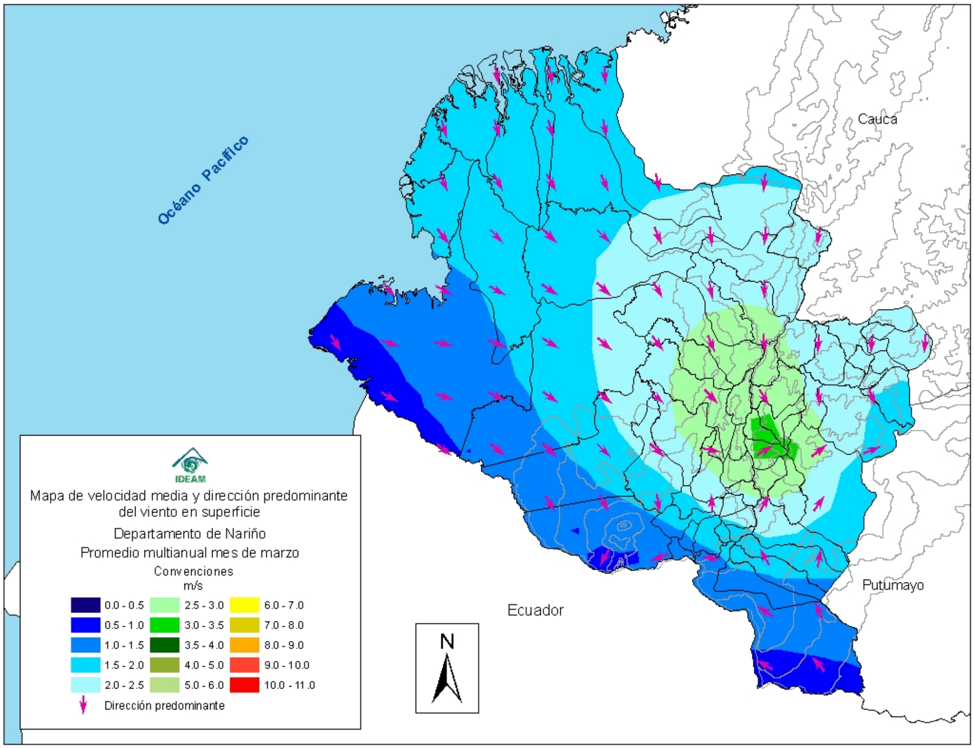

Map of the Mean speed and predominant surface wind
Province of Nariño
Multi-annual Mean – March
Convention m/s
↓Predominant direction

In March, the wind flows parallel to the borderline from the West to the East on the western and central sectors. At the eastern end, the wind comes from Ecuador and enters Colombian territory. The wind speed varies from 0.5 m/s (dark blue) and 1.5 m/sec (light blue).

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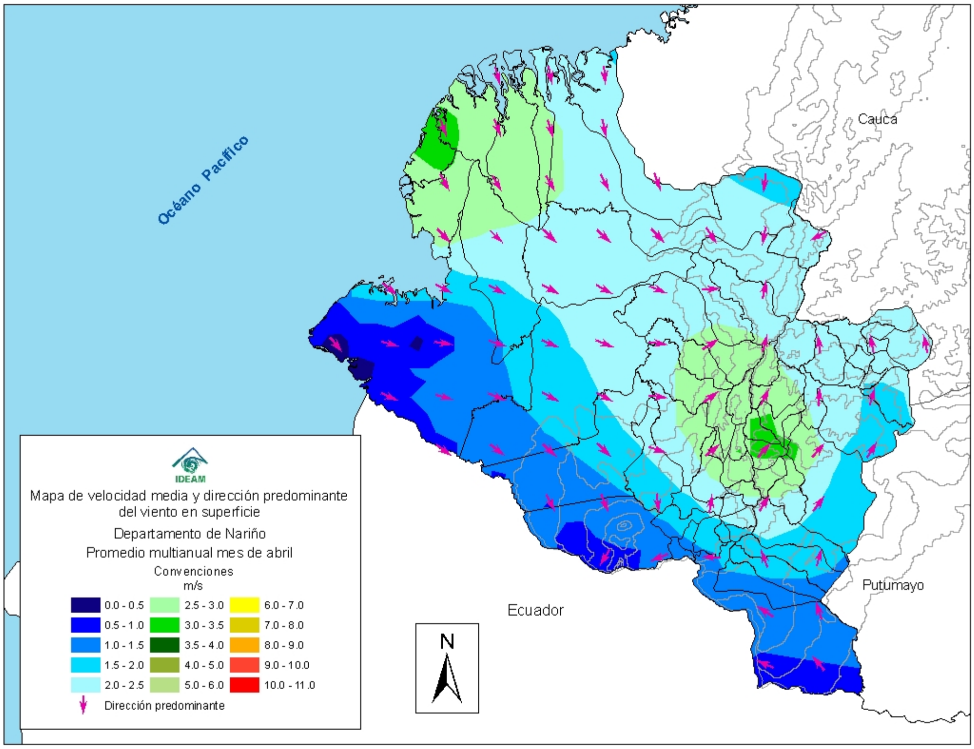

Map of the Mean speed and predominant surface wind
Province of Nariño
Multi-annual Mean – APril
Convention m/s
↓Predominant direction

During April, the wind blows from west to east in the western and central sectors of the border, while in the eastern part of the area it goes from Ecuador to the northwest and northeast of Colombia. The predominant wind speed values are from 0.5 m/s (dark blue) to 1.5 m/s (light blue). Some isolated areas record rates below 0.5 m/s (black).

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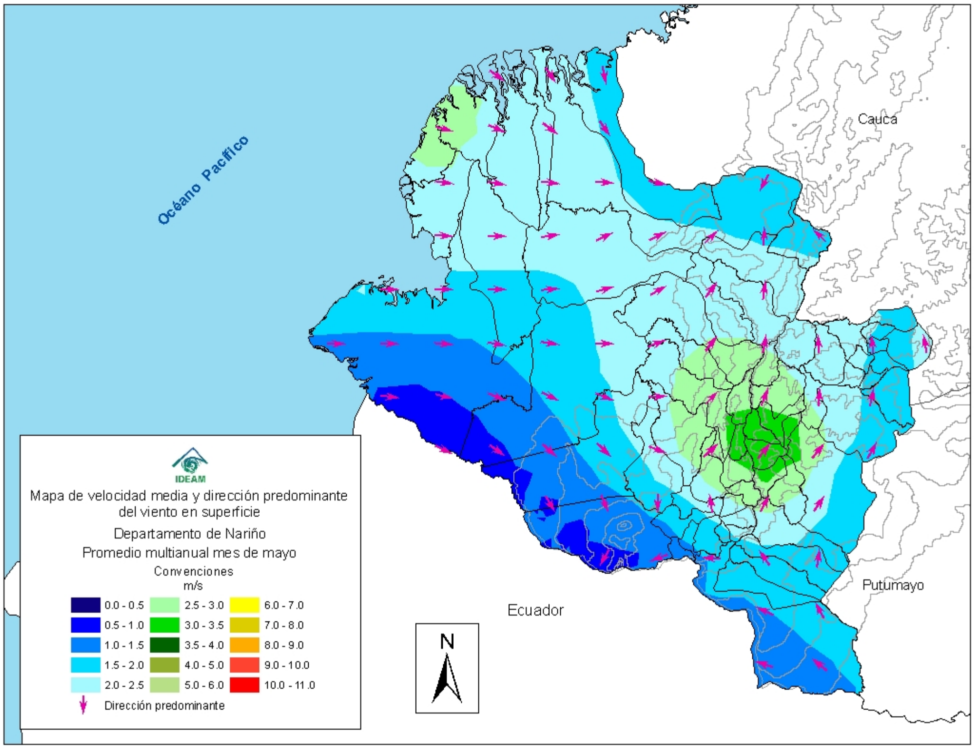

Map of the Mean speed and predominant surface wind
Province of Nariño
Multi-annual Mean – May
Convention m/s
↓Predominant direction

In May, while continuing the pattern of predominant direction (leaving the Ecuadorian border toward Colombia), speed intensifies a little from 1.5 m/s (light blue) in the west of the area, up to 2.0 m/s (aqua blue) on the eastern border.

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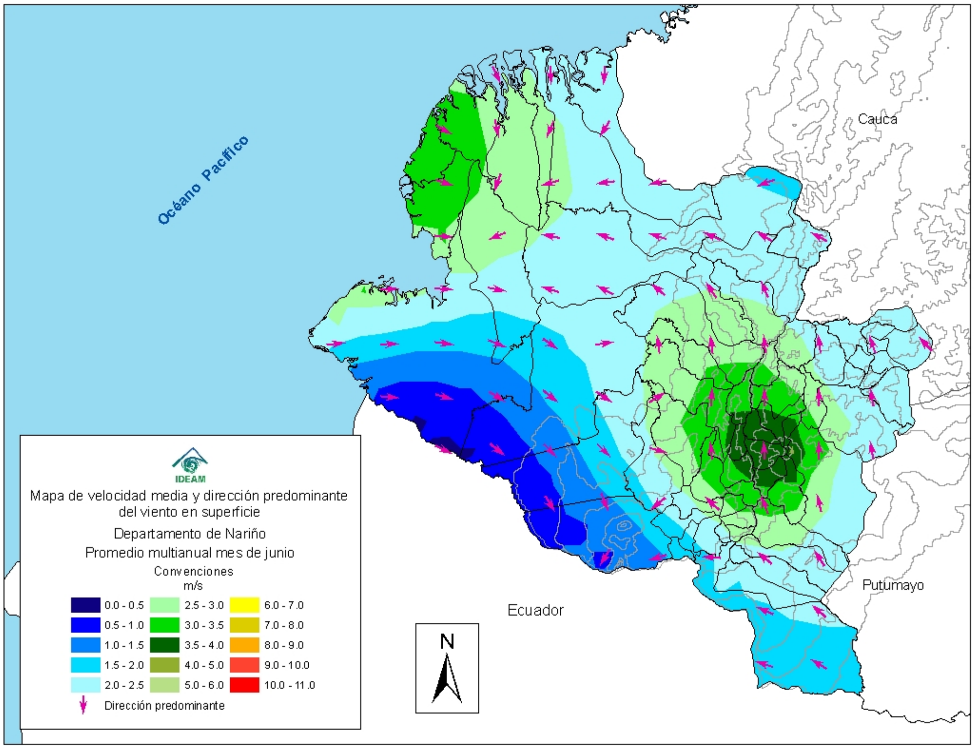

Map of the Mean speed and predominant surface wind
Province of Nariño
Multi-annual Mean – June
Convention m/s
↓ Predominant direction

For the month of June, the wind flow that is recorded comes from the West onto the center and west of the border, and southeast, in the east, entering in both cases, from Ecuador to Colombia . The speeds range from 0.5 m/s (dark blue) and 2.5 m/s (aqua blue). The wind is strongest in the northeast of the border area, over the province of Nariño, where it reaches values up to 4.0 m/s (dark green).

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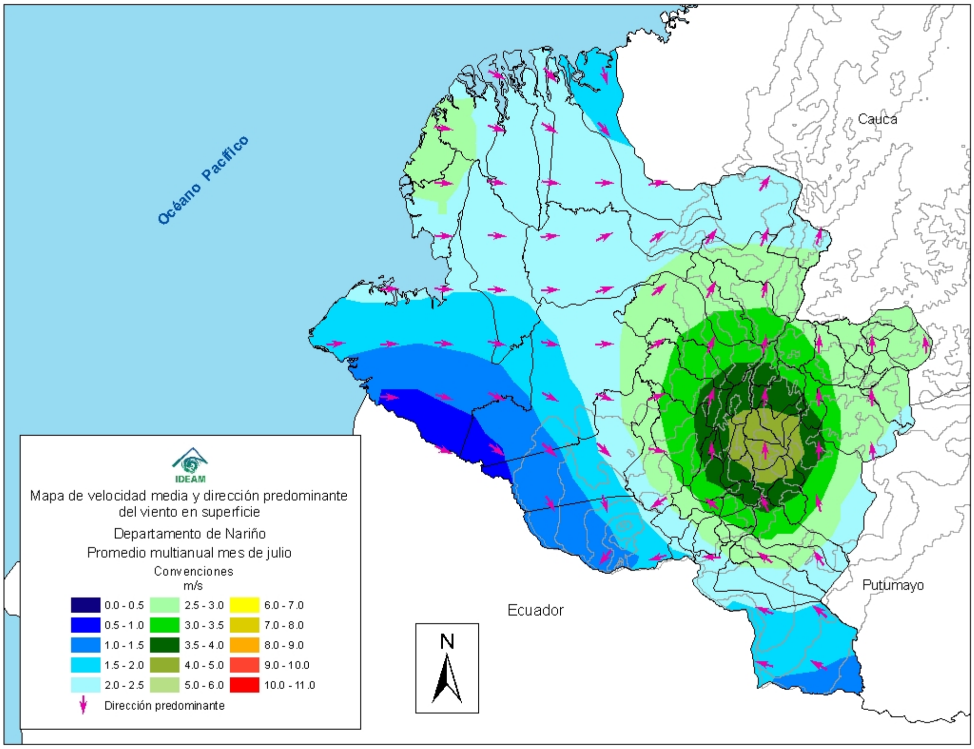

Map of the Mean speed and predominant surface wind
Province of Nariño
Multi-annual Mean – July
Convention m/s
↓Predominant direction

July has the same wind path of the previous months, that is, blowing predominantly from Ecuador to Colombia. The wind speed values range from 0.5 m/s (dark blue), to the west of the border, up to 2.5 m/s (light aqua blue) on the east of the area. the wind speed strengthens in the northeastern part of Nariño, far from the border, reaching values of 5.0 m/s (olive green).

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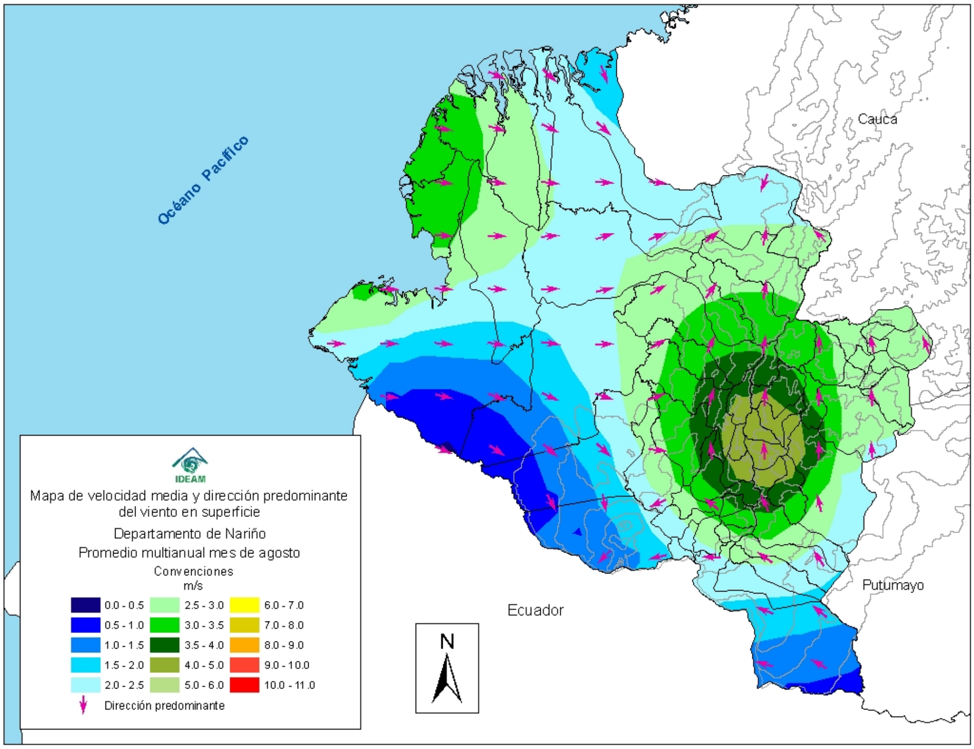

Map of the Mean speed and predominant surface wind
Province of Nariño
Multi-annual Mean – August
Convention m/s
↓Predominant direction

In August the wind blows predominantly from Ecuador to Colombia, and accelerates the speed, particularly in the western sector of the province of Nariño. The wind speed values range from 0.5 m/s (dark blue), west of the border, up to 2.5 m/s (aqua blue) on the east of the area. The wind speed strengthens in the northeastern part of the border, over Nariño, reaching values of 5.0 m/s (olive green).

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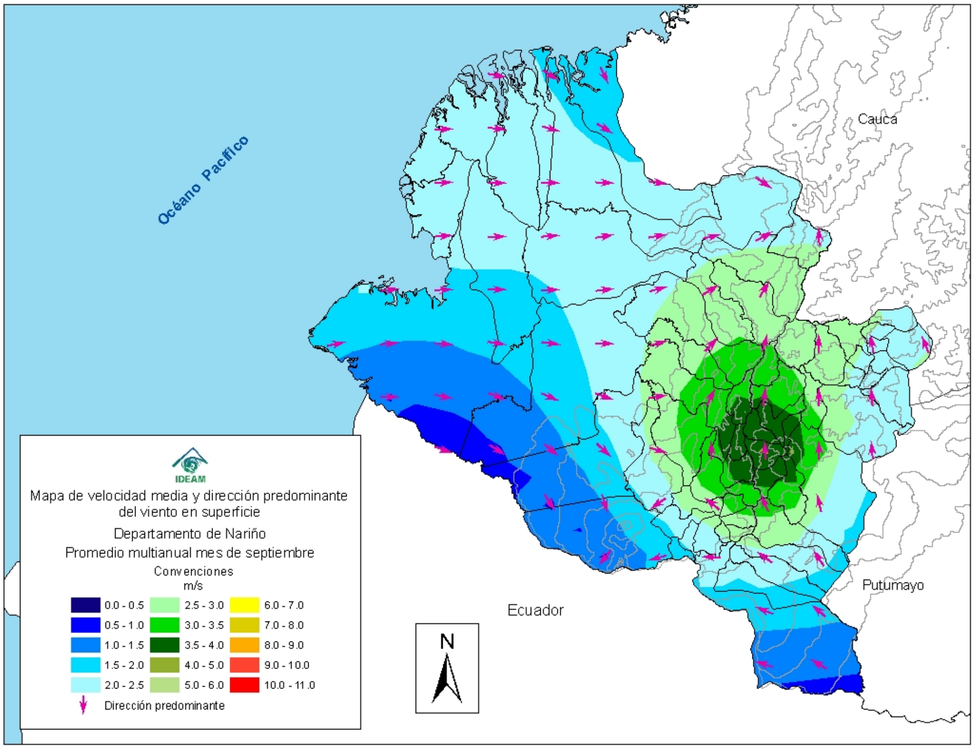

Map of the Mean speed and predominant surface wind
Province of Nariño
Multi-annual Mean – September
Convention m/s
↓Predominant direction

September has a very similar trend to August. The flow is predominantly from Ecuador to Colombia, with the exception of a small central sector of the border. The wind speed values range from 0.5 m/s (dark blue), west of the border, up to 2.5 m/s (aqua blue) on the east of the area. The wind speed values continue in the north-eastern border of Nariño, away from Ecuador, close to 4.0 m/s (dark green).

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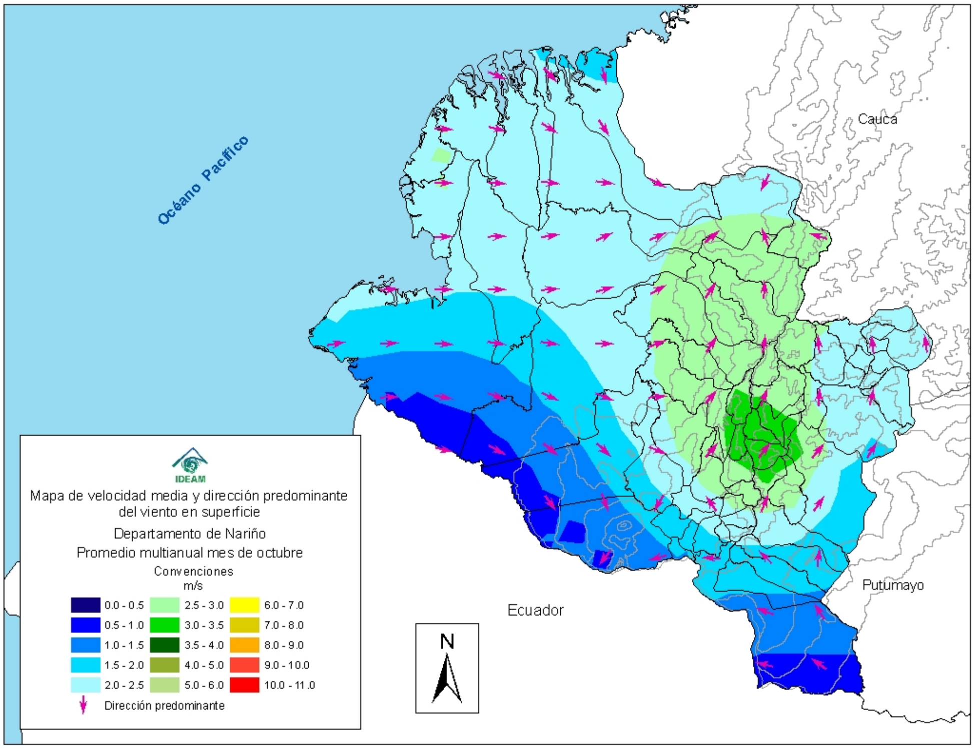

Map of the Mean speed and predominant surface wind
Province of Nariño
Multi-annual Mean – October
Convention m/s
↓Predominant direction

In October, the strength of the wind weakens, recording speeds between 0.5 m/s (dark blue), up to 2.0 m/s (aqua blue). The wind blows from Ecuador to Colombia in broad sectors of the border, particularly in the western and eastern areas, where it takes a westerly direction and northwest, respectively.

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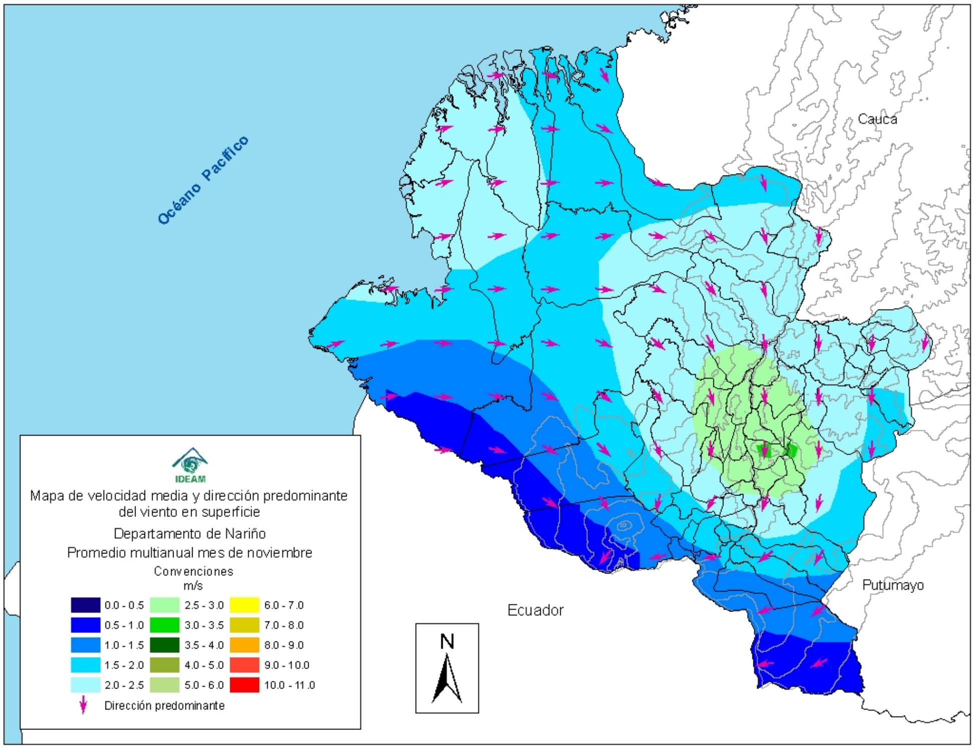

Map of the Mean speed and predominant surface wind
Province of Nariño
Multi-annual Mean – November
Convention m/s
↓Predominant direction

In the month of November predominant wind speed conditions observed in February are reestablished. The wind, from Ecuador, blows towards the northwest and the East on the western and central sectors and the East and Northeast prevails at the east of the area. Speeds range from 0.5 m/s (dark blue) and 1.5 m/s (light blue). The central-eastern area of the province of Nariño has wind speeds of up to 3.5 m/s (light green).

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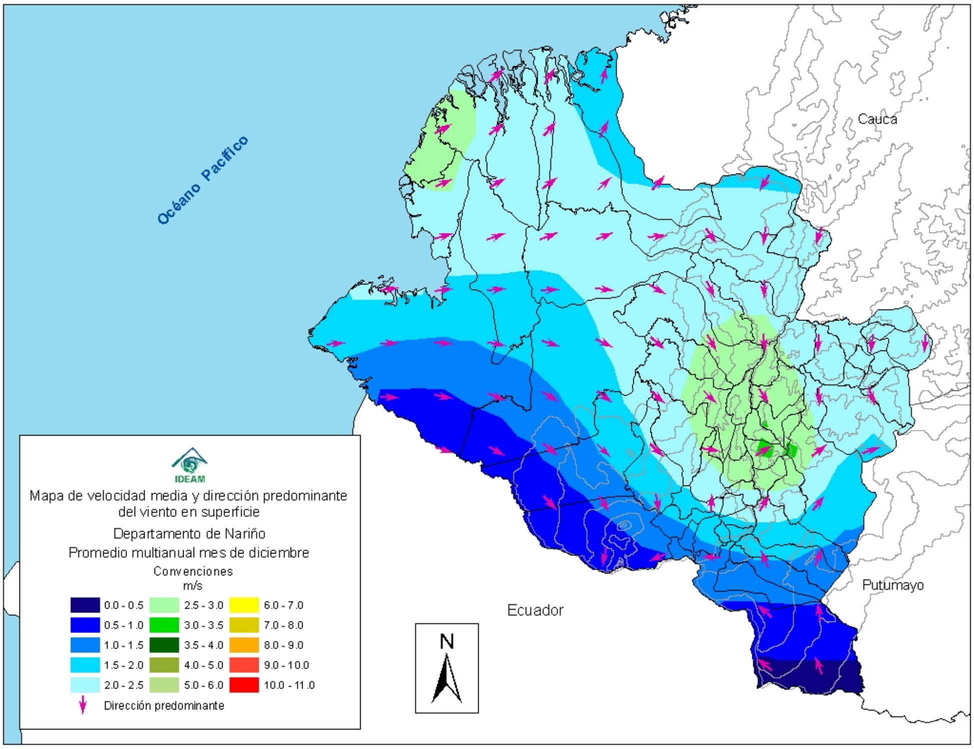

Map of the Mean speed and predominant surface wind
Province of Nariño
Multi-annual Mean – December
Convention m/s
↓Predominant direction

The month of December, as in previous months, shows the wind mostly coming from Ecuador and entering Colombia. The winds are weak in much of the border area, with speeds ranging from 0.5 m/s (intense dark blue), up to 2.0 m/s (aqua blue, in southwestern Nariño).

ANNEX 2B
MEAN MONTHLY WIND MAPS FOR THE PROVINCE OF PUTUMAYO AND BORDER AREA WITH ECUADOR

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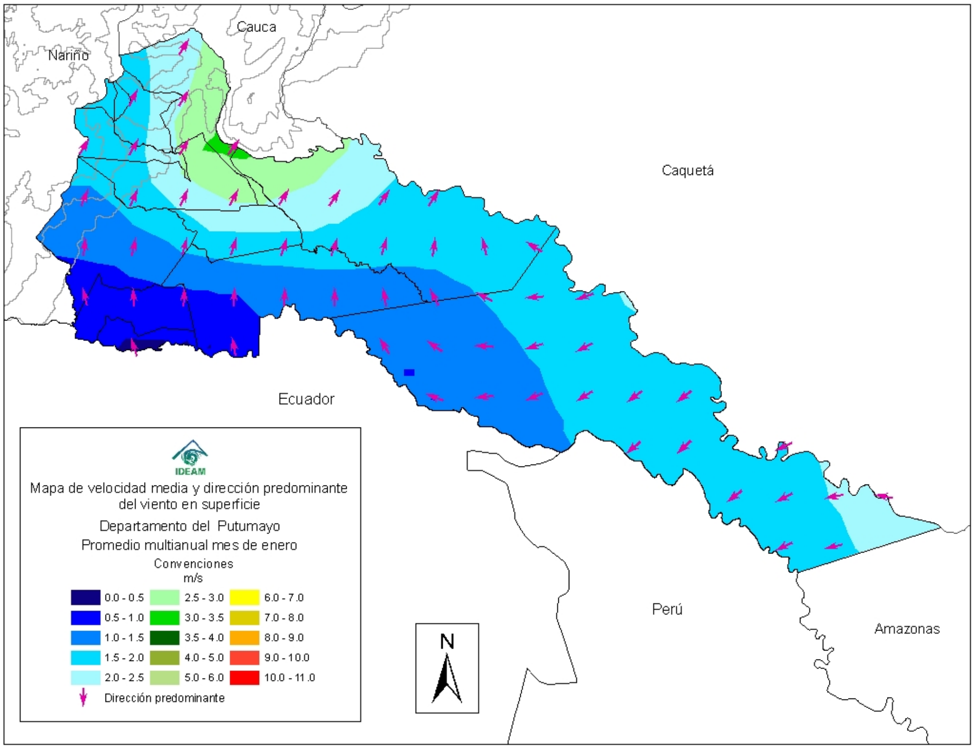

Map of the Mean speed and predominant surface wind
Province of Putumayo
Multi-annual Mean – January
Convention m/s
↓ Predominant direction

The predominant wind flow in January, along the border with Ecuador, is southern (coming from Ecuador and toward Colombia). The speed ranges from 0.5 m/s (dark blue) at the west of the province up to 2.0 m/s (aqua blue) east of it.

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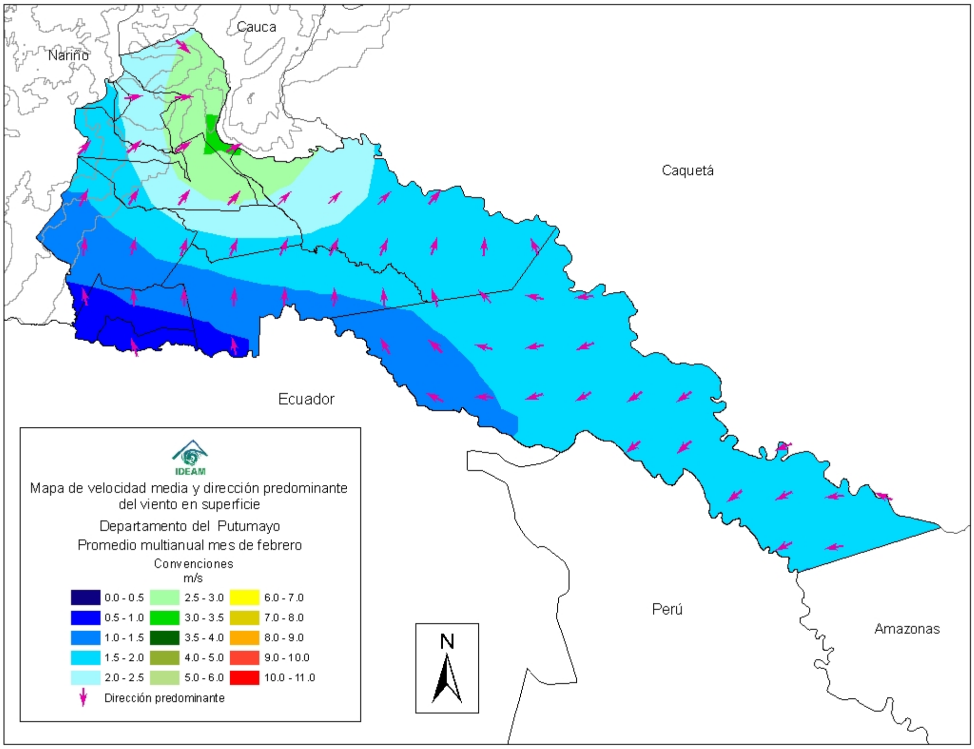

Map of the Mean speed and predominant surface wind
Province of Putumayo
Multi-annual Mean – February
Convention m/s
↓Predominant direction

In February, along the border with Ecuador, the predominant wind direction is southern (leaving Ecuador and entering Colombia). The speeds continue at 0.5 m/s (dark blue) to 2.0 m/s (aqua blue).

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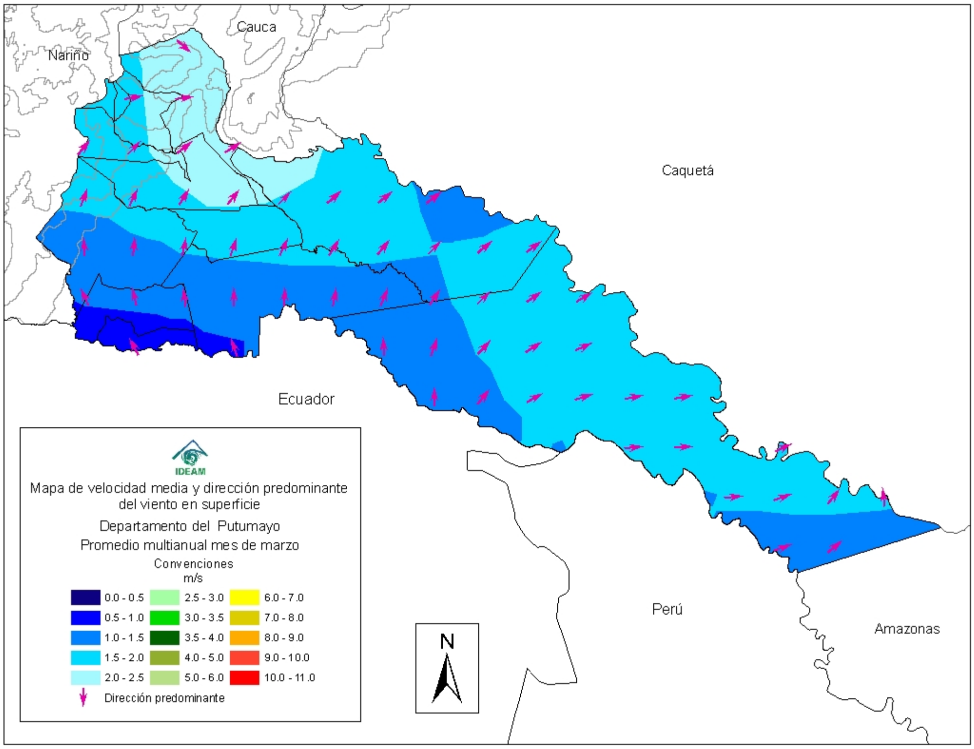

Map of the Mean speed and predominant surface wind
Province of Putumayo
Multi-annual Mean – March
Convention m/s
↓Predominant direction

In March, the predominant wind flow is southern over the entire Putumayo border with Ecuador, that is, the wind leaves Ecuador in the direction of Colombia covering Ecuador completely. The speeds are kept between 0.5 m/s (dark blue) west of the border area and intensify to reach 2.0 m/s to the east (aqua blue).

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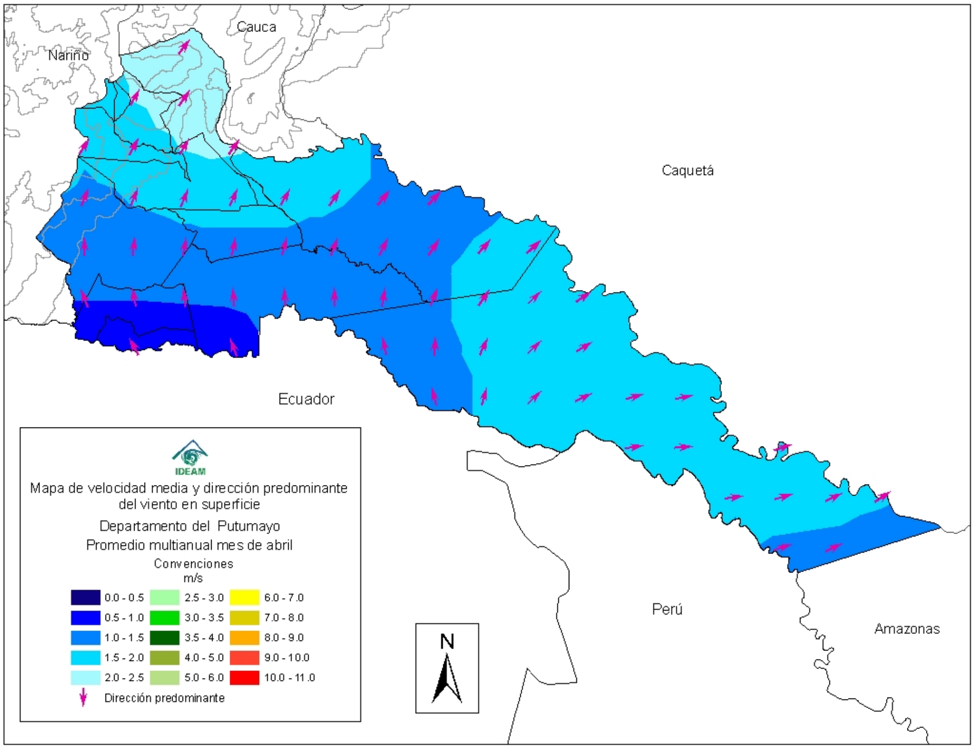

Map of the Mean speed and predominant surface wind
Province of Putumayo
Multi-annual Mean – April
Convention m/s
↓ Predominant direction

In April, the predominant wind flow is from the south, that is, blowing from Ecuador to Colombia, all across the province. With respect to the previous months, there is no major variation in the intensity of the speed: 0.5 m/s (dark blue) in the western sector of the border and 2.0 m/s (aqua blue) in the eastern sector.

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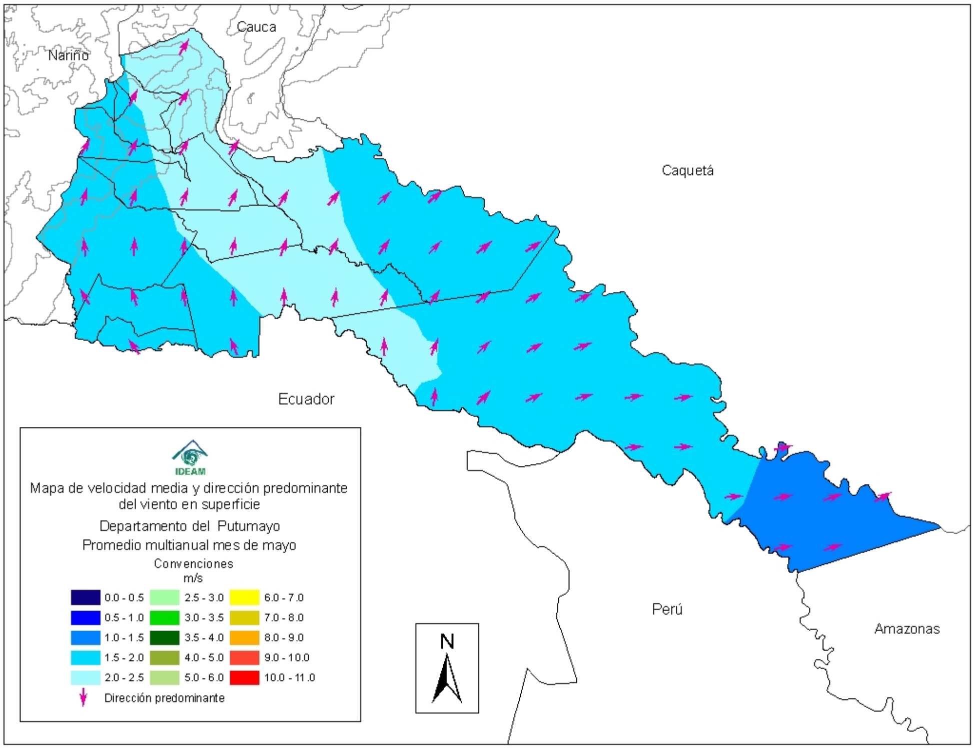

Map of the Mean speed and predominant surface wind
Province of Putumayo
Multi-annual Mean – May
Convention m/s
↓ Predominant direction

While the direction of wind continues predominant from the south (from Ecuador and Peru to Colombia), its speed is enhanced, reaching values of 2.0 m/s (aqua blue) and 2.5 m/s (light aquamarine blue).

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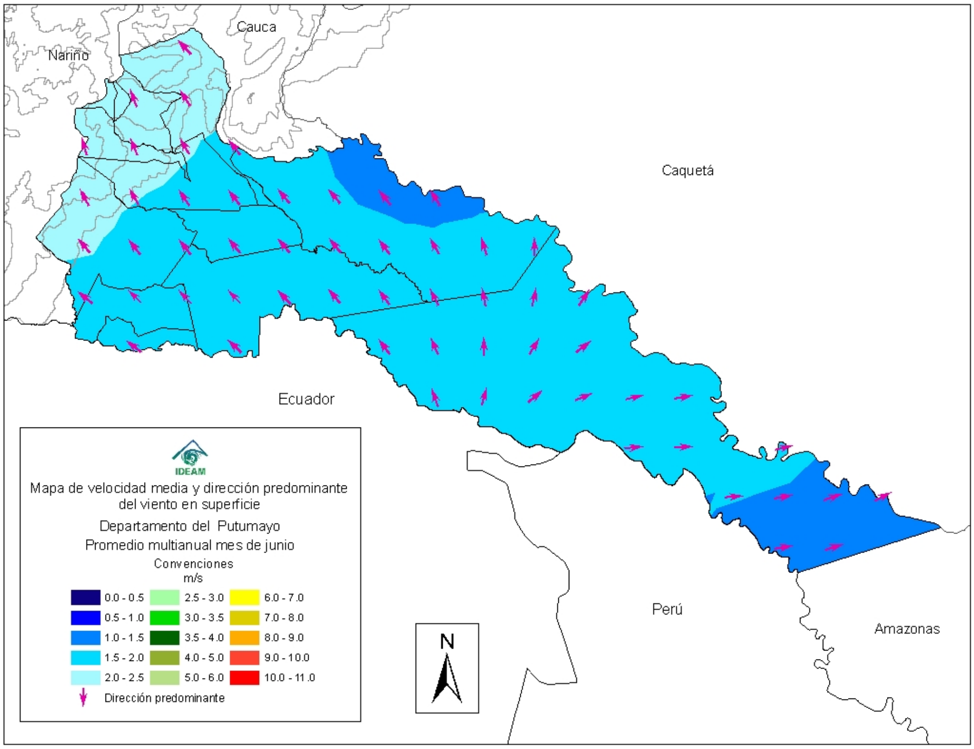

Map of the Mean speed and predominant surface wind
Province of Putumayo
Multi-annual Mean – June
Convention m/s
↓Predominant direction

The month of June is characterized by wind speeds of around 2.0 m/s (aqua blue). The predominant wind direction is south, that is, it goes from Ecuador to Colombia, as in all previous months.

The wind speed along the border with Ecuador is always less than 2.0 m/s (aqua)

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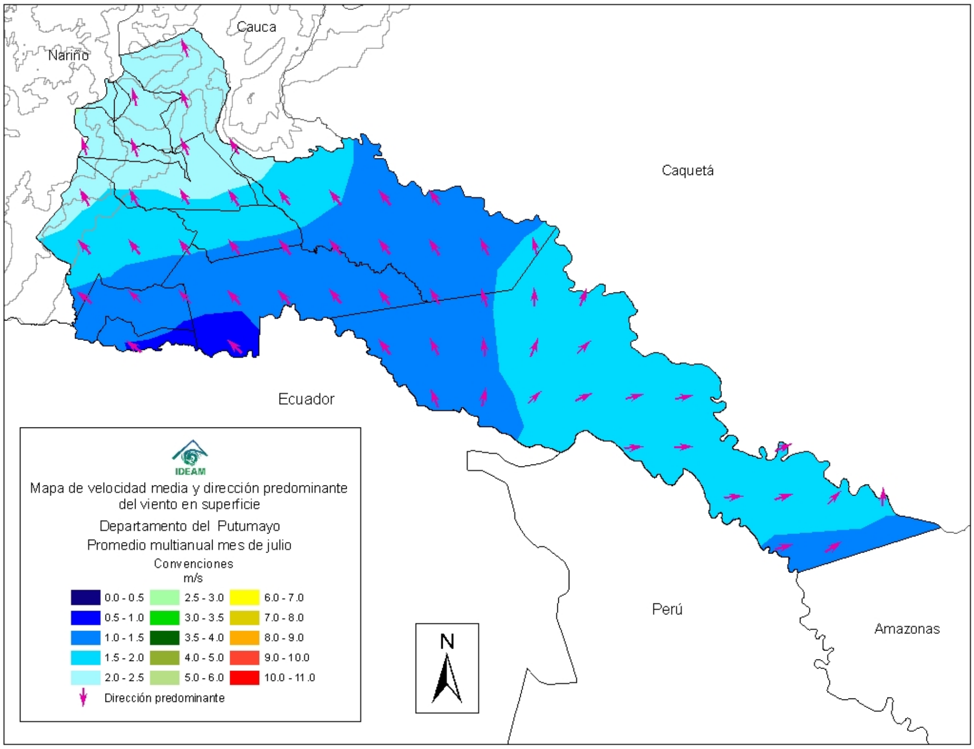

Map of the Mean speed and predominant surface wind
Province of Putumayo
Multi-annual Mean – July
Convention m/s
↓Predominant direction

July is no exception in terms of wind direction, which remains dominant in the south (blowing from Ecuador to Colombia), with speeds ranging from 0.5 m/s (dark blue) to 2.0 m/s (blue aquamarine), east of the area.

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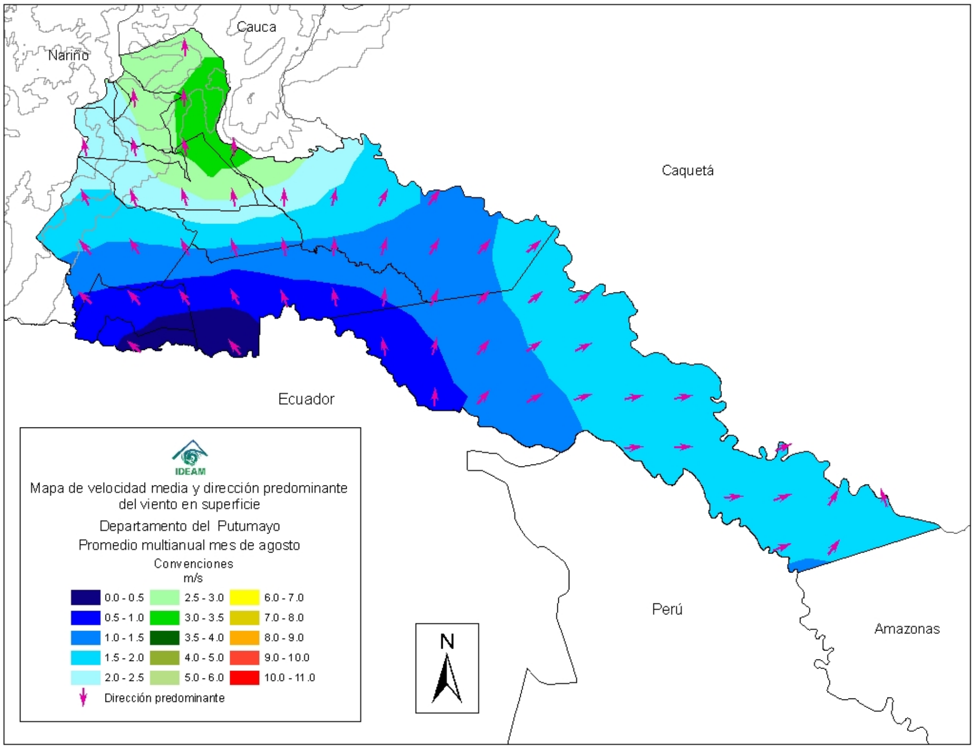

Map of the Mean speed and predominant surface wind
Province of Putumayo
Multi-annual Mean – August
Convention m/s
↓Predominant direction

During the month of August as in previous months, the wind blows in the direction towards the north, from Ecuador to Colombia. The wind speed weakens a bit on the border with Ecuador, with values of 0.5 m/s to 1.0 m/s (dark blue), the eastern part of the province continues with winds of 2.0 m/s (aqua blue).

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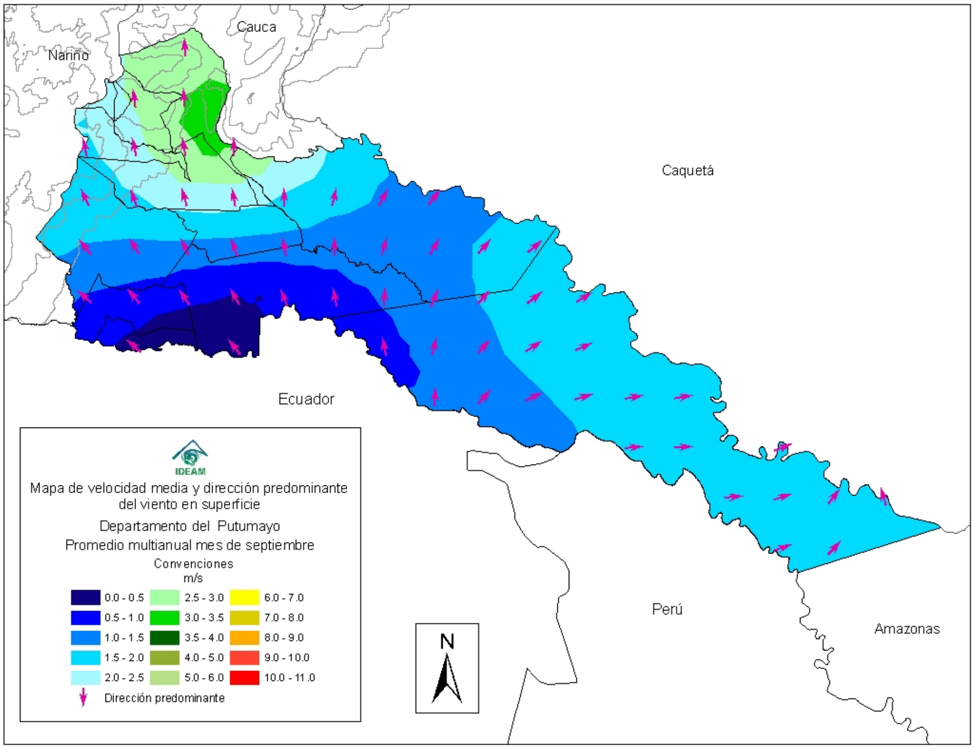

Map of the Mean speed and predominant surface wind
Province of Putumayo
Multi-annual Mean – September
Convention m/s
↓Predominant direction

In September, the condition is similar to August. The predominant direction is from the south (always directed from Ecuador into the Colombian territory), while the wind speed weakens, a little, on the border with Ecuador, with values of 0.5 m/s to 1.0 m/s (dark blue); the eastern part of the province continues with winds of 2.0 m/s (aqua blue).

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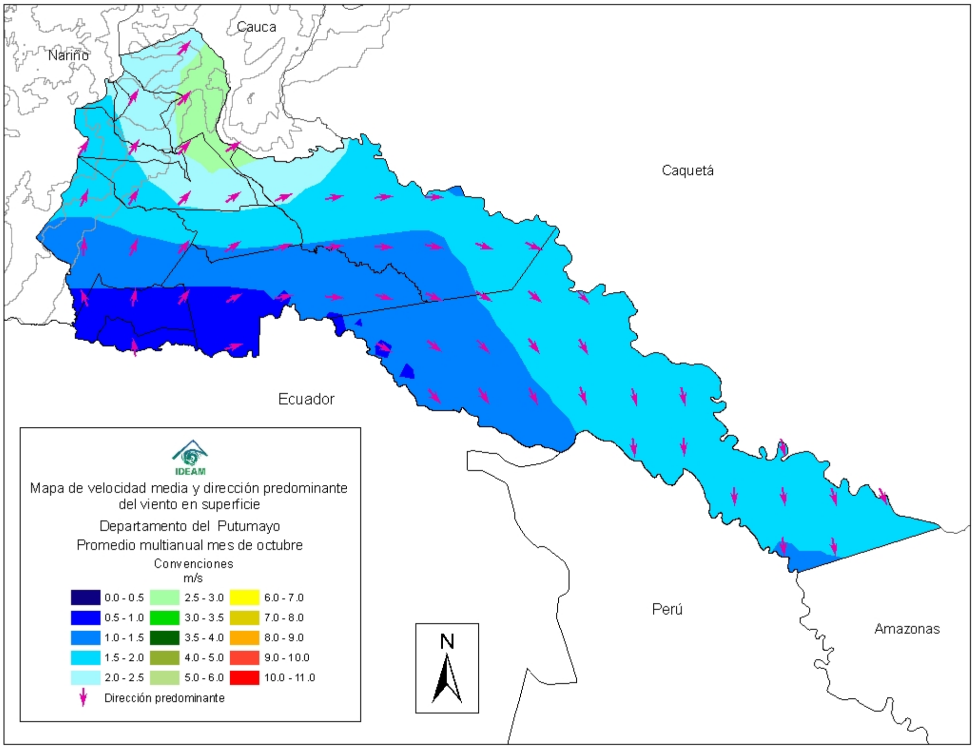

Map of the Mean speed and predominant surface wind
Province of Putumayo
Multi-annual Mean – October
Convention m/s
↓ Predominant direction

In October the wind direction varies slightly, even though much of the border with Ecuador remains in the south, going from Ecuador to Colombia. The speeds are kept in the values observed in previous months, from 0.5 m/s (dark blue) to 2.0 m/s (aqua blue).

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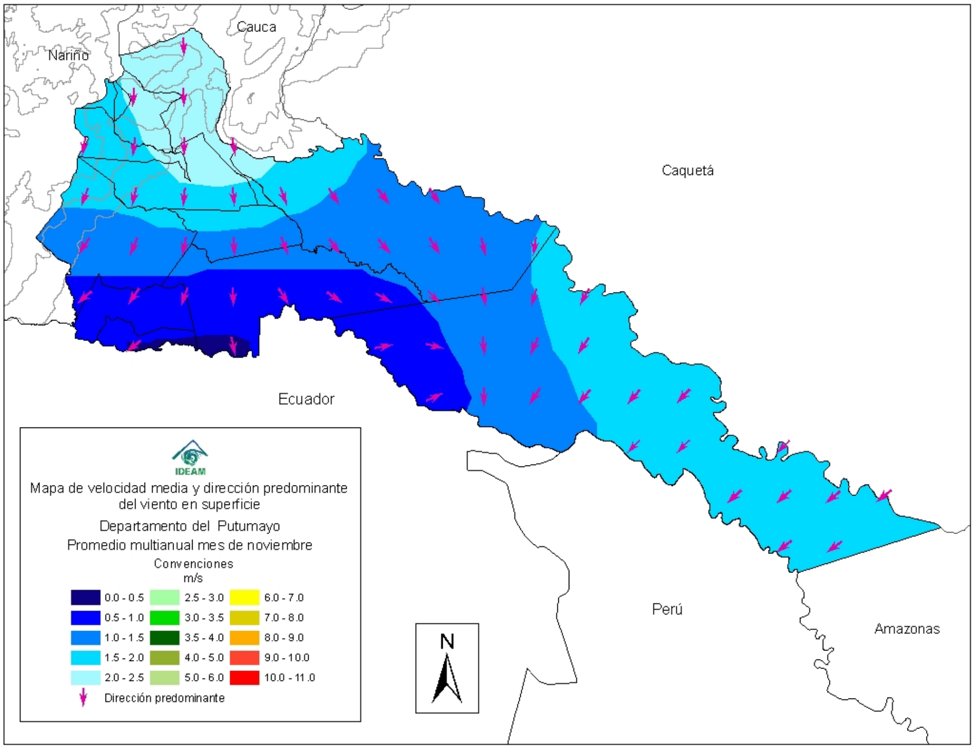

Map of the Mean speed and predominant surface wind
Province of Putumayo
Multi-annual Mean – November
Convention m/s
↓Predominant direction

November is atypical compared to other months of the year. The wind flow is predominantly from the north, that is, heading south, but it can be observed that the speeds are low, they vary from 0.5 m/s (dark blue) to 1.5 m/s (light blue) in the Ecuadorian border.

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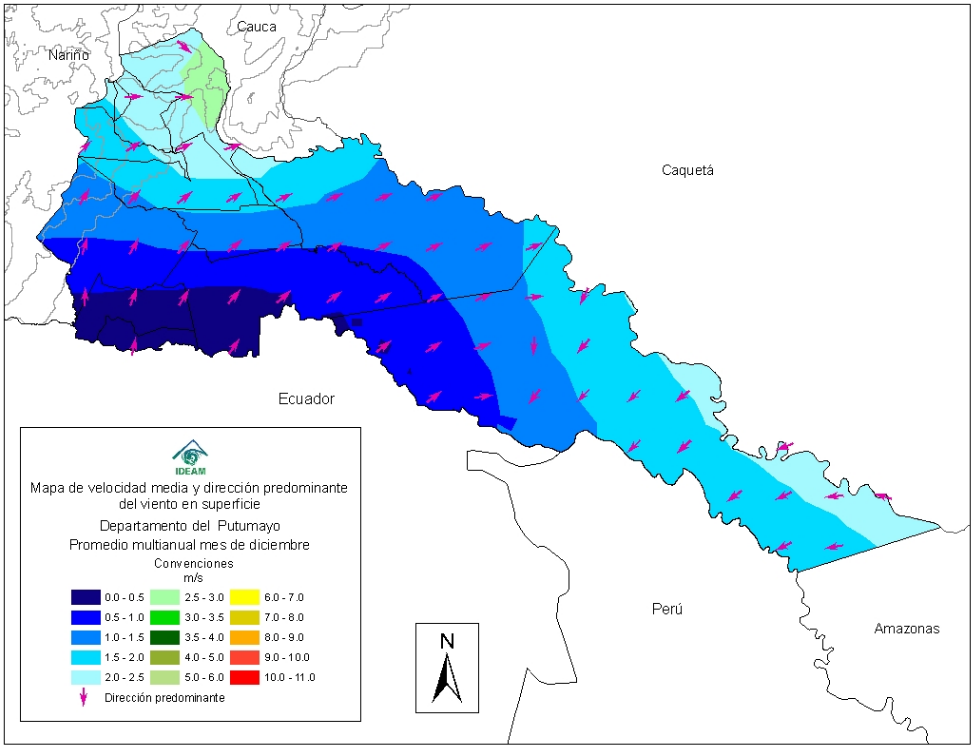

Map of the Mean speed and predominant surface wind
Province of Putumayo
Multi-annual Mean – December
Convention m/s
↓ Predominant direction

In the month of December, the wind returns to its normal condition, being predominant in the south, that is, blowing from Ecuador to Colombia, along the entire border with Ecuador. The speed ranges from 0.5 m/s (dark blue) to 1.5 m/s (light blue). East of the province, the wind blows north, toward Peru, with a velocity of 2.0 m/s (aqua blue).

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I Annex 1 additional information on trend of wind mean fields is provided.

In Annexes 2A and 2B maps of monthly mean wind (predominant direction and mean speed) are shown for the provinces on Nariño and Putumayo, respectively. Wind speed is classified based on a color scale, in which blue and black tones correspond to speed below or equal to 2,5 m/s (9 Km/h); the green ones to speed between 2,5 and 6,0 m/s (9 to 21,6 Km/h), and the yellow and red colors correspond to speed above 6,0 m/s (21,6 Km/h). On these maps, predominant wind direction is shown by the arrows or vectors direction.

In general terms, maps in Annexes 2A and 2B allow to state that for most part of the year, predominant winds in the border zone between both countries blow from Ecuador towards Colombia and their speeds are low. At the bottom of each map a brief description of the wind trend is given for the corresponding month.

The following officials from the Meteorology Under-division of IDEAM took part in the preparation of this report:

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