INTERNATIONAL COURT OF JUSTICE

CASE CONCERNING
AERIAL HERBICIDE SPRAYING

ECUADOR
v.
COLOMBIA

REPLY OF ECUADOR

VOLUME II

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Analysis of Aerial Eradication Spray Events in the Vicinity of the Border Between Colombia and Ecuador from 2000 to 2008

January 2011

R. John Hansman
Carlos F. Mena

Annex 1

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Executive Summary

Flight track data which documented 114,525 aerial eradication spray events conducted by Colombia within 10 kilometers of the border between Colombia and Ecuador from 2000 to 2008 were analyzed to determine compliance with territorial and operational restrictions identified in Colombia's Environmental Management Plan and in other limitations imposed at various times by the Colombian government. Numerous, and in some cases pervasive, exceedances of territorial and operational criteria were observed in the data.

There were 114,525 documented spray events within 10 km of the Ecuadorian border which sprayed an estimated 326,658 gallons (1,236,535 liters) of herbicide. A minimum of 25,050 spray events were observed within 2.7 km of Ecuadorian territory. During periods in which Colombia voluntarily suspended eradication within 10 km of the Ecuadorian border, 6,046 spray events were recorded. There were 1,078 spray events documented within 2 km of Ecuador's National Parks or Indigenous Reserves and numerous spray events were observed within 2 km of communities in both Colombia and Ecuador.

The operational parameters established by Colombia to control spray drift were routinely violated. Of the spray events for which data was recorded 96% (89,124 of 92,643 spray events) were flown higher than the 25 meter maximum ceiling referred to in Colombia's submission to the Inter-American Commission on Human Rights. In addition, 17% (16,143) were higher than the 50 ft meter altitude ceiling referred to in the *Counter-Memorial*. These are conservative figures for the 2000 to 2008 period because the altitude data for two years (2001 and 2004) was not included as it could not be accurately analyzed due to lack of identification of altitude units (feet vs. meters) in the data set. Of the spray events for which data was recorded 69% (75,841 of 110,418 spray events) were flown faster than the 165 mph (265 km/hr) "maximum operational speed" and 10% (11,113) exceeded the 333 km/hr "worst case scenario" referenced in the *Counter-Memorial*. The 140 mph (225 km/hr) maximum speed reported by Colombia to the Inter-American Commission on Human Rights was exceeded in 98% (108,563) of the spray events. With respect to application rate, at least 27,429 documented spray events exceeded the 23.65 liters per hectare maximum application rate established by Colombia's Environmental Management Plan. With respect to the time of day, a total of 24,540 spray events were recorded within 10 km of the Ecuador border during night time hours (8 pm to 4 am) when temperature inversions are most likely to occur. The data indicate that the AT-802 aircraft referenced in the *Counter-Memorial* was only used in 35% (38,142 of 110,418) of the spray events and 2 other aircraft types, the T-65 and OV-10 were used for a majority of the spray events. The OV-10 was designed as a military observation aircraft and it is unusual for it to be used in for aerial application of herbicides.

Complete analysis of the spray events database was not possible because some information, such of the calendar day of the flight, was missing, and in other cases, other information, such as the application rate of the spray released, was

not recorded. If this information was missing from the data available to Colombia, then Colombia would not have been able to determine its compliance with relevant operational parameters.

In addition to the parameters described above, meteorological factors also affect spray drift. The data set analyzed for this report did not contain information concerning wind speed, temperature, humidity or other meteorological parameters. Therefore, based on the data available, it was not possible to determine compliance with these parameters. Nor is it clear whether Colombia had a mechanism in place to verify compliance.

1. Introduction

This report presents an analysis of data regarding aerial eradication spray events conducted by Colombia within 10 km of the border between Colombia and Ecuador from 2000 to 2008. The analysis was conducted to determine the extent to which the spray operations respected territorial and operational limits defined in the Colombian Environmental Management Plan (EMP) (Republic of Colombia, 2003) and other statements made by the Government of Colombia.

The basis of the analysis are records provided by the U.S. Department of State which document coca eradication spray events during the period by T-65, AT-802, and OV-10 aircraft. The entire dataset comprises 245,977 spray lines within approximately 20 kilometers of the Ecuador-Colombia border. However, the analysis in this report focuses primarily on 114,525 spray events conducted within 10 kilometers of the border. The spray events were analyzed in terms of their proximity to the Ecuadorian border and other geographical features as well as other flight parameters such as altitude and airspeed which influence the drift and dispersion of the chemical herbicide. These parameters were compared with the requirements of EMP and other relevant statements by Colombia.

The data set analyzed in this report was provided to us by counsel to the Government of Ecuador, which obtained the data from the United States Department of State on November 13, 2009 as a result of a request under the United States Freedom of Information Act (FOIA). Counsel subsequently received a description of the units associated with the data from the Department of State on March 12, 2010. The 20 kilometer extent of the dataset is an artifact of the request for data within that geographical area. Colombia's aerial spraying operations extend beyond the dataset analyzed for this report (e.g. UNODC, 2005). Nevertheless, this report focuses on spray events within 10 kilometers of the international border, because these flights are most relevant to the occurrence of spray drift into Ecuador.

2. Methodology

2.1 Description of Spray Data

The data analyzed for this report was automatically collected by onboard computer systems in the spray aircraft. As explained by the U.S. Department of State:

> Onboard computer and digital global positioning systems (D/GPS)-driven equipment (SATLOC and Del Norte) automatically record each aircraft's actual flight parameters, including differential-GPS track, airspeed, altitude (mean sea level), application rate, and precise geographic location (longitude and latitude coordinates) at the time of aspersion. This allows precise evaluation of each spray event in order to ensure that spraying is conducted within proper target areas and within specified parameters. As part of the end-of-mission check, the mission planner and pilots review the spray logs for any inconsistencies in the recorded spray data. (U.S. Department of State, 2002)

Differential-GPS is a higher precision GPS system where small errors such as the ionospheric propagation and satellite clock errors are corrected through reference stations at known positions. The accuracy will depend on the specific reference stations (which were not documented in the data) but differential-GPS normally have accuracies 5 meters or better (Misra & Enge 2001). In addition to the differential-GPS data the SATLOC and Del Norte systems also receive data from sensors installed on the spray system to monitor spray rates and valve positions. (Hemisphere GPS 2010).

For each of the 245,977 spray events in the data provided by the U.S. Department of State there is a "spray line" in a standard Geographical Information System (GIS) format (Shapefile[1]). Spray lines represent aircraft ground tracks when chemicals were being sprayed. Typical examples of spray lines are shown in Figure 1.

[1] Shapefile is the format used by ArcGIS software and store vector models (lines, points, polygons).

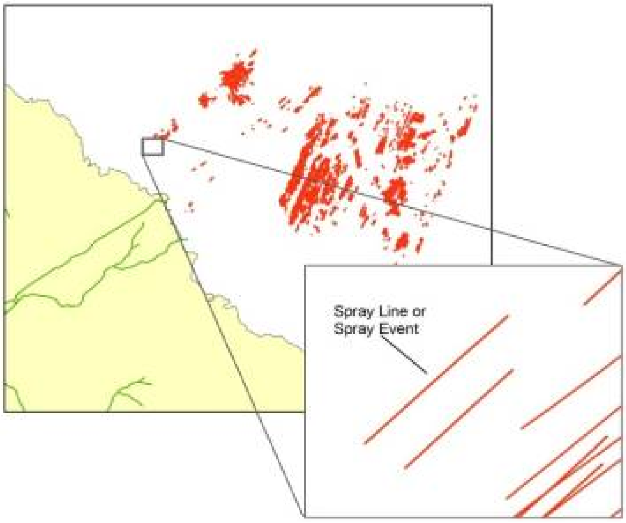

Figure 1: Examples of Spray Lines Recorded by the GPS Systems.

The data also included linked files of spray event attributes which were correlated to each spray line. The variables in the attribute files varied slightly between years presumably due to changes in the data acquisition system or reporting procedure. The set of attributes and the years they were available are shown in Table 1.

Table 1: Variables Contained in the U.S. Department of State Files

Variable	Description	Units	Year
FID_	ArcGIS internal ID		2000-2009
SEG	Event number		2002-2009
FILE_NAME	Binary log filename		2002-2009
LINE_ID	Line ID and Job ID		2002-2009
TIME_	Time of the spray event		2002-2009
LINE	Target line for spraying		2002-2009
START_TIME	Start time of the spray event		2002-2009
LATITUDE	Latitude. The exact location within the line (initial point, center, or final point) is unknown	Degrees	2002-2009
LONGITUDE	Longitude The exact location within the line (initial point, center, or final point) is unknown	Degrees	2002-2009
ALTITUDE	Altitude (mean sea level) of the event	In feet (2000, 2002-2003) and in meters (2005-2009).	2000-2009

		Mixed units in 2001 and 2004	
XTRACK	Deviation from planned flight path	Feet	2000-2001
MPH	Ground speed	Miles per hour	2000-2001
HEADING	Aircraft Flight direction	Degrees	2000-2001
S	Spray Valve Position (0-shut, 1,2,3-open)		2000-2001
SPRAY_RATE	Chemical application rate	Gallons per minute	2000-2001
DOP	GPS Dilution of Precision which relates to the geometry of the GPS satellites. Lower values <2 indicate good geometry and measurements are considered accurate		2000-2001
SV	Number of satellites being tracked by the GPS receiver		2000-2001
USED	Number of GPS satellites used to calculate the position		2000-2001
FLT_TIME	Length of time of spray event	Seconds	2002-2009
DF	Differential correction age: time used by the GPS receiver to differentially correct the GPS position.	Seconds	2000-2001
FLT_LENGTH	Spray event length	Feet (2002-2003) Meters (2005-2009)	2002-2009
STNID	Station ID used for differential correction		2000-2001
OTE	Deviation from planned flight path	Feet (2003) Mixed units (2004) Meters (2005-2009)	2003-2009
ASCIINAME	Binary log filename		2000-2001
SPEED	Ground speed	Miles per hour	2002-2009
VOLUME	Chemical application rate	Gallons/Acre (2002-2003); Mixed units (2004); Gallons/hectare (2005-2009)	2002-2009
AREA	Calculated area for each spray event	Acres (2002-2003) Mixed units (2004) Hectares (2005-2009)	2002-2009
LOG	Binary log filename		2000-2009
MISSION	Target crop		2000-2001
LENGTH	Spray line length	Meters	2000-2009
MONTH_	Month of the spray event		2000-2009
SWATH	Half of the effective swath width	Feet	2000-2009
AIRCRAFT	Aircraft type		2000-2009
SOURCETHM	Intermediate merge (in a GIS) filename		2000-2001
A_C_CROP	Aircraft type and targeted crop		2000-2001
CROP	Target Crop: Coca		2000-2009
GROUP_	Assigned names of squadrons		2009

A sample extract of the spray data from 2001 is depicted in Figure 2. It is notable that the MONTH and the precise TIME of each spray event were included in data but the date of the spray event was not. It is not clear why this data was omitted from the files as date is a basic parameter in the GPS system and is normally included in data logs.

LINE_ID	TIME	ALTITUDE	XTRACK	MPH	HEADING	S	SPRAY_RATE	DOP	SV	USED	DF	STNID	ASCIINAME	LENGTH	MONTH	SWATH	TYPE
001204	07:39:21.18	1976.0	-10.13	169.99	180.30	1	0.000	0.8	12	11	0	-1	I011ebac	0.003	0112	50	Coca
001245	07:39:58.89	1852.0	-7.76	169.99	178.70	1	0.000	0.8	12	11	0	-1	I011ebac	0.001	0112	50	Coca
001256	07:40:06.83	1830.0	15.17	172.81	179.10	1	0.000	0.8	10	11	0	-1	I011ebac	0.001	0112	50	Coca
001264	07:40:11.74	1804.0	35.59	174.70	178.60	1	0.000	0.8	10	11	0	-1	I011ebac	0.002	0112	50	Coca
001286	07:40:30.51	1730.0	25.23	165.10	179.70	1	0.000	0.8	12	11	0	-1	I011ebac	0.001	0112	50	Coca
001295	07:40:36.92	1729.0	12.11	161.47	180.20	1	0.000	0.8	12	11	0	-1	I011ebac	0.001	0112	50	Coca
001518	07:44:16.64	1742.0	11.02	167.73	0.10	1	0.000	0.8	12	11	0	-1	I011ebac	0.002	0112	50	Coca
001548	07:44:43.92	1842.0	41.58	161.45	0.00	1	0.000	0.8	12	11	0	-1	I011ebac	0.002	0112	50	Coca
001582	07:45:15.02	1924.0	53.65	157.63	359.60	1	0.000	0.8	12	11	0	-1	I011ebac	0.002	0112	50	Coca

Figure 2: Excerpt of Spray Data From 2001.

In some cases the SPRAY_RATE or spray VOLUME data appeared to be missing. This was particularly significant in the 2000 data when 26% (1487 of 5,770) of the spray events indicated zero SPRAY_RATE and the 2002 data where 27% (17,703 of 66,107) of the spray events indicated zero VOLUME. In the 2001 data 47% (12,090 of the 25,742) of the spray events had only GPS derived data (ALTITUDE, HEADING, satellite data, etc, as well as the GIS spray track). This indicates that the module with flow sensors was not functioning or not connected for these flights. As a consequence, as show in Figure 2, there was no SPRAY_RATE data reported for these events.

In order to determine the validity of the missing spray rate and spray volume events, the spray valve position was evaluated in the 2000 and 2001 data. In all cases where spray reporting system was operational, the spray valve was open indicating that the lack of spray rate and spray volume was due to a failure of the spray rate sensors or a failure to include the data. As a consequence these spray tracks were assumed to be valid. Spray valve data was not reported after 2001 but based on the 2000 and 2001 data it was assumed that all spray tracks were valid in subsequent years.

The position data was provided as latitude and longitude in standard GPS World Geographic Coordinate System (WGS) by the U.S. Department of State. The ALTITUDE data was referenced to altitude above Mean Sea Level (MSL) and was provided in either feet or meters. Normally the units for ALTITUDE were consistent through a particular year but in some years (2001 and 2004) the units were mixed. Because the altitude units in the 2001 and 2004 data could not be definitively determined, the altitude values for these years, a total of 21,452 spray events, were not included in the altitude analysis. Thus, the number of violations of altitude criteria presented in this report are an underestimate of the total number of altitude violations from 2000 to 2008.

The spray AREA was also in mixed units either acres or hectares 2004; similarly the VOLUME was in either gallons per acre or gallons per hectare in 2004. The units appeared to be consistent within a single flight record so it was possible to calculate the quantity of herbicide sprayed by multiplying the AREA by the VOLUME and the ambiguous units would cancel. However, for analysis of compliance with application rate criteria, the 2004 data could not be used due to the unit ambiguity and was not included in the analysis. Thus, the number of violations of maximum application rate presented in this report are an underestimate of the total number of violations.

2.2 Data Analysis Methods

2.2.1 Spray Line Position

The analysis of spray line positions were conducted in a Universal Transversal Mercator (UTM), WGS84 projection to allow comparison with topographic maps. The spray lines were re-projected from geographical coordinates to UTM to make them compatible. The position data was known to be logged with differential GPS and are assumed to have an error significantly less than 10 meters (Misra & Enge 2001). Topographic maps of 1:50,000 and 1:25,000 were used to define the ground reference. Topographic maps with a 1:50,000 scale can have a positional error of 0 to 10 meters and topographic maps with a 1:25,000 scale can have 0 to 5 meters of positional error. Based on topographic map reference, the location of the Ecuador-Colombia border was determined to better than 10 meter accuracy which is consistent with the 10 meter or better accuracy of the differential GPS used to determine the spray line positions.

2.2.2 Altitude of Spray Aircraft

Because the ALTITUDE parameter was provided as height above Mean Sea Level (MSL) the terrain elevation was subtracted from the ALTITUDE parameter to provide aircraft elevation above the terrain or height Above Ground Level (AGL) as can be seen in Figure 3a.

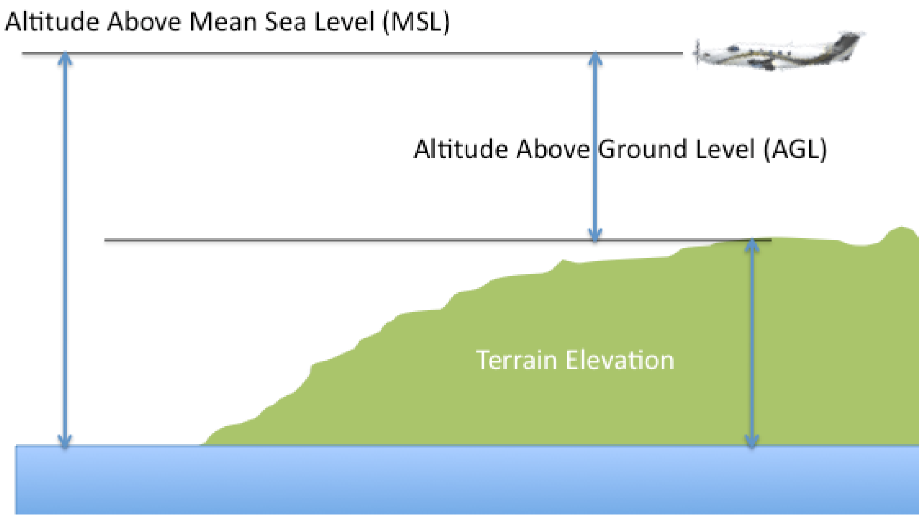

Figure 3a: Determination of Altitude Above Ground Level (AGL) From Altitude Above Mean Sea Level (MSL).

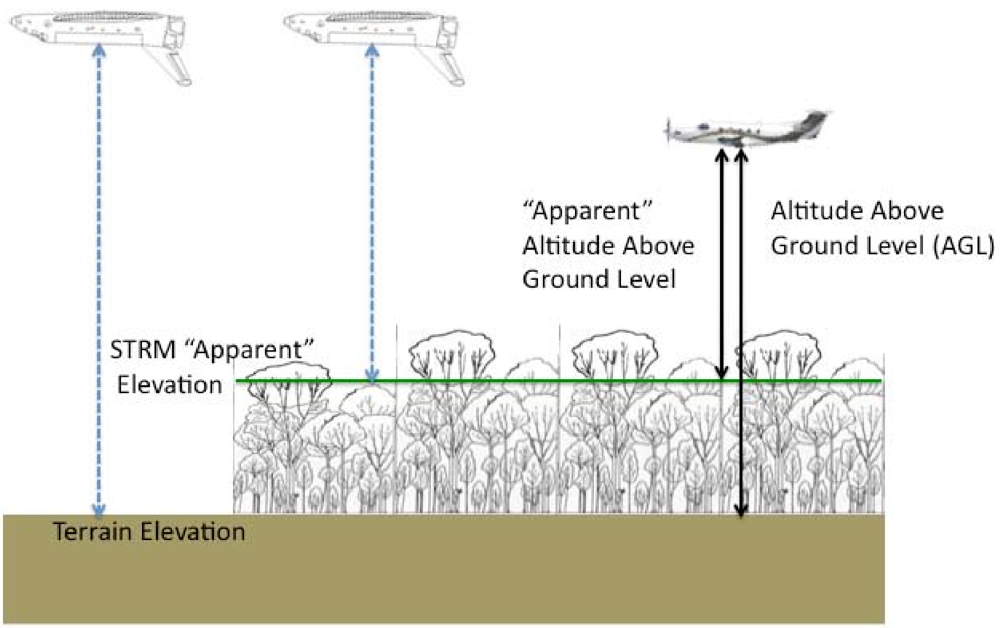

Figure 3b: Increase in SRTM Digital Elevation Model "Apparent" Altitude of Terrain in Forested Regions.

The terrain elevation was provided by a Digital Elevation Model (DEM) generated by the NASA/NGA Shuttle Radar Topography Mission (SRTM).[2] This was necessary due to the lack of high quality topographic maps of Colombia with adequate terrain elevation resolution. The SRTM data has known offset errors produced by the intrinsic characteristic of the measurement system, atmospheric conditions, and characteristics of the land surface. In order to compensate for these bias errors the SRTM elevation data was corrected by a regression analysis of 97 unforested reference points on the Ecuadorian side of the border.[3]

It is important to note that the SRTM system works from radar reflections off of the highest reflective objects within the measurement area. In regions where there is bare ground, the SRTM data will give an accurate measurement of terrain elevation because the radar will reflect off of the solid ground, as shown in Figure 3b. However, in forested regions, the SRTM does not measure the "bare earth" surface elevation, but rather the elevation of various scatterers (leaves and branches). Therefore, the SRTM based DEM represents neither the "bare earth" surface nor the tree canopy surface, but some elevation between (Hofton, Dubayah et al. 2006; Bourgine & Baghdadi 2005) and will tend to overestimate apparent terrain elevation in forested regions.

For the purpose of the aircraft altitude analysis the SRTM based DEM was used. The altitudes AGL were determined by subtracting the $SRTM_{corrected}$ DEM elevation from the reported ALTITIDE. Using the SRTM data is conservative in that it will tend to provide a low estimate of AGL altitude in forested regions since the apparent elevation in the SRTM data will be higher than the actual terrain elevation. As a consequence the apparent altitude AGL of the aircraft will tend to be lower than the actual altitude AGL and the analysis will tend to under report exceedences of altitude limits.

The SRTM DEM elevation data was applied to the centroid of the line representing the flight path of the spray aircraft. This SRTM DEM elevation at the centroid of the flight path is the $SRTM_{uncorrected}$ value used in the regression equation.

To determine how conservative the SRTM based analysis is in forested regions, the height of the apparent ground level (the difference between tree canopy height and the vertical penetration of the SRTM signal into the tree canopy) was estimated:

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[2] The SRTM data was obtained from SENPLADES (Secretaría Nacional de Planificación del Ecuador).

[3] This methodology is based on Sharma, Arabinda, Tiwari, K. N. and Bhadoria, P. B. S. (2010) Vertical accuracy of digital elevation model from Shuttle Radar Topographic Mission - a case study, Geocarto International, 25: 4, 257-267 and Taramelli, A., Reichenbach, P. and Ardizzone, F. (2008) Comparison of SRTM Elevation Data With Cartographically Derived DEMs in Italy, Rev. Geogr. Acadêmica v.2 n. viii, 41-52. A Ordinary Least Squares (OLS) regression model was applied to the SRTM data against the reference points that come from topographic maps in non-forested places identified with Landsat imagery. The regression obtained is $SRTM_{corrected} = SRTM_{uncorrected} (1.0194) – 5.8165$. The magnitude of the correction across the entire dataset ranges from -9.39 m to 5.82 m.

- The canopy height of the rainforest in the Ecuador-Colombia border region is in the range of 30 to 35 meters. Emergent trees may extend even higher, reaching 50 or even 65 meters above ground (Balslev, 2010). For the purposes of this calculation, we assumed a more conservative tree canopy height of 25.91 meters, based on the Hewitt et al. (2009) study.

- The vertical penetration of the SRTM signal into the tree canopy has been measured by two studies of similar tropical forest ecosystems. Bourgine & Baghdadi (2005) used airborne laser altimeter data as a reference and estimated vertical penetration of SRTM wavelengths 8.5 m into a tropical forest in French Guinea. Hofton, Dubayah et al. (2006) used a Laser Vegetation Imaging Sensor (LVIS) as a reference and estimated vertical penetration of SRTM wavelengths 8.03 meters into a tropical forest in Costa Rica. An intermediate value of (8.25) was used for this estimate.

Thus, the estimated height of the apparent ground in forested regions, which is the difference between the tree canopy height and the vertical penetration of the SRTM satellite into the tree canopy, is 17.66 meters (25.91 meters - 8.25 meters). Therefore, the actual altitude AGL is likely to be at least 17.66 meters higher in forested regions than the AGL altitudes based on the SRTM DEM data.

Because it was not possible to accurately identify all data points which corresponded to forested regions, this correction was not made in the altitude of spray aircraft analysis presented in this report. Therefore, the data will tend to underestimate the number of spray events at altitudes above a specific threshold.

2.2.3 Volume of Herbicide Sprayed

The quantity of herbicide sprayed was determined from the available attribute field data. For 2000 the SPRAY_RATE was multiplied by the LENGTH divided by the MPH with appropriate unit corrections. For 2003-2009 the VOLUME was multiplied by the AREA. For 2001 and 2002 when specific spray data was not reported, spray quantity was estimated as 2.855 gal/track which was the average quantity per track from the years when spray data was available.

3. Analysis of Spray Event Locations

3.1 Analysis of Spray Events With Respect to the International Border

3.1.1 10 Kilometer Analysis

The location of spray events in the data can be seen in Figure 4 which depicts the spray tracks as well as a line drawn 10 kilometers from the Ecuadorian border. Spraying began within 10 kilometers of Ecuador's Sucumbíos province in January 2000 and within 10 kilometers of Ecuador's Esmeraldas province in September 2000. A high concentration of spray events can be seen adjacent to Ecuador's Esmeraldas and Sucumbíos Provinces. A total of 114,525 spray tracks were documented within 10 kilometers of the border. The data indicates a total of 326,658 gallons (1,236,535 liters) of chemical herbicide were dispersed within 10 kilometers of the border. A breakdown of the volume of chemicals sprayed per year is shown in Table 2.

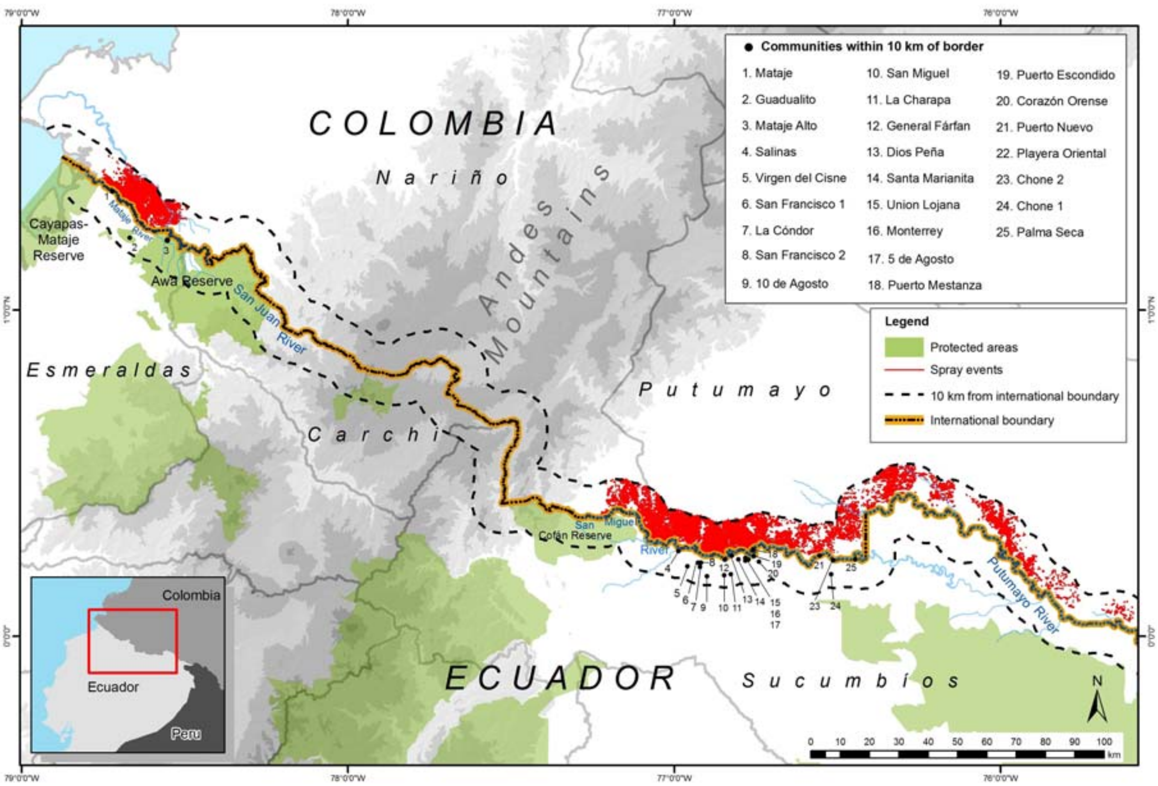

Figure 4: Map of Spray Events Within 10 km of the Ecuadorian Border.

Table 2: Number of Tracks and Volume of Chemical Sprayed Within 10 Kilometers of the Ecuadorian Border

YEARS	# OF TRACKS	GALLONS SPRAYED	LITERS SPRAYED
2000	4,838	14,208	53,783
2001	13,366	38,160	144,451
2002	38,922	111,122	420,643
2003	7,159	20,688	78,313
2004	8,086	11,799	44,664
2005	13,608	33,632	127,311
2006	17,532	56,483	213,811
2007	10,925	40,249	152,359
2008	89	317	1,200
TOTAL	114,525	326,658	1,236,535

3.1.2 2.7 to 3.0 Kilometer Safety Margin Analysis

In a diplomatic note sent from Colombia to Ecuador in July 2001, Colombia stated that “in the particular case of the border with Ecuador, the safety margin of 2.7 to 3.0 kilometers is believed to be enough.” (Republic of Colombia, 2001a).

The spray event data were analyzed to determine the extent to which Colombia sprayed within 2.7 kilometers of the Ecuadorian border. A total of 25,050 spray events took place within 2.7 km of the Ecuadorian border and 29,057 events within 3.0 km of Ecuadorian border between 2000 and 2008.

3.1.3 Analysis of Spraying Within 10 Kilometers of the Ecuadorian Border During Suspensions

A report by the Anti-Narcotics Direction of the Colombian National Police states that Colombia suspended aerial spraying operations within 10 kilometers of the international border during several periods since 2005. In the Colombian province of Nariño (adjacent to the Ecuadorian province of Esmeraldas), Colombia describes two suspensions: from December 27, 2005 to December 17, 2006; and from January 15, 2007 to the present. In the Colombian province of Putumayo (adjacent to the Ecuadorian province of Sucumbíos), Colombia describes three suspensions: from January 1, 2005 to September 24, 2005; from December 11, 2005 to December 11, 2006; and from January 22, 2007 to the present. (Republic of Colombia, 2010).

Our analysis of the spray event database determined that in Nariño province, during the voluntary suspension that started on January 15, 2007, at least 5,287 spray events occurred within 10 km of the Ecuadorian border. Those spray events released 20,630 gallons (78,093 liters) of herbicide. In total, at least 6,046 spray events were conducted within 10 kilometers of Ecuador's border during the five voluntary suspensions by Colombia.[4]

3.1.4 Spray Events Conducted Over Ecuadorian Territory

Our analysis of the flight path data indicates that there were at least 4 spray events conducted over Ecuadorian territory in the Esmeraldas Province near the community of Corriente Larga, one in March 2003 and three in April 2004.[5]

[4] Because the data set does not include specific calendar dates, our analysis of these suspensions took into account data for whole months only. For example, the analysis of the suspension in the Nariño Province from January 15, 2007 to the present included data from February 2007 to January 2009. Consequently, any spray events that may have occurred between January 15, 2007 and January 31, 2007 were not counted. In addition, this analysis does not include any spraying that occurred after January 2009 because the dataset analyzed ends with that month.

[5] The record numbers for these flights are: line 32, line 33, line 43 (2004) , line 42 (2003)

3.2 Analysis of Compliance With Buffer Zones Required By the Colombian Government

3.2.1 Buffer Zones to Protect Human Habitations and National Parks

Colombia has stated that it would respect buffer zones to protect sensitive areas such as water bodies, National Parks and human settlements. Aerial spraying was not permitted within these zones.

In particular, on November 26, 2001, the Colombian Ministry of the Environment issued a Resolution (Republic of Colombia, 2001b) imposing the following buffer zones with respect to the following areas:

- 200 m for standing bodies of water;
- 2,000 m for "Sub-highland, headwaters and aquifer recharge areas";
- 2,000 m for National Parks;
- 2,000 m for human settlements; and
- 1,600 m for "productive projects, pact areas".

Analysis of the dataset indicates numerous spray events occurred within 2,000 meters of Ecuadorian human settlements.

For example, between 2000 and 2008, a total of 719 spray events were conducted within 2,000 meters of the community of Mataje in the Esmeraldas province of Ecuador. During the same time period, a total of 174 spray events occurred within 2,000 meters of the community of Puerto Mestanza in Ecuador's Sucumbíos province.

Spray events were also documented within 2,000 meters of Ecuador's Indigenous Reserves. Between 2000 and 2008, 57 spray events were documented within 2,000 meters of Ecuador's Awá Indigenous and Forest Reserve. During that same time period, 10,913 spray events were documented within 10 kilometers of the Reserve. In addition, 1,021 spray events were documented within 2,000 meters of Ecuador's Cofán-Bermejo Ecological Reserve, and 12,398 were documented within 10 kilometers of the Reserve.

3.2.2 Analysis of 100 Meter Buffer Zones

In the *Counter-Memorial,* Colombia refers to a buffer zone of 100 meters around certain sensitive areas. This 100 meter buffer zone protects "bodies of water or watercourses, main roads, human or animal nuclei, or any other area that requires special protection." (Republic of Colombia, 1991).

We used satellite imagery from the IKONOS satellite system to evaluate compliance with this 100 meter buffer zone in Colombia. The analysis reveals numerous spray events within 100 meters of bodies of water, human settlements and individual houses. Several examples of these violations are shown in Figures 5 and 6.

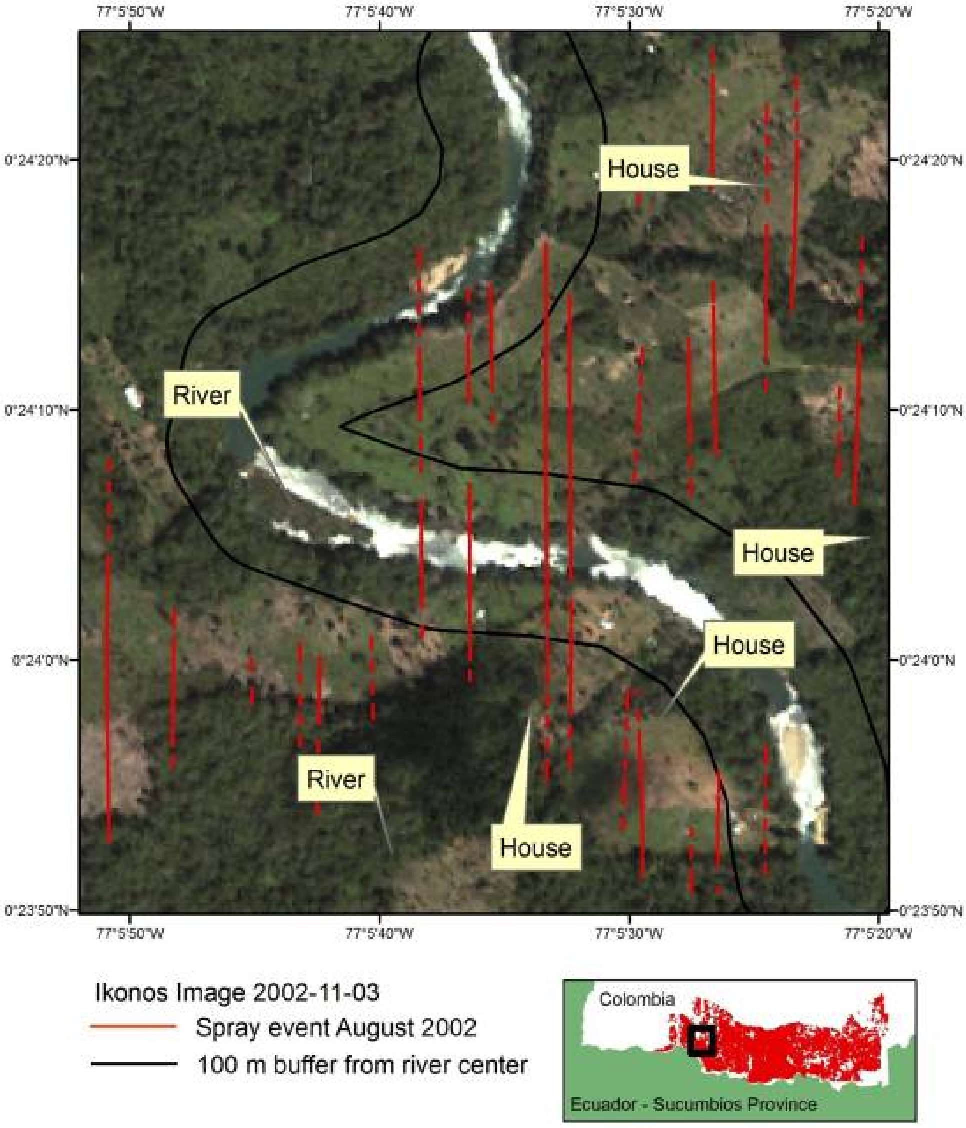

Figure 5: Spray Events in August 2002 Over River and Houses.

Annex 1

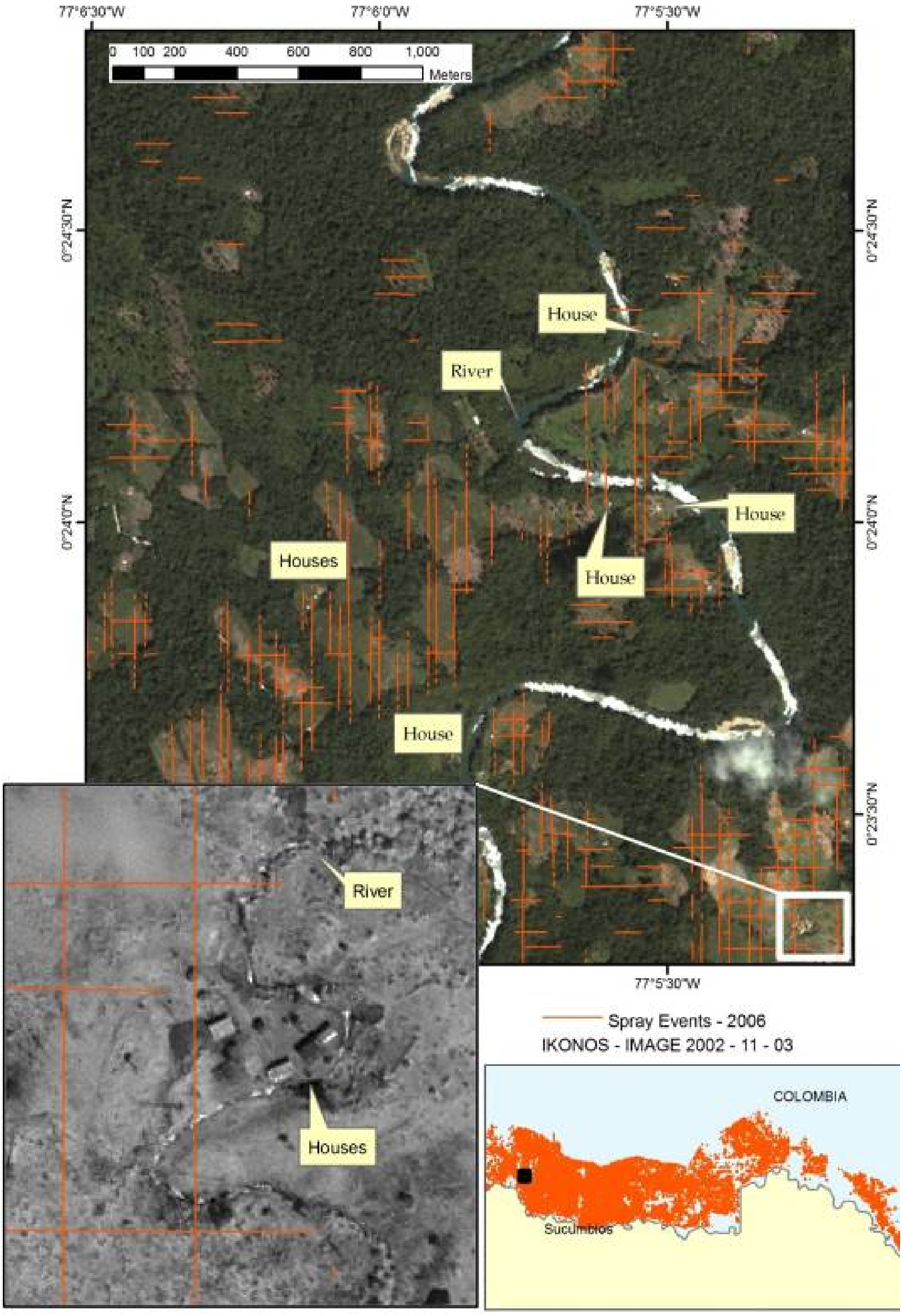

Figure 6: Spray Events in 2006 Over River and Houses.

4. Analysis of Compliance with Operational Parameters

On September 30, 2003, Colombia's Ministry of Environment approved an Environmental Management Plan (EMP) for its aerial spraying program. Among other things, the EMP contains "Operational Parameters" for flying altitude, application rate of the herbicide, droplet size, maximum ambient temperature, and maximum wind velocity. (Republic of Colombia, 2003). Colombia's *Counter-Memorial* states:

> spray drift depends essentially on wind speed and direction, as well as on a number of other atmospheric factors including temperature, relative humidity and atmospheric stability. It is also dependent on the altitude at which spraying takes place and the air speed of the spraying aircraft, as well as the calibration of the spraying equipment, the density of the spray mix and the initial size of the spray droplets. The PECIG's Environmental Management Plan has taken into account all these factors and set minimum and maximum figures for the parameters upon which drift is contingent, with the purpose of reducing it as much as possible. … These parameters are strictly observed by the personnel involved in spraying operations. (Colombia Counter-Memorial, para. 7.17).

In addition to the EMP, Colombia has identified mandatory operational parameters associated with its aerial spraying program in the *Counter-Memorial*, in diplomatic correspondence to Ecuador, and in submissions to the Inter-American Commission on Human Rights (IACHR). Colombia's statements with respect to certain mandatory operational parameters are summarized in Table 3, and are described in greater detail in the text below.

Table 3: Colombia's Statements Regarding Operational Parameters.

	Environmental Management Plan (Republic of Colombia, 2003)	***Counter-Memorial***	**Other Colombia Statements**
Altitude	"The highest application altitude will be 50 meters; notwithstanding, the operation will be conditioned to the height of the obstacles present in the target spray zones."	50 meters (¶ 4.62)	25 meters = maximum height reported to IACHR in 2005 (Republic of Colombia, 2005) 25 meters = maximum height reported to Ecuador in diplomatic note in 2004 (Republic of Colombia, 2004)
Speed	n/a	165 mph = "maximum operational air speed" (¶ 4.62, 7.32) 333 km/hr (207 mph) = "worst case scenario" (¶ 7.25)	90-140 mph = airplane speed reported to IACHR in 2005 (Republic of Colombia, 2005)
Application Rate	10.4 liters / ha of glyphosate-based formulation (23.65 liters / ha of total tank mix)	23.65 liters / ha (¶ 4.62, 6.18, 7.32)	n/a
Time of Day	n/a	Only after sunrise (¶ 7.27)	Only during daylight hours before mid-afternoon (Solomon et al. 2005)
Type of Aircraft	n/a	AT-802 (¶ 4.63)	n/a

The discussion that follows evaluates the dataset and where possible, assesses compliance with the following operational parameters, as presented in Colombia's EMP, *Counter-Memorial*, and in other statements: altitude, speed, application rate, time of day of spray events, type of aircraft, swath width, track density and track separation and meteorological conditions.

4.1 Altitude

According to the Colombian EMP, the maximum application altitude is 50 meters, "subject to geographical features or obstacles so as to avoid risks to the pilots." (Republic of Colombia, 2003).[6] In addition to the 50 meter limit in the EMP, Colombia has stated that spraying does not occur above 25 meters of altitude above ground. In that regard, in April 2004, Colombia stated in a diplomatic note to

[6] The altitude above ground level impacts spray drift. The higher the initial spray application, the more time the spray has to drift during its descent to the ground.

Ecuador that the "[h]ighest release height" is "25 meters in compliance with technical parameters." (Republic of Colombia, 2004). Similarly, in a 2005 submission to the Inter-American Commission on Human Rights, Colombia stated that the maximum altitude of its spraying operations was "not above 25 meters." (Republic of Colombia, 2005).

The altitude of spray events occurring within 10 km of the Ecuadorian border was analyzed. It was observed that 96% of spray events occurred at altitudes higher than 25 meters (89,124 out of 92,643 spray events for which data was recorded). It was further observed that 17% of spray events occurred at altitudes higher than 50 meters (16,143). Figure 7 presents a map indicating the location of spray events flown at altitudes higher than these altitude thresholds.

As discussed in Section 2.2.2, the altitude data presented above do not take into account the effect of the tree canopy height. In densely forested areas, the actual height of the spray planes is on the order of 17.66 meters higher, and thus the number of exceedances of the 50 m and 25 m altitude parameters would be greater.

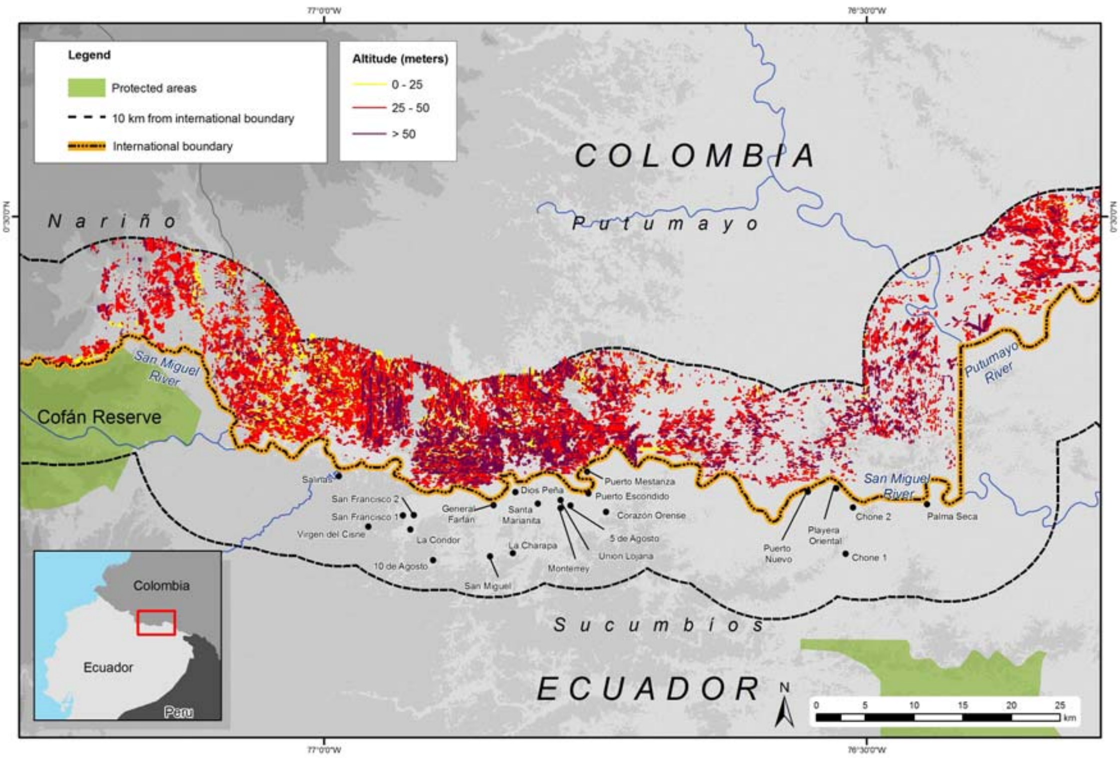

Figure 7: Altitude of Spray Events Conducted Within 10 Kilometers of Ecuador's Sucumbíos Province.

4.2 Speed

Colombia in its *Counter-Memorial* describes 165 miles per hour (265 km/hr) as the "maximum operational airspeed" and 333 kilometers per hour (207 miles per hour), as modeled by Hewitt et al. (2009), as the "worst-case scenario". (Colombia Counter-Memorial, para. 7.25). In addition, Colombia has reported to the Inter-American Commission on Human Rights in 2005 that aircraft speed ranged between 90 and 140 miles per hour (144 to 225 km/hr). (Republic of Colombia, 2005).[7]

The airspeed of spray events occurring within 10 km of the Ecuadorian border was analyzed and the distribution of airspeeds is shown in Figure 8. It was observed that 98% of spray events occurred at speeds faster than 140 mph (108,563 of 110,418 recorded spray events). It was further observed that 69% of spray events occurred at speeds faster than 165 mph (75,841). Finally, it was observed that 10% of spray events occurred at speeds faster than 333 km/h (11,113). Figure 9 presents a map indicating the location of spray events flown at speeds greater than 140 mph, 165 mph and 333 km/hr (207 mph), respectively.

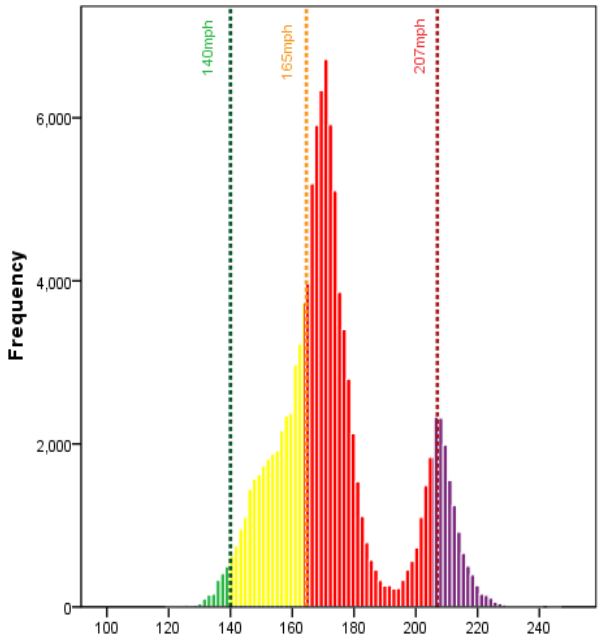

Figure 8: Distribution of Speed of Spray Events Within 10 km of Ecuadorian Border

[7] Airspeed has an important impact on spray drift and dispersion through its effect on the size of the spray droplets. For minimal spray drift it is desirable for the spray to be composed of relatively large (500-1000 micron) droplets which fall relatively more quickly to the ground. Smaller droplets fall more slowly and are pushed by winds as the ratio of aerodynamic forces to gravitational forces increase for smaller droplets. 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.

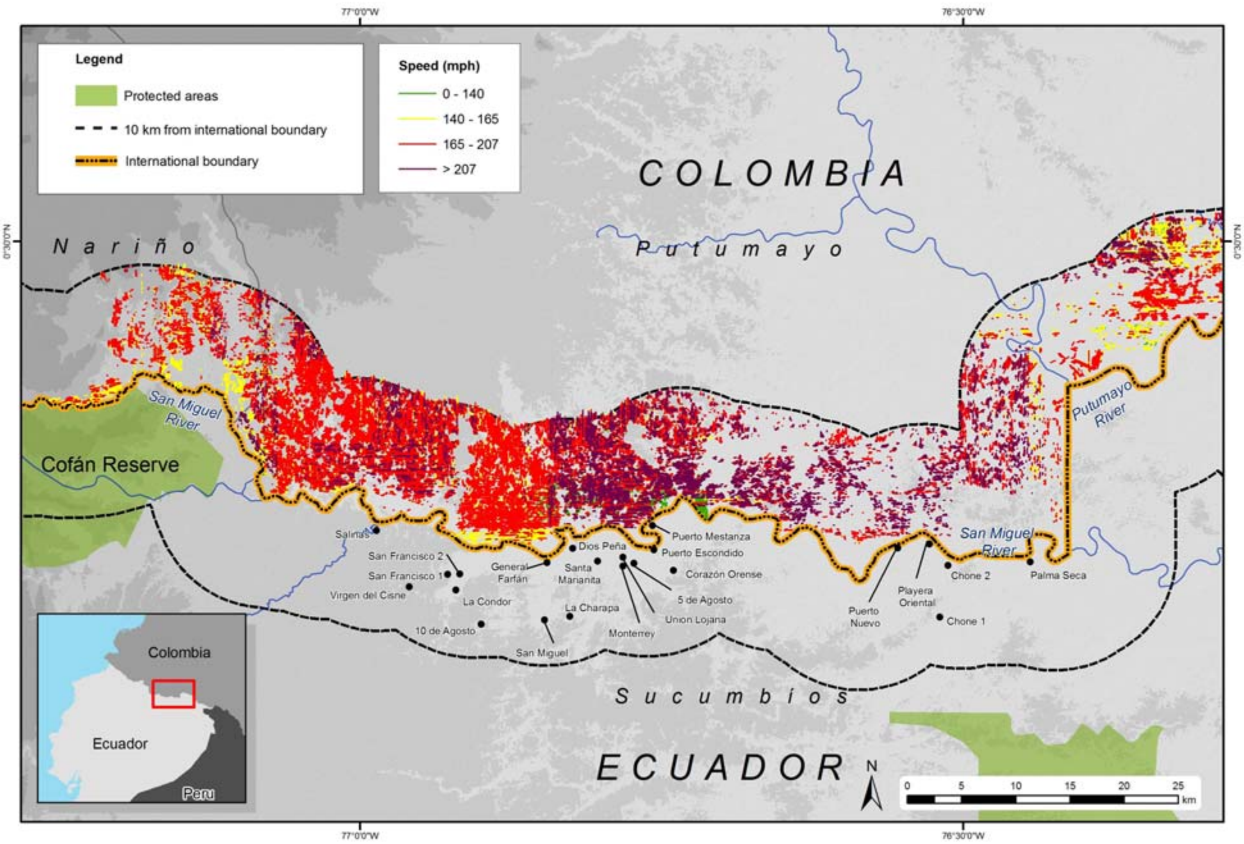

Figure 9: Speed of Spray Events Conducted Within 10 Kilometers of Ecuador's Sucumbíos Province.

4.3 Combined Speed and Altitude Analysis

We analyzed the dataset to determine whether the speed and height operational parameters were exceeded simultaneously. We observed that there were 12,155 spray events that occurred within 10 kilometers of the Ecuadorian border which were simultaneously flown higher than 50 meters and faster than 165 mph (13% of all spray events with recorded data for both parameters). We further observed that there were 85,364 spray events that were simultaneously flown faster than 140 mph and higher than 25 meters (92%).

As discussed further in Section 4.6, the dataset shows that 3 different types of aircraft have been employed by Colombia. Tables 4 through 6 summarize, by aircraft type, the height and speed of spray events by cumulative percentile. For each percentile indicated, the altitude and speed numbers represent the value for which the indicated percentage of flights are below that value. The 50th percentile represents the median value.

Percentile	Altitude (m)	Speed (mph)	Speed (km/hr)
50	40.61	171.20	275.52
60	42.50	172.60	277.77
70	44.72	174.10	280.19
80	47.37	176.30	283.73
90	51.52	179.50	288.88
95	55.24	182.30	293.38
99	64.57	188.60	303.52

Table 4. Analysis of Operational Parameters for AT-802 Aircraft based on 38,142 spray events with valid speed data and 32,432 spray events with valid altitude data (invalid altitude data from 2001 and 2004 was not included in the altitude statistics).

Percentile	Altitude (m)	Speed (mph)	Speed (km/hr)
50	42.56	207.50	333.94
60	44.89	208.90	336.19
70	47.58	210.34	338.51
80	50.66	212.40	341.83
90	55.46	215.60	346.98
95	59.54	218.50	351.64
99	68.39	225.00	362.10

Table 5. Analysis of Operational Parameters for OV-10 Aircraft based on 20,251 spray events with valid speed data and 16,269 spray events with valid altitude data (invalid altitude data from 2001 and 2004 was not included in the altitude statistics).

Percentile	Altitude (m)	Speed (mph)	Speed (km/hr)
50	39.46	162.80	262.00
60	42.24	166.34	267.70
70	45.47	169.50	272.78
80	49.43	172.79	278.08
90	55.88	177.10	285.02
95	62.51	180.64	290.71
99	83.97	188.00	302.56

Table 6. Analysis of Operational Parameters for T-65 Aircraft based on 52,025 spray events with valid speed data and 43,924 spray events with valid altitude data (invalid altitude data from 2001 and 2004 was not included in the altitude statistics).

4.4 Application Rate

The EMP establishes a maximum application rate for the glyphosate formulation of 10.4 liters per hectare, which translates to 23.65 liters per hectare of the total spray mix. (Republic of Colombia, 2003).[8] Colombia reports that the 23.65 liters per hectare application rate is broken down into 10.4 liters per hectare of glyphosate formulation, 0.25 liters per hectare of Cosmo-Flux 411 and 13 liters per hectare of water. (Republic of Colombia, 2010; Republic of Colombia, 2003). Colombia states in the *Counter-Memorial* that "[t]he nozzles have an automatic calibration mechanism that determines the amount of spray mix to be released in order for the number of liters discharged per hectare to be kept constant at 23.65 liters per hectare." (Colombia Counter-Memorial, para. 4.62).

Analysis of the dataset determined that 27,429 spray events (31%) within 10 km of the border with Ecuador released more than 23.65 liters per hectare. There were likely more such spray events because application rate data were missing or unusable for 26,290 of the flights.

4.5 Time of Day of Spray Events

Colombia states in the *Counter-Memorial* that "spraying operations take place after sunrise." (Colombia Counter-Memorial, para. 7.27). The report by Solomon et al. (2005) also states that "[s]praying is only conducted in daylight hours before mid-afternoon." (Solomon et al., 2005).[9]

Figure 10 presents the distribution of spray events by time of day. Assuming that the data recorded corresponds to local time and not Greenwich Mean Time (GMT), a total of 24,540 spray events were documented between 20:00 (8 pm) local time and 04:00 (4 am) local time. This represents 22% of the spray events conducted within 10 kilometers of Ecuador's border between 2000 and 2008.

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[8] Application rate influences the amount of chemical that is deposited in the target and non-target areas.

[9] Aerial application is normally conducted during daylight hours for at least 2 reasons. First, it is easier to accurately identify the target zone in well lighted conditions. Second, during daylight the atmosphere has better mixing and it is less likely that the spray will drift away from the intended target zone. At night the temperature of the surface is often lower than the warmer air above due to rational cooling. This results in a low altitude temperature inversion with a cool lower layer of air often only 10 or 20 meters thick. This phenomena will result in calm winds at night and ground fog if there is sufficient moisture in the air. The inversion stratifies the atmosphere and prevents mixing between the layers. As a consequence, if the aircraft sprays in the warm layer above the inversion most of the spray (particularly the smaller droplets) will not hit the target area but will drift with the winds in the upper layer. This can result in advection or drift of the spray significant distances.

If the hours before mid-afternoon are added to the night time total (16:00 – 04:00 or 4 pm – 4 am), a total of 47,262 spray events were documented, representing 43% of flights.

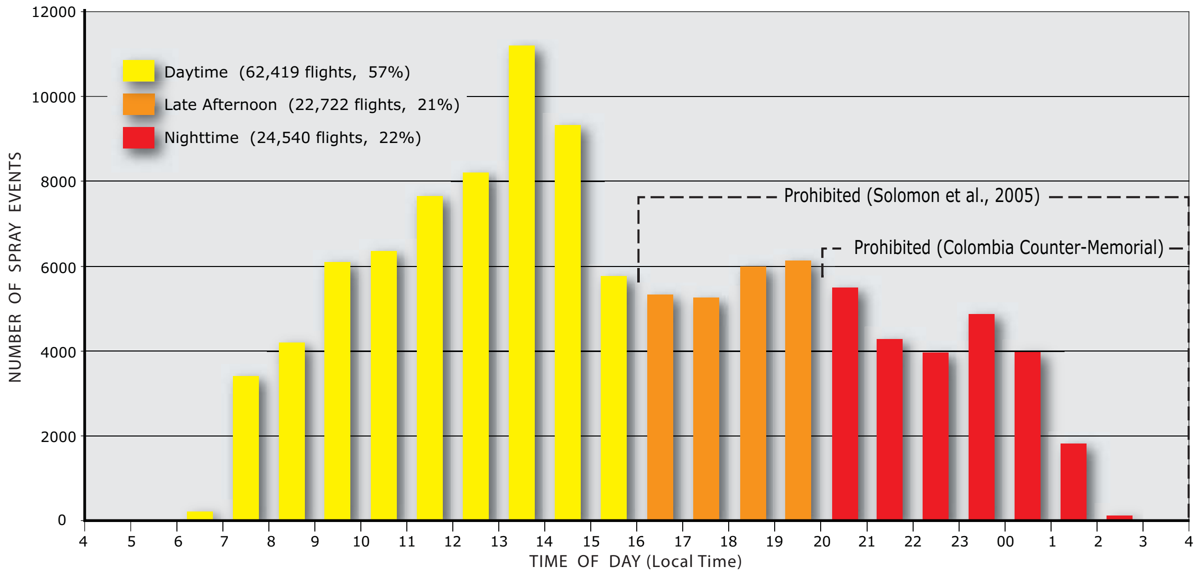

Figure 10: Distribution of Time of Day of Spray Events Within 10 km of Ecuadorian Border.

4.6 Type of Aircraft

In the *Counter-Memorial*, Colombia states that “[t]he aircraft used for spraying operations are AT-802 planes manufactured by Air Tractor; they are specially designed to operate with precision during those tasks and possess a system of tank, nozzles and pumps similar to those used for the spraying of crops in other parts of the world.” (Colombia Counter-Memorial, para. 4.63).

The data indicate that the AT-802 was only used in 35% of the spray events. Two other aircraft types, the T-65 and OV-10, were used for a majority of the spray events.

4.6.1 AT-802

The AT-802 is an aircraft specially designed for aerial application. It is a single engine, low wing turboprop with a wing span of 17.68 meters, a maximum take off weight of 6,804 kg and a maximum wing loading of 190.48 kg/m^2 (Jane's All the Worlds Aircraft, 2008-2009, pp. 900-901). An example of an AT-802 is shown in Figure 11.

Figure 11: Example of AT-802 Aircraft. (Source: Pablo Andrés Ortega Ch. - Aviacol.net, published with permission)

4.6.2 T-65

The S2RGH T-65 is designed for aerial application. It is a single engine, low wing turboprop with a wing span of 14.48 meters, a typical maximum operating weight of 4,400 kg and a maximum wing loading of 135.3 kg/m^2. (Jane's All the Worlds Aircraft 1992-1993, pp. 326). An example of a T-65 is shown in Figure 12.

Figure 12: Example of T-65 Aircraft. (Source: http://www.governmentauctions.org/labels/Thrush%20S2R-T65.asp)

4.6.3 OV-10

The OV-10 was designed as a military observation aircraft and it is unusual for it to be used in aerial application. It is a high wing design with 2 turboprops. It has a wing span of 12.19 meters, a normal maximum takeoff weight of 4,494 kg, an overloaded takeoff weight of 6,552 kg and a maximum wing loading of 242.4 kg/m^2. (Jane's All the Worlds Aircraft 1978-1979, pp.421-422). An example of an OV-10 aircraft is shown in Figure 13.

Figure 13: Example of OV-10 Aircraft. (Source: Andres Luna, 2008, EL OV-10 BRONCO EN LA FUERZA AÉREA COLOMBIANA, http://www.unffmm.com)

As can been seen in the distribution of observed airspeeds by aircraft type in Figure 14, the OV-10 was operated at a significantly higher airspeed than the other aircraft types. As noted above, the high speed results in smaller droplets in the spray which will drift further. The reason that the OV-10 is not able to operate at slower airspeeds is due to a combination of its higher wing loading (which requires it to fly faster in order to carry the same weight) and the twin engine design. If an engine fails, the asymmetric thrust makes the aircraft difficult to control and below the minimum single engine control speed it is not enough control authority to maintain directional control. Due to its powerful engines, the OV-10 has a history of numerous loss of control accidents of this type. Therefore, it is dangerous to fly the OV-10 too slowly at relatively low altitudes.

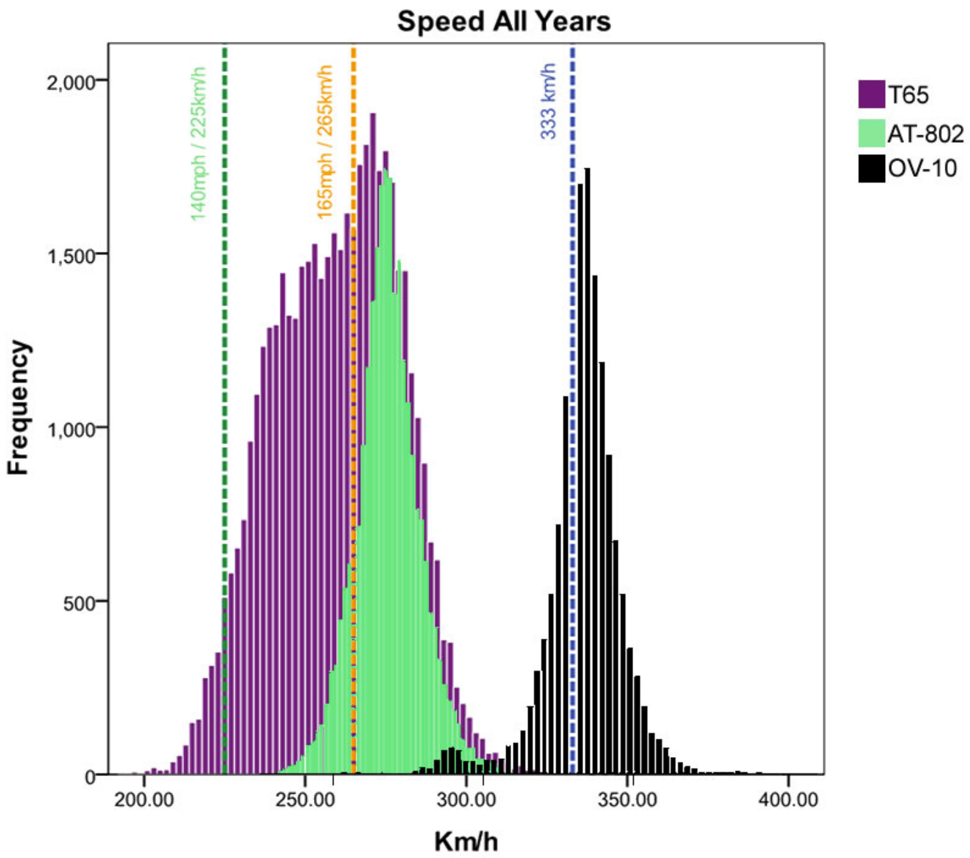

Figure 14: Distribution of Speed of Spray Events Within 10 km of Ecuadorian Border with Spray Aircraft Type Indicated.

4.7 Swath Width

Swath width is the linear extent of the spray coverage pattern perpendicular to the line of flight of the aircraft. In aerial spraying applications, the spray disperses outward beyond the width of the actual spray boom. Therefore, the separation between parallel flight lines is greater than the width of the spray boom.

The SWATH records in the data set represent half of the effective swath width in feet. The SWATH values were the same for all records for each plane type. For the AT-802 and the OV-10 the SWATH value was 85 ft indicating a swath width of 170 feet (51.82 meters). For T-65 aircraft the SWATH value was 50 indicating a swath width of 100 feet (30.48 meters).

4.8 Track Separation and Track Density

To evaluate the typical track separation a sample of tracks for each of the 3 aircraft types were analyzed in detail. It was found that for adjacent spray tracks the inter track separation for each aircraft type was generally similar to the value of the swath width. This is consistent with a spray pattern generated to provide full coverage of a target area which is wider than a single swath width.

An example of the density of spray events conducted during a single month is shown in Figure 15.

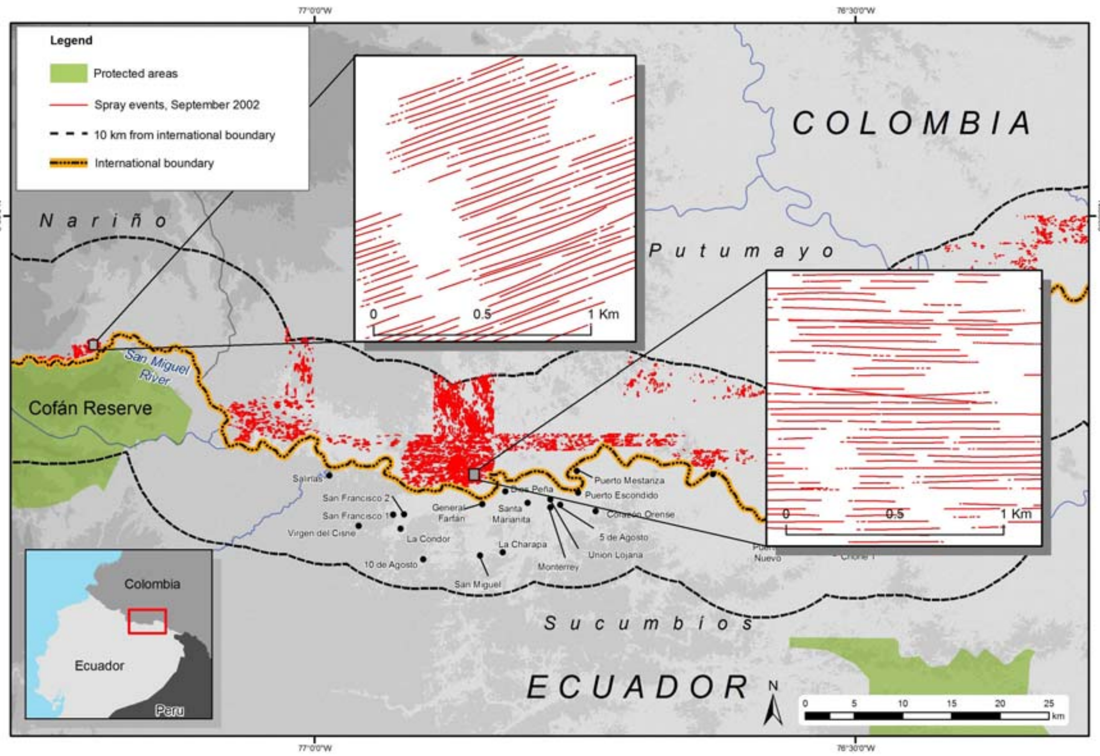

Figure 15: Example of Track Density – September 2002.

4.9 Meteorological Conditions

Colombia's EMP states that the "maximum outside temperature during application" is 35 degrees Celsius and the "maximum wind velocity" is 5 knots (9.26 km/hr or 2.57 meters/sec) (Republic of Colombia, 2003).

The data set analyzed for this report did not contain information concerning wind speed, temperature, humidity or other meteorological parameters. Therefore, based on the data available to us, it is not possible to determine compliance with the parameters in Colombia's EMP.

5. Conclusion

The analysis of flight track data demonstrated numerous violations of territorial and operational criteria established by Colombia. There were 114,525 events within 10 km of the Ecuadorian border which sprayed an estimated 326,658 gallons (1,236,535 liters) of herbicide. A minimum of 25,050 spray events were observed within 2.7 km of the Ecuadorian border. During periods of voluntary suspension of eradication within 10 km of the Ecuadorian border 6,046 spray events were recorded. There were 1,078 spray events within 2 km of National Parks or Indigenous Regions and numerous spray events were observed within 2 km of communities in both Colombia and Ecuador.

The operational parameters established by Colombia were routinely violated. The 25 ft altitude ceiling was exceeded in 96% of the spray events (89,124 violations) and the 50 ft altitude ceiling was exceeded in 17% of the events (16,143 violations). The 165 mph "maximum operational speed" was exceeded in 69% (75,841 violations) and the 333 km/hr "worst case scenario" was exceeded in 10% of the spray events (11,113 violations). The 140 mph speed was exceeded in 98% of the spray events (108,563 violations). The database also demonstrates violations of parameters established for the application rate of the herbicide and time of day of spray missions. Three types of spray aircraft were used, including the OV-10, which was designed as a military observation aircraft and is unusual to be used in aerial application of herbicides.

Complete analysis of the spray events database was not possible because some information was missing or not recorded. In particular, the data set analyzed did not contain any information regarding meteorological parameters. If this information was missing from the data available to Colombia, then Colombia would not have been able to determine its compliance with relevant operational parameters.

* * *

This report is accompanied by two companion reports. The first, "Spray Drift Modeling of Conditions of Application for Coca Crops in Colombia," by Dr. Durham

K. Giles, is a drift modeling analysis that uses the flight path data analyzed in this report as inputs. Dr. Giles demonstrates that the drift modeling study by Hewitt et al. (2009) significantly underestimated the amount of spray drift from Colombia's aerial spraying program because it assumed compliance with operational parameters such as aircraft height and speed which were routinely violated, as discussed in this report. Dr. Giles models scenarios using recorded flight data and determines that off-target drift and the resultant deposition of herbicide is significantly greater than the Hewitt et al. (2009) study predicted at distances of at least 10 kilometers from the application site. The second report, "Glyphosate-Based Herbicides and Potential for Damage to Non-Target Plants Under Conditions of Application in Colombia," by Dr. Stephen Weller, discusses the effects of glyphosate-based herbicides on non-target plants, applying a dose-response analysis based on the Giles drift modeling results. Dr. Weller concludes that a range of drift modeling scenarios consistent with Dr. Giles' analysis result in plant injury at distances up to at least 10 kilometers from the application site. In summary, the Giles and Weller reports demonstrate that Colombia's aerial spraying program is expected to cause adverse impacts in Ecuador as a result of spray drift.

6. About the Authors

R. John Hansman

R. John Hansman is a Professor of Aeronautics & Astronautics at the Massachusetts Institute of Technology (MIT), where he is the Director of the MIT International Center for Air Transportation. Dr Hansman received an interdisciplinary Ph.D. (Physics, Aeronautics & Astronautics, Meteorology, Electrical Engineering) from the Massachusetts Institute of Technology ("MIT"), and an A.B. in Physics from Cornell University. Professor Hansman teaches in the fields of aircraft design, flight testing, navigation and instrumentation systems, human factors, airline management and air traffic control. He conducts research in the application of information technology in operational aerospace systems. Dr. Hansman holds 6 patents and has authored over 250 technical publications.

Professor Hansman is a pilot with commercial, multi-engine, glider airplane, helicopter, instrument, LR-JET and flight instructor ratings. He has over 5300 hours of pilot in-command time in airplanes, helicopters and sailplanes including meteorological, production and engineering flight test experience. Professor Hansman chairs the U.S. Federal Aviation Administration Research & Development Advisory Committee (REDAC) and is a member of the NASA Aeronautics Advisory Committee. He is a Fellow of the AIAA and has received numerous awards including the AIAA Dryden Lectureship in Aeronautics Research, the ATCA Kriske Air Traffic Award, a Laurel from Aviation Week & Space Technology, and the FAA Excellence in Aviation Award.

Carlos F. Mena

Carlos F. Mena is Professor of Geography and Ecology in the School of Life and Environmental Sciences at Universidad San Francisco de Quito (USFQ), where is also Co-Director of the Galapagos Science Center. Dr. Mena received a Ph.D. in Geography from the University of North Carolina at Chapel Hill (UNC), a M.Sc. in Environmental Studies from Florida International University and Geographical and Environmental Engineering from Escuela Politécnica del Ejercito, Ecuador. Dr. Mena specializes in geographic information systems, remote sensing, spatial analysis, population geography, tropical and political ecology and population and environment interactions.

Dr. Mena is also Adjunct Professor in the UNC Department of Geography, Member, Steering Committee of the International Geographic Union, Land Use and Land Cover Commission, and Member of the Editorial Board of Population and Environment. Dr. Mena has received many awards including the Earth Systems Science Fellowship from the National Aeronautics Space Administration (NASA), Traineeship from the US National Institutes of Health (NIH) Fogarty International Center, the Anne U. White Grant from the Association of American Geographers, and the Future Faculty Fellowship from UNC Center for Teaching and Learning. Dr. Mena research projects and publications focuses in the analysis of relationships between people and environment in the Andean-Amazon Region and the Galapagos islands using geospatial technologies and social survey.

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Appendix 1

Curriculum Vitae of R. John Hansman, Ph.D.

Annex 1

ROBERT JOHN HANSMAN JR.

Department of Aeronautics and Astronautics
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Room 33-303, 77 Massachusetts Ave.
Cambridge, MA 02139-4307 USA

Voice (617) 253-2271 Fax (617) 253-4196
rjhans@mit.edu

http://web.mit.edu/aeroastro/www/people/rjhans/bio.html

Education

MASSACHUSETTS INSTITUTE OF TECHNOLOGY - Cambridge, MA
- Ph.D. in Physics, June 1982.
Thesis under Professor Walter Hollister, "The Interaction of Radio Frequency Electromagnetic Waves with Atmospheric Water Droplets and Applications to Aircraft Ice Prevention."
- M.S. in Physics, May 1980.
Thesis under Professor George Bekefi, "Reflexing in a Relativistic e-Beam Diode."

CORNELL UNIVERSITY - Ithaca, NY
- A.B. Magna Cum Laude in Physics & Distinction in all Subjects, June 1976.

Member

Phi Beta Kappa, Sigma Xi, FAA Research and Development Advisory Committee (Chair), NRC Aeronautics & Space Engineering Board, NASA Aeronautics Technology Advisory Committee, Soaring Society of America (Director), Soaring Safety Foundation (Director), American Institute of Aeronautics & Astronautics (Fellow), Atmospheric Environment Technical Committee, American Meteorological Society, Society of Automotive Engineers, Human Factors Society, Aeronautical Flight Measurements and Techniques Working Group, Editorial Board *Air Traffic Control Quarterly* and *Journal of Aircraft*.

Experience

MIT DEPARTMENT OF AERONAUTICS AND ASTRONAUTICS - Cambridge, MA
1982 - present
Faculty member in the fields of Flight Safety, Flight Information Systems, Instrumentation, Aviation Meteorology, Human Factors, Air Transportation; Head of the Division of Humans and Automation; Director of the International Center for Air Transportation.

2006 T. Wilson Professor of Aeronautics and Astronautics
1995 Professor.
1987 Associate Professor.
1985 Esther and Harold E. Edgerton Assistant Professor.
1984 Boeing Assistant Professor of Aeronautics and Astronautics.
1983 Assistant Professor.
1982 Lecturer.

Experience (cont.)

MIT FLIGHT TRANSPORTATION LABORATORY - Cambridge, MA
1980 - 1982
Graduate Research Assistant working on the physics of advanced aircraft ice prevention concepts.

MIT RESEARCH LABORATORY OF ELECTRONICS - Cambridge, MA
1976 - 1980
Graduate Research Assistant working on high power relativistic electron beam magnetrons and high current density diodes.

FRANCIS & JACKSON ASSOCIATES - Marion, MA
1976 - 1977
Consultant working on total-energy wind shear detection and autothrottle control.

CORNELL UNIVERSITY DEPARTMENT OF PHYSICS - Ithaca, NY
1975 - 1976
Recitation Instructor involved in teaching basic courses in Mechanics and Modern Physics (Optics and Quantum Mechanics).

SCHWEIZER AIRCRAFT CORPORATION - Elmira, NY (also Sugarbush, VT, Franconia, NH, North Conway, NH, and Plymouth, MA)
Summers 1971-1977
Glider and airplane flight instructor, glider and banner tow pilot, ferry pilot and test pilot for several companies.

FLIGHT EXPERIENCE - 5400+ hours: Commercial, Multi-Engine, Glider Airplane, Helicopter, Instrument and Flight Instructor Ratings. Type rated in Lear Jet 24, 35 and 55 series. Graduate of the Union Alpen Selelflugschule (Neideroblarn, Austria). Extensive mountain and instrument flight experience. Engineering, Production, and Meteorological Flight Test Experience.

Awards

2007 Plenary Lecture at American Control Conference
2005 Best Paper in 6th USA/Europe ATM, R&D Seminar
2005 AIAA Dryden Lecture in Aviation Research
2005 Kriske Career Award from Air Traffic Control Association
2004 Laurel from Aviation Week and Space Technology
2002 Fellow of the American Institute of Aeronautics & Astronautics.
2001 NASA Turning Goals into Reality Award
1998 Bose Award for Excellence in Teaching
1998 FAA/Eurocontrol Best Paper in Air Traffic Management
1997 FAA Excellence in Aviation Award.
1994 AIAA Losey Atmospheric Sciences Award.
1990 OSTIV Diploma for Technical Contribution.
Federation Aeronautique Internationale Gold C Award with 3 Diamonds.
1986 Presidential Young Investigator Award.
Esther & Harold E. Edgerton Professorship 1985.
Boeing Professorship in Aeronautics & Astronautics 1984.
1986 AIAA Award for the Best Paper in Thermophysics.
Soaring Society of America, Exceptional Service Award 1989.
Region 1 Soaring Champion 1980 and 1990.
1984 NASA Astronaut Selection Finalist.

Patents

Microwave Ice Prevention System, U.S. Patent #4365131 issued December 21, 1982.

Method and Apparatus for Measurement of Ice Thickness Employing Ultrasonic Pulse-Echo Technique, U.S. Patent #4628736 issued December 16, 1986.

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System and Method for Measuring the Workload of a Driver. U.S. Patent #7428449, issued September 23, 2008.

Video Production

"MIT Video Series on Measurement" (author, co-producer, and presenter), 1995:
- "Introduction to Measurement"
- "Calibration, Accuracy and Error"
- "Measuring Dynamic Variables"
- "Contact Temperature Measurement"
- "Infrared Temperature Measurement"
- "Distance, Velocity and Acceleration"
- "Mass, Force, Strain, Torque, and Pressure"
- "Measurement"
- "Fluid Quantity and Flow"

Congressional Testimony

"The Dynamics of the Emerging Capacity Crisis in the U.S. Air Traffic Control System", House Appropriations Committee –Subcommittee on Transportation, 3/15/01.

"Developing the Next Generation Air Traffic Management System", House Science Committee – Subcommittee on Space and Aeronautics", 7/19/01.

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(with J.-P. Clarke), "Systems Analysis of Noise Abatement Approach Procedures Enabled by Advanced Flight Guidance Technology," AIAA-97-0490, AIAA 35th Aerospace Sciences Meeting, January 1997.

Additional Publications (cont.)

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(with R. Barhydt), "Experimental Studies of Intent Information on Cockpit Traffic Displays," Ninth International Symposium on Aviation Psychology, Columbus, OH, April 1997.

(with A. Dershowitz), "An Exploration of Options in Value Based Aeronautical Decision Making," Ninth International Symposium on Aviation Psychology, Columbus, OH, April 1997.

(with A. Pritchett), "Pilot Non-Conformance to Alerting System Commands," Ninth International Symposium on Aviation Psychology, Columbus, OH, April 1997.

(with A. Pritchett), "Experimental Studies of Pilot Performance at Collision Avoidance During Closely Spaced Parallel Approaches," Ninth International Symposium on Aviation Psychology, Columbus, OH, April 1997.

(with E. Bachelder), "Enhanced Spatial State Feedback for Night Vision Goggle Displays," U.S. Naval Air Warfare Center Situational Awareness Symposium, June 1997.

(with J. Kuchar, A. Pritchett, J.-P. Clarke, S. Vakil, and R. Barhydt), "Integrated Human Centered Systems Approach to the Development of Advanced Air Traffic Management Systems," FAA/Eurocontrol 1st International Air Traffic Management R&D Seminar (ATM-97), Saclay, France, June 1997.

(with S. Vakil), "Human Centered Development of Information Systems and Decision Aids in Advanced Air Traffic Management and Flight Management Systems," Paper No. 844, International Ergonomics Association 13th Triennial Congress (IEA '97), Tampere, Finland, June/July 1997.

Additional Publications (cont.)

(with S. Vakil), “Predictability as a Metric of Automation Complexity,” Human Factors & Ergonomics Society 41st Annual Meeting, September 1997.

(with E. Bachelder), “A Methodology for State Feedback Perception Measurement Applied to Rotorcraft Night Vision Goggle Displays,” 16th IEEE/AIAA Digital Avionics Systems Conference, October 1997.

(with J. Kuchar, J.-P. Clarke, S. Vakil, R. Barhydt and A. Pritchett), “Integrated Human Centered Systems Approach to the Development of Advanced Cockpit and Air Traffic Management Systems,” 16th IEEE/AIAA Digital Avionics Systems Conference, October 1997.

(with A. Pritchett), “Pilot Non-Conformance to Alerting System Commands During Closely Spaced Parallel Approaches,” 16th IEEE/AIAA Digital Avionics Systems Conference, October 1997.

(with S. Vakil), “Functional Models of Flight Automation Systems to Support Design, Certification, and Operation,” AIAA-98-1035, AIAA 36th Aerospace Sciences Meeting, January 1998.

(with J. Deyst and R. Kornfeld), “Single Antenna GPS Based Aircraft Attitude Determination,” Institute of Navigation National Technical Meeting: Navigation 2000, Long Beach, CA, January 1998.

(with O. De Weck and D. Miller), “Adaptive Technique for Radiation Pattern Shaping of Parabolic Mesh Antennas: A Low Cost Application of SMA Actuators in Spacecraft,” ACTUATOR 98, Bremen, Germany, June 1998.

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(with K. Amonlirdviman, T. Farley, J. Ladik, and D. Sherer), “A Distributed Simulation Facility to Support Human Factors Research in Advanced Air Transportation Technology,” 1998 Fall Simulation Interoperability Workshop, Orlando, FL, September 1998.

(with M. Endsley and T. Farley), “Shared Situation Awareness in the Flight Deck - ATC System,” 17th IEEE/AIAA Digital Avionics Systems Conference, Seattle, WA, October-November 1998.

(with R. Kornfeld and J. Deyst), “Preliminary Flight Test of Pseudo-Attitude Control Using Single Antenna GPS Sensing,” 17th IEEE/AIAA Digital Avionics Systems Conference, Seattle, WA, October-November 1998.

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(with S. Vakil), "Analyzing Mode Transition Matrices," 17th IEEE/AIAA Digital Avionics Systems Conference, Seattle, WA, October-November 1998.

(with S. Vakil), "Operator Directed Common Conceptual Models for Advanced Aircraft Automation," 17th IEEE/AIAA Digital Avionics Systems Conference, Seattle, WA, October–November 1998.

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(with L. Vigeant-Langlois), "Human-Centered Design Considerations for In-Flight Remote Sensing Icing Avoidance," Fourth International Airborne Remote Sensing Conference and Exhibition, Ottawa, Ontario, Canada, June 1999.

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(with S. Vakil), "Approaches to Mitigating Complexity-Driven Issues in Commercial Autoflight Systems," 3rd Workshop on Human Error, Safety, and System Development (HESSD'99), Liège, Belgium, June 1999.

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Aeronautics and Space Administration (NASA) AeroSpace Technology Advisory Committee (ASTAC), Washington, DC, February 2001.

(with L. Vigeant-Langlois), "A Hazardous Weather Risk Characterization Model Based on Icing Information Requirements Studies," Eleventh Biennial International Symposium on Aviation Psychology, Columbus, OH, March 2001.

(with J. Saleh, W. Kaliardos, D. Hastings, and D. Newman), "On Flexibility in System Design," 11th Annual INCOSE International Systems Engineering Symposium (INCOSE 2001), Melbourne, Australia, July 2001.

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(with L. Vigeant-Langlois), "Trajectory-Based Performance Assessment of Aviation Weather Information," 10th AMS Conference on Aviation, Range, and Aerospace Meteorology, Portland, OR, May 2002.

(with E. Bachelder and D. McRuer), "Experimental Study of 3-D Synthetic Cues on Rotorcraft Hover Performance," AIAA Atmospheric Flight Mechanics Conference, Monterey, CA, August 2002.

<u>Additional Publications</u> (cont.)

(with Reynolds,T.G, Histon, J.M. and Davison, H), "Structure, Intent & Conformance Monitoring in ATC," Workshop on Advanced Technologies and their Impact on Air Traffic Management in the 21st Century (ATM 2002), Capri, Italy, September 2002.

(with Reynolds, T.G.) "Conformance Monitoring Approaches in Current and Future Control Environments," 19th IEEE/AIAA Digital Avionics Systems Conference, Irvine, CA, October 2002.

(with Doble, N.),"Preliminary Design and Evaluation of Portable Electronic Flight Progress Strips," 19th IEEE/AIAA Digital Avionics Systems Conference, Irvine, CA, October 2002.

(with Histon, J.), "Structural Considerations and Cognitive Complexity in Air Traffic Control," 19th IEEE/AIAA Digital Avionics Systems Conference, Irvine, CA, October 2002.

(with Tam, R.), "Impact of Air Transportation on Regional Economic and Social Connectivity in the United States", AIAA Aircraft Technology, Integration, and Operations Forum, Los Angeles, CA, October 2002.

(with Davison, H. J.), "Use of Structure as a Basis for Abstraction in Air Traffic Control", Proceedings of the International Symposium on Aviation Psychology, Wright-Patterson Air Force Base, March, 2003.

(with L. Vigeant-Langlois) "Implications of Contingency Planning Support for Weather and Icing Information". Proceedings of the FAA/SAE In-Flight Icing / Ground De-Icing International Conference, Chicago, IL, June 15-20, 2003

(with A. Mozdzanowska, J. Histon, D. Delehay**) "**Emergence of Regional Jets and the Implications on Air Traffic Management," FAA/Eurocontrol 5th International Air Traffic Management R&D Seminar (ATM-2001), Budapest , June 2003.

(with T. Reynolds) "Investigating Fundamental Issues In Lateral Conformance Monitoring Using A Fault Detection Approach," FAA/Eurocontrol 5th International Air Traffic Management R&D Seminar (ATM-2001), Budapest, June 2003.

(with H. Davison, M.D. Ringsdoitter, J. Histon), " Impact of Operating Context on the Use of Structure in Air Traffic Control Cognitive Processes," FAA/Eurocontrol 5th International Air Traffic Management R&D Seminar (ATM-2001), Budapest , June 2003.

(with Mozdzanowska, A.), "Observations and Potential Impacts of Regional Jet Operating Trends", <u>Aviation Management Education and Research Conference (AMERC)</u>, Montreal, July 2003.

Additional Publications (cont.)

(with Tam, R.), "Air Transportation And Socioeconomic Connectivity In The United States Since Deregulation", Aviation Management Education and Research Conference (AMERC), Montreal, July 2003.

(with T. G. Reynolds)"Analyzing Conformance Monitoring in Air Traffic Control Using Fault Detection Approaches & Operational Data", AIAA Guidance, Navigation & Control Conference, Austin, TX, 11-14 August 2003.

(with H. Jiang, L.Ren) "Market And Infrastructure Analysis of Future Air Cargo Demand in China", AIAA Aviation Technology, Integration, and Operations (ATIO) Technical Forum, Nov. 17-19, 2003, Denver, Colorado. (to be presented).

(with E. Murman, J-P Clarke) "Aircraft and Air Transportation Systems Curriculum at MIT", ICAS 2004-7.8.1, ICAS 2004 Congress of the International Council of the Aeronautical Sciences, Yokohama , Japan, Sept 1, 2004

(with T. Reynolds, R. Bolszak, R. Tarakan), 'Improving Surveillance of Clearances in Future Air Traffic Control Systems," AIAA Aviation Technology, Integration, and Operations (ATIO) Technical Forum, Chicago, Sept 2004

(with P. Bonnefoy), "Emergence and Impact of Secondary Airports in the United States," AIAA Aviation Technology, Integration, and Operations (ATIO) Technical Forum, Chicago, Sept 2004

(with R. Weibel), "Safety Considerations for Operation of Different Classes of UAVs in the NAS," AIAA Aviation Technology, Integration, and Operations (ATIO) Technical Forum, Chicago, Sept 2004

(with M. C. Lohrenz,), "Investigating Issues Of Display Content Vs. Clutter During Air-To-Ground Targeting Missions." Proceedings of the Human Factors and Ergonomics Society (HFES) 48th Annual Meeting, New Orleans, LA, September 20-24, 2004

(with L. Major, H. Johannsson, H. Davison, E. Hvannberg), "Key Human-Centered Transition Issues for Future Oceanic Air Traffic Control Systems," HCI-Aero, Toulouse, Sept 2004

(with H. Jiang), "Parametric Analysis of Cyclicality in the Airline Industry," International Conference on Research in Air Transportation (ICRAT 2004), November 22-24 2004, Zilina, Slovakia

"The Impact of Information Technologies on Air Transportation" AIAA-2005-0001, AIAA 44th Aerospace Sciences Meeting, Reno, NV, January 2005. (presented as the Dryden Lecture)

(with L. Major-Forrest) "Experimental Analysis of the Integration of Mixed Surveillance Frequency Into Oceanic ATC Operations", Aviation Psychology, April 2005.

<u>Additional Publications</u> (cont.)

(with Davison-Reynolds, H., Reynolds, T. G.), "Human Factors Implications of Continuous Descent Approach Procedures for Noise Abatement in Air Traffic Control", Proceedings of the 6th USA/Europe Air Traffic Management R & D Seminar, Baltimore. June 23, 2005.

(with R. Weibel) "An Integrated Approach to Evaluating Risk Mitigation Measures for UAV Operational Concepts in the NAS", Infotech Aerospace, Washington DC, September 2005.

(with Jaing, H.) "An Analysis of Profit Cycles in the Airline Industry", AIAA-2006-7732, 6th AIAA Aviation Technology, Integration and Operations Conference, Wichita, September 2006.

(with Mozdzanowska, A., Weibel, R., Lester, E.,), "The Dynamics of Air Transportation System Transition", In Proceedings of the 7th Air Traffic Management Conference. Barcelona Spain. July 2007.

(with Mozdzanowska, A.), "Crisis Events as a Catalyst for Change in the US Air Transportation System - Implications for Capacity". In Proceedings of the 10th International Conference on Technology Policy and Innovation. Stavanger, Norway. June 2007, Awarded Best Paper.

(with Mozdzanowska, A.), "The US Air Transportation System", <u>Handbook of Transportation Policy and Administration</u>, pp. (9-27), CRC Press, 2007.

(with Bonnefoy, P.), "Scalability and Evolutionary Dynamics of Air Transportation Networks in the United States", AIAA-2007-7773 , 7th AIAA Air Transportation Integration and Operations Conference, Dublin, September 2007.

(with Mozdzanowska, A., Webel, R., Lester, E. Weigel, A., and Marais, K), "Dynamics of Air Transportation System Transition and Implications for ADS-B Equipage" AIAA-2007-7776, 7th AIAA Air Transportation Integration and Operations Conference, Dublin, September 2007.

(with Ishutkina, M.) "Analysis of the Interaction between Air Transportation and Economic Activity" ICAS-2008-10-4-2, AIAA-2008-8888 , 26th Congress of the International Council of the Aeronautical Sciences, Anchorage Alaska, September 15-18, 2008.

(with Campos, N.V. and Weigel, A.L) "Preliminary Analysis of Strategies to Encourage Data Link Adoption Over the North Atlantic Airspace " ICAS-2008-8-8-3, AIAA-2008-8953, 26th Congress of the International Council of the Aeronautical Sciences, Anchorage Alaska, September 15-18, 2008.

(with Brown, S., Barimo, B., et al) "Report from the ADS-B Aeronautical Rulemaking Committee to the Federal Aviation Administration" September 26, 2008.

(with Alan Melrose, Ted Elliff et al) "The 2008/9 Independent Expert Group's First Report for Operational Environmental Goals", ICAO Committee on Aviation Environmental Protection (CAEP) WG2 Operations, (TG2) ATM. Florence, Italy April 2009.

(with Kar, R., Bonnefoy, P., Sgouridis, S.) "Dynamics of Implementation of Mitigating Measures to Reduce Commercial Aviation's Environmental Impacts" 9th AIAA Aviation Technology, Integration, and Operations Conference, Hilton Head, AIAA-2009-6935. September 2009.

(with Abrahamson, N. et al) "Advancing Aeronautical Safety", National Academy Press, Washington, D.C., September 2010

(with Morrison, J. and Bonnefoy, P.) "Investigation of the Impact of Effective Fuel Cost Increase on the US Air Transportation Network and Fleet", 10th AIAA Aviation Technology, Integration, and Operations Conference, Fort Worth, to be presented Oct 2010.

(with Azzam, M. and Bonnefoy, P.)"Investigation of the Fuel Economy of the US Air Transportation Network Structure", 10th AIAA Aviation Technology, Integration, and Operations Conference, Fort Worth, to be presented Oct 2010.

(with Li, L., Cho, H. and Palacios, R.)"Aircraft-Based Complexity Assessment for Radar Controllers in the Multi-Sector Planner Experiment", 10th AIAA Aviation Technology, Integration, and Operations Conference, Fort Worth, to be presented Oct 2010.

(with Butchibabu, A., Midkiff, A., Kendra, A. and Chandra, D.) "Analysis of Safety Reports Involving Area Navigation and Required Navigation Performance Procedures" International Conference on Human-Computer Interaction in Aerospace, Cape Canaveral to be presented Nov 2010.

Annex 1

Appendix 2

Curriculum Vitae of Carlos F. Mena, Ph.D.

Annex 1

CARLOS F. MENA

Darwin 001
Campus Cumbaya
Interoceanica y Diego de Robles s/n
Universidad San Francisco de Quito
Quito, Ecuador
Telf: 2-297-1866; Cell: 084439927
Email: cmena@usfq.edu.ec
www.cmena.org

Professor, College of Life and Environmental Sciences
Co-Director, Galapagos Science Center
Co-Director, USFQ GeoCenter
Universidad San Francisco de Quito, Ecuador

Adjunct Professor, Department of Geography
University of North Carolina at Chapel Hill, USA

Member, Steering Committee 2008-2010
International Geographic Union, Land Use and Land Cover Commission

Member, Editorial Board
Population and Environment

EDUCATION

University of North Carolina at Chapel Hill
Ph.D., Geography, 2007
Graduate Certificate in International Development
Dissertation: Land use trajectories in the Ecuadorian Amazon: socioeconomic drivers, spatial explicit modeling, and future scenarios.
Advisor: Dr. Stephen J. Walsh

Florida International University, Miami, FL
Master in Science, Environmental Studies Department, 2001
Thesis: Deforestation and land use patterns in the Napo Basin
Advisor: Dr. Michael McClain

Escuela Politécnica del Ejército, Quito, Ecuador
Ingeniero Geógrafo y del Medio Ambiente, 1999
Tesis: Sensibilidad Ambiental del Parque Nacional Llanganates

PROFESSIONAL EXPERIENCE:

Universidad San Francisco de Quito, Ecuador
Professor, College of Life and Environmental Sciences, 2008-Present
Co-Director, Galapagos Science Center, 2010-Present
Director, Graduate Program in Tropical Ecology, 2009

University of North Carolina at Chapel Hill
Post-Doctoral Researcher, Department of Geography, Fall 2007
Teaching Fellow, Department of Geography, Fall 2006
Research Assistant, Department of Geography/ Carolina Population Center, 8/2002 to 8/2007

Florida International University.
Research Assistant, Andean Amazon Rivers Analysis and Management Project (AARAM). 01/2000 to 08/2002

EcoCiencia, Fundación de Estudios Ecológicos. Quito, Ecuador.
Geographer. 07/1998 to 12/1999

Fundación Natura. Quito, Ecuador.
Technical Assistant. 10/1997 to 06/1998

ACADEMIC HONORS:

- American Society for Photogrammetry and Remote Sensing, 2009 ESRI Award for Best Paper in Geographic Information Systems (2nd Place).
- Earth Systems Science Fellowship. *National Aeronautics Space Administration* (NASA), 2004-2007, $72,000
- Pre-Doctoral Traineeship. *NIH Fogarty International Center - Carolina Population Center*, 2002-2004, $74,000
- Anne U. White Fund Grant. *Association of American Geographers*, 2006, $1,000
- Residency Grant. Mellon Foundation - *Carolina Population Center*, 2005, $12,000
- Future Faculty Fellowship. U*NC Center for Teaching and Learning*, 2006, $500
- Pre-dissertation Fieldwork Award. *UNC Institute Latin American Studies* - The Tinker Foundation, 2004, $1,500
- NSF-IGERT Travel Grants. IGERT Program. *Carolina Population Center* - National Science Foundation, 2004-2007, $4,500
- Latin America and Caribbean Scholarship, *Florida International University*, 2000-2001, $18,000
- Programa de la Conservación de la Biodiversidad, *EcoCiencia*, Fundación de Estudios Ecológicos, Quito, Ecuador, 1998, $1,200

PEER REVIEWED PUBLICATIONS

Mena CF (In Review). Spatial Heterogeneity and Non-Stationarity of the Drivers of Deforestation and Agriculture Extensification. *Global Environmental Change.*

Bilsborrow RE, **Mena CF**, Arguello (In Review) Colombian Refugees in Ecuador: Sampling Scheme, Demographic Characteristics, and Migratory Patterns. *GeoJournal*

Quiroga D, **Mena CF**, Suzuki H, Guevara A, Murillo JC (In Review). Socioeconomic Effects of Climate Change in the Galapagos Islands: A Theoretical Framework and Exploratory Impacts in Kerr, DiCarlo et al (Eds.) Climate Change in MMAs

Samonte-Tan G., Suman D, Wang X, Mate J, Catzim-Sanchez A, Fong P, Quiroga D, **Mena CF**, Guevara A, Suzuki H. (In Review) Governance Factors for Improving Marine Management. *Journal of Environmental and Resource Economics*

Walsh SJ, Malanson GP, Brown DG, Messina JP, **Mena CF** (In Press). Biocomplexity. In: *Handbook of Biogeography,* M. Blumler M, G. MacDonald, A. Millington, U. Schickhoff (Editors), Sage Publications, London.

Walsh SJ, McCleary A, Heumann B, Brewington L, Raczkowski E, **Mena CF**. (In Press). Community Expansion and Infrastructure Development: Implications for Human Health and Environmental Quality in the Galápagos Islands of Ecuador. *Journal of Latin American Geography*

Mena CF, Walsh SJ, Frizzelle FG, Xiaozheng Y, Malanson GP (In Press) Land Use Change on Household Farms in the Ecuadorian Amazon: Design and Implementation of an Agent-Based Model. *Applied Geography*.

Lu, F, Gray C, Bilsborrow RE, **Mena CF**, Erlien CM, Bremner J, Barbieri A, and Walsh SJ (2010), Contrasting Colonist and Indigenous Impacts on Amazonian Forests. *Conservation Biology* 24 (3): 881 – 885

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Walsh, SJ, **Mena CF,** DeHart J, Frizzelle FG (2009). Stylized environments and ABMs: educational tools for examining the causes and consequences of land use/land cover change**.** *Geocarto International*, 24: 1752-0762

Mena, CF (2008). Trajectories of Land Use and Land Cover in the Northern Ecuadorian Amazon: Temporal Composition, Spatial Configuration, and Probability of Change. *Photogrammetric Engineering and Remote Sensing* 74(6): 737-752

Walsh, SJ, Shao Y, **Mena CF**, McCleary A (2008). Integration of Hyperion Satellite Data and a Household Social Survey to Characterize the Causes and Consequences of Reforestation Patterns in the Northern Ecuadorian Amazon. *Photogrammetric Engineering and Remote Sensing* 74(6): 725-736

Walsh SJ, McCleary A, **Mena CF**, Tuttle J, Shao Y, Atkinson R, Gonzales A, (2008). Hyper-Spatial and Hyper-Spectral Remote Sensing of an Invasive Plant in the Galapagos National Park and Archipelago: Spatial Structure and Implications for Control. *Remote Sensing of the Environment* 112(5):1927-1941

Walsh SJ, Messina JP, **Mena CF**, Malanson GP, Page PH (2008). Complexity and Land Use Dynamics in the Northern Ecuadorian Amazon, *GeoForum* 39:867-878.

Rindfuss RR, Entwisle B, Walsh SJ, An L, Badenoch N, Brown DG, Deadman P, Evans TP, Fox J, Geoghegan J, Gutmann M, Kelly M, Linderman M, Liu J, Malanson G P, **Mena CF**, et al. (2008) "Land use change: complexity and comparisons" *Journal of Land Use Science* 3(1): 1 – 10

Rindfuss RR, Entwisle B, Walsh SJ, **Mena CF**, Erlien CM, Gray CL (2007). Frontier Land Use Change: Synthesis and Next Steps, *Annals of the Association of American Geographers* 97(4): 739-754

Mena CF, Bilsborrow RE, McClain ME (2006). Socioeconomic Drivers of Deforestation in the Northern Ecuadorian Amazon. *Environmental Management* 37(6): 802-815.

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Messina J, Walsh SJ, **Mena CF**, Delamater P (2006). Land Tenure and Deforestation Patterns in the Ecuadorian Amazon: Conflicts in Land Conservation in Frontier Settings. *Applied Geography* 26(2): 113-128.

Erlien CM, Tuttle JP, McCleary AL, **Mena CF**, Walsh SJ (2006). Complexity Theory and Spatial Models of Land Use/Land Cover Dynamics: Implications of "What if" Scenarios for Education, Land Management, and Decision-Making, *Geocarto* 21(4):67-74.

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Mena CF (2001) Mapa de Uso de Suelo y Cobertura Vegetal del Parque Nacional Llanganates en *Biodiversidad del Parque Nacional Llanganates*, Vazquez M. (Editor). EcoCiencia. Quito

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Murshed SM, Arsel M, Pellegrini L, **Mena CF**, van de Schoot T, Gruenberger J. *Nationalization of natural resources, cooperation and conflict in Bolivia and Ecuador*. 2010-2014. Netherlands Organization for Scientific Research, EUR€ 600,000.

Quiroga D, **Mena CF**. *Assessment of the Vulnerability of Biodiversity and Related Well Being in the Galapagos Islands to Climate Change*. 2009-2010. Conservation International and World Wildlife Fund, US$ 30,000.

Quiroga D, **Mena CF.** *Socioeconomic Effects of Climate Change in the Galapagos Islands: An Emphasis on the Marine Resources and Marine Reserve.* 2009. Conservation International, US$ 57,000.

Mena CF. *Design of the Territorial Information System for Ecuador´s Patrimony.* 2010. Ministry of Coordination of Patrimony of Ecuador, US$ 20,000.

Mena CF. *Subtle Changes in Tropical Forest Condition using High Resolution Satellite Images*. 2010. US$ 30,000.

Mena CF. *Links between Invasive Species and Agriculture Abandonment in the Galapagos Islands*. 2010. USFQ-GAIAS Internal Seed Grant. US$ 10,000.

Mena CF. Review of the Cartographic Processes in the Ecuadorian Institute of Census and Statistics. 2010. United Nations Population Fund. US$ 5,000.

Mena CF. *Institutional Cartography of Culture of Ecuador*. 2009. Ministry of Culture of Ecuador, Spanish Cooperation Agency. US$ 51,220

Mena CF. *Design of the Environmental Information Systems for the Galapagos National Park.* 2009. Galapagos National Park. US$ 13,000

Mena CF. Systematization of Information of the Protected Forest of Ecuador: Limits and Conflicts. 2008. Ministry of Environment of Ecuador. US$ 31,000.

Mena CF. Urban Change in Galapagos. Unfunded active research.

Mena CF. Secondary forest succession in the Ecuadorian Amazon. Unfunded active research.

REVIEWER

- United States National Science Foundation (NSF) - Geography and Regional Science Program
- Population and Environment (Editor Board)
- Geocarto International
- Journal of Environmental Management
- Journal of Earth Systems Science
- Development and Change
- Applied Geography
- Progress in Physical Geography

ORGANIZER / SELECTED PRESENTATIONS

Organizer, 2010. Workshop Conflict and Cooperation in the Nationalization of Natural Resources. International Institute of Social Studies of Erasmus University and Universidad San Francisco de Quito. Puyo, Ecuador.

Invited Session Co-Organizer, 2009 (C.F. Mena & S.J. Walsh). Population-Environment Interactions in the Galapagos Islands, Galapagos Science Symposium, Puerto Ayora, Santa Cruz Island, Galapagos, Charles Darwin Foundation.

Invited Workshop Participant, 2009. Vulnerability of the Galapagos Islands to Climate Change, Conservation International and World Wildlife Fund, Santa Cruz Island, Galapagos Islands, Ecuador.

Session Organizer (with C. Gray), *Conservation and Development from the Andes to the Amazon* I, II, III, and IV. Set of Sessions Organized for the Annual Meeting of the Association of American Geographers. San Francisco, California, April 21, 2007.

Workshop Organizer (with S.J. Walsh), *Geographic Information Systems and Remote Sensing for the Conservation and Sustainable Management of the Galapagos Islands.* Santa Cruz, Galapagos, June 21-22, 2006

Session Organizer (with C. Gray), *Human-Environment Studies from the Andes to the Amazon*. Session Organized for the Annual Meeting of the Association of American Geographers. Denver, Colorado, April 5-9, 2005.

Symposium Organizer (with S.J. Walsh), *Methods for the Characterization of Landscape Change*. Hotel Quito, Quito, June 6, 2005.

Workshop Organizer (with R.E. Bilsborrow and B. Torres), *Agricultural Colonization in the Ecuadorian Amazon: Meetings for Farmers and Local Authorities*. Lago Agrio and Coca, Ecuador, July 2004.

Mena CF, Walsh SJ, Malanson G, Frizzelle BG. 2008. “Agent Based Modeling for the simulation of endogenous and exogenous shocks in the Northern Ecuadorian Amazon”, Poster presented at the Meeting Tough Choices - Land Use under a Changing Climate, US Nacional Science Foundation and German Researhc Foudation, invited participant. Berlin, Germany.

Mena CF. "Exploring the heterogeneous nature of the drivers of deforestation and land extensification in the Northern Ecuadorian Amazon" Paper presented at the Annual Meeting of the Association of American Geographers. San Francisco, California, April 21, 2007.

Mena CF, Walsh SJ, Bilsborrow RE, Erlien CF. "Demography and Land Use/Cover Change in the Cuyabeno and Lago Agrio in Ecuador: Implications for Development". Poster presented at the NASA Land-Cover and Land-Use Change Science Team Meeting, Maryland. April 11-13, 2006

Mena CF, Walsh SJ. "Demographic, Socioeconomic, and Biophysical Factors Affecting Land Use and Land Cover Change in the Northern Ecuadorian Amazon: Drivers, Statistical and Spatial Explicit Models". Paper presented at the XXV Conference of the International Union for the Scientific Study of Population, Tours, France. July 18-23, 2005.

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Mena CF "Deforestation and Spatially Explicit Models for Land Change Research". Department of Geography, Appalachian State University. Boone, NC. April 19, 2006.

Mena CF, Walsh SJ. "Socioeconomic and Demographic drivers of Forest Succession in Northern Ecuadorian Amazon". Paper presented at the 100th Annual Meeting of the Association of American Geographers (AAG), Philadelphia, PA. March 14-19, 2004.

Barbieri AF, **Mena CF**, Erlien CM, Bilsborrow RE, and Torres B. 2003. Settler Welfare and Land Cover Change in the Ecuadorian Amazon Communities. Poster presented at the Human Dimensions of Global Change Open Meeting. Montreal, Canada. October 16-18, 2003,

Mena CF, Erlien CM, Walsh SJ, Bilsborrow RE, and Baquero F. "Modeling the Scale Dependent Drivers of LCLU Dynamics in Northeastern Ecuador: Population, Biophysical, and Geographical Factors.” Paper presented at the 99th Annual Meeting of the Association of American Geographers (AAG), New Orleans, LA. March 4-7, 2003

Mena CF. 2002. “Socioeconomic Drivers of Deforestation in the Northern Ecuadorian Amazon”. American Association of Geographers, South East Division (SEDAAG) Meeting, 23-26 November 2002, Richmond, VA

Mena CF. 2001. “Spatial Patterns, metrics, and socioeconomic factors driving deforestation in the Napo Basin of Ecuador”. Open Meeting of the Human Dimensions of Global Environmental Change Research Community, October 6-8, 2001, Rio de Janiero, Brazil

Mena CF, Taff G, Frizzelle B, McGregor SJ. 2000. “Integrating Geographic Information Science Techniques and Household Socio-economic Surveys of Population Environment research: A Preliminary Report.” Presented at the Meeting of the Latin American Studies Association, March 16-18, Miami, Florida.

PROFESSIONAL ASSOCIATIONS

American Association of Geographers (AAG)
Population Association of America (PAA)
International Union for the Scientific Study of Population (IUSSP)

Appendix 3

Statistics

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I. Altitude

Annex 1

Flights Within 10 km of Ecuador's Border Exceeding Altitude Thresholds of 25 m and 50 m (2000 – 2008)

Threshold	Count	Percentage
< 25 m	3,519	4%
>25 m	89,124	96%
TOTAL	**92,643**	**100%**

Threshold	Count	Percentage
< 50 m	76,500	83%
>50 m	16,143	17%
TOTAL	**92,643**	**100%**

Note: Data for 2001 and 2004 not included due to mixed units (feet and meters)

Altitude Statistics By Year: Flights Within 10 km of Ecuador's Border Exceeding 25 m and 50 m Thresholds

2000

Threshold	Count	Percentage
< 25 m	91	2%
>25 m	4,720	98%
TOTAL	**4,811**	**100%**

Threshold	Count	Percentage
< 50 m	1,796	37%
>50 m	3,015	63%
TOTAL	**4,811**	**100%**

2002

Threshold	Count	Percentage
< 25 m	1,483	4%
>25 m	37,293	96%
TOTAL	**38,776**	**100%**

Threshold	Count	Percentage
< 50 m	32,210	83%
>50 m	6,566	17%
TOTAL	**38,776**	**100%**

2003

Threshold	Count	Percentage
< 25 m	94	1%
>25 m	6,996	99%
TOTAL	**7,090**	**100%**

Threshold	Count	Percentage
< 50 m	5,849	82%
>50 m	1,241	18%
TOTAL	**7,090**	**100%**

2005

Threshold	Count	Percentage
< 25 m	310	2%
>25 m	13,275	98%
TOTAL	**13,585**	**100%**

Threshold	Count	Percentage
< 50 m	11,343	83%
>50 m	2,242	17%
TOTAL	**13,585**	**100%**

2006

Threshold	Count	Percentage
< 25 m	1,222	7%
>25 m	16,237	93%
TOTAL	**17,459**	**100%**

Threshold	Count	Percentage
< 50 m	16,025	92%
>50 m	1,434	8%
TOTAL	**17,459**	**100%**

2007

Threshold	Count	Percentage
< 25 m	312	3%
>25 m	10,533	97%
TOTAL	**10,845**	**100%**

Threshold	Count	Percentage
< 50 m	9,208	85%
>50 m	1,637	15%
TOTAL	**10,845**	**100%**

Annex 1

2008

Threshold	Count	Percentage
< 25 m	0	0%
>25 m	77	100%
TOTAL	**77**	**100%**

Threshold	Count	Percentage
< 50 m	56	73%
>50 m	21	27%
TOTAL	**77**	**100%**

Note: Data for 2001 and 2004 not included due to mixed units (feet and meters)

Altitude Range of Flights Conducted Within 10 km of Ecuador's Border

YEAR / RANGE (meters)	2000	2002	2003	2005	2006	2007	2008	Total by range	Cumulative Total
0 TO 10	6	9	1	3	9	3		31	92,655 over 0 m
10 TO 20	24	353	14	89	339	91		910	92,624 over 10 m
20 TO 30	188	4,223	417	1,026	2,741	969	2	9,566	91,714 over 20 m
30 TO 40	506	13,975	2,482	4,966	7,487	4,369	23	33,808	82,148 over 30 m
40 TO 50	1,074	13,654	2,936	5,260	5,451	3,777	33	32,185	48,336 over 40 m
50 TO 60	1,537	5,296	1,020	1,834	1,098	1,086	13	11,884	16,146 over 50 m
60 TO 70	884	1,060	156	324	190	270	4	2,888	4,259 over 60 m
70 TO 80	289	149	48	44	76	130		736	1,371 over 70 m
80 TO 90	123	13	11	16	31	67	1	262	635 over 80 m
90 TO 100	54	8	4	10	14	32		122	373 over 90 m
100 TO 110	22	6		9	8	27	1	73	251 over 100 m
110 TO 120	17	12		1	4	12		46	178 over 110 m
120 TO 130	14	12			5	5		36	132 over 120 m
130 TO 140	26	6		1	6	2		41	96 over 130 m
140 TO 150	16			1		1		18	55 over 140 m
150 TO 160	9					3		12	37 over 150 m
160 TO 170	12							12	25 over 160 m
170 TO 180	5					1		6	13 over 170 m
180 TO 190	2							2	7 over 180 m
190 TO 200	3							3	5 over 190 m
200 TO 270			1					1	2 over 200 m
270 TO 440				1				1	1 over 270 m
Total by year	4,811	38,776	7,090	13,585	17,459	10,845	77	92,643	92,655

Note: Data for 2001 and 2004 not included due to mixed units (feet and meters)

Annex 1

Top Ten Highest Flights Per Year

YEAR	Altitude (meters)
2000	196.94
2000	192.55
2000	191.88
2000	184.05
2000	180.89
2000	179.94
2000	178.24
2000	174.26
2000	174.13
2000	171.83

YEAR	Altitude (meters)
2002	135.48
2002	135.48
2002	135.17
2002	135.17
2002	134.87
2002	134.87
2002	129.88
2002	129.27
2002	128.66
2002	128.35

YEAR	Altitude (meters)
2003	263.51
2003	99.55
2003	92.85
2003	91.46
2003	90.41
2003	89.92
2003	88.68
2003	87.16
2003	84.59
2003	83.81

YEAR	Altitude (meters)
2005	430.32
2005	147.25
2005	135.52
2005	117.20
2005	105.44
2005	105.32
2005	103.48
2005	102.87
2005	102.08
2005	101.48

YEAR	Altitude (meters)
2006	137.76
2006	134.14
2006	133.76
2006	131.22
2006	131.04
2006	130.22
2006	128.76
2006	128.10
2006	123.76
2006	121.41

YEAR	Altitude (meters)
2007	170.36
2007	159.99
2007	154.44
2007	153.01
2007	140.31
2007	136.08
2007	133.41
2007	129.87
2007	129.14
2007	126.91

YEAR	Altitude (meters)
2008	102.28
2008	83.99
2008	67.90
2008	66.18
2008	65.36
2008	61.11
2008	58.73
2008	58.46
2008	57.26
2008	57.25

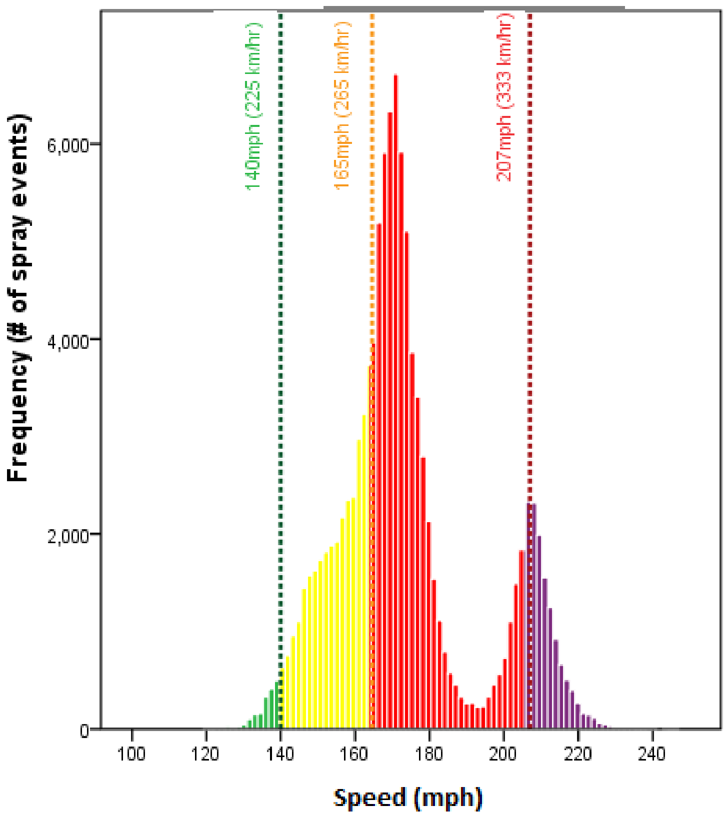
Note: Data for 2001 and 2004 not included due to mixed units (feet and meters)

Annex 1

II. Speed

Annex 1

Speed Distribution of Flights Within 10 km of Ecuador's Border (2000 – 2008)



Flights Within 10 km of Ecuador´s Border Exceeding Speed Thresholds of 140 mph, 165 mph and 333 km/h (2000 – 2008)

Threshold	Count	Percentage
< 140 mph	1,855	2%
>140 mph	108,563	98%
TOTAL	**110,418**	**100%**

Threshold	Count	Percentage
< 165 mph	34,577	31%
>165 mph	75,841	69%
TOTAL	**110,418**	**100%**

Threshold	Count	Percentage
< 333 km/h	99,305	90%
>333 km/h	11,113	10%
TOTAL	**110,418**	**100%**

Annex 1

Speed Statistics By Year: Flights Within 10 km of Ecuador's Border Exceeding 140 mph Threshold

2000

Threshold	Count	Percentage
< 140 mph	31	1%
>140 mph	4,807	99%
TOTAL	**4,838**	**100%**

2001

Threshold	Count	Percentage
< 140 mph	35	0.30%
>140 mph	11,483	99.70%
TOTAL	**11,518**	**100%**

2002

Threshold	Count	Percentage
< 140 mph	560	2%
>140 mph	36,103	98%
TOTAL	**36,663**	**100%**

2003

Threshold	Count	Percentage
< 140 mph	280	4%
>140 mph	6,879	96%
TOTAL	**7,159**	**100%**

2004

Threshold	Count	Percentage
< 140 mph	7	0.09%
>140 mph	8,079	99.91%
TOTAL	**8,086**	**100%**

2005

Threshold	Count	Percentage
< 140 mph	0	0%
>140 mph	13,608	100%
TOTAL	**13,608**	**100%**

2006

Threshold	Count	Percentage
< 140 mph	775	4%
>140 mph	16,757	96%
TOTAL	**17,532**	**100%**

2007

Threshold	Count	Percentage
< 140 mph	167	1.53%
>140 mph	10,758	98.47%
TOTAL	**10,925**	**100%**

2008

Threshold	Count	Percentage
< 140 mph	0	0%
>140 mph	89	100%
TOTAL	**89**	**100%**

Speed Statistics By Year: Flights Within 10 km of Ecuador's Border Exceeding 165 mph Threshold

2000

Threshold	Count	Percentage
< 165 mph	1,596	33%
>165 mph	3,242	67%
TOTAL	4,838	100%

2001

Threshold	Count	Percentage
< 165 mph	3,500	30%
>165 mph	8,018	70%
TOTAL	11,518	100%

2002

Threshold	Count	Percentage
< 165 mph	17,069	47%
>165 mph	19,594	53%
TOTAL	36,663	100%

2003

Threshold	Count	Percentage
< 165 mph	2,407	34%
>165 mph	4,752	66%
TOTAL	7,159	100%

2004

Threshold	Count	Percentage
< 165 mph	1,315	16 %
>165 mph	6,771	84%
TOTAL	8,086	100%

2005

Threshold	Count	Percentage
< 165 mph	1,791	13%
>165 mph	11,817	87%
TOTAL	13,608	100%

2006

Threshold	Count	Percentage
< 165 mph	4,677	27%
>165 mph	12,855	73%
TOTAL	17,532	100%

2007

Threshold	Count	Percentage
< 165 mph	2,203	20%
>165 mph	8,722	80%
TOTAL	10,925	100%

2008

Threshold	Count	Percentage
< 165 mph	19	21%
>165 mph	70	79%
TOTAL	89	100%

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Speed Statistics By Year: Flights Within 10 km of Ecuador's Border Exceeding 333 km/h Threshold

2000

Threshold	Count	Percentage
<333 km/h	4,329	89%
>333 km/h	509	11%
TOTAL	**4,838**	**100%**

2001

Threshold	Count	Percentage
<333 km/h	10,033	87%
>333 km/h	1,485	13%
TOTAL	**11,518**	**100%**

2002

Threshold	Count	Percentage
<333 km/h	30,671	84%
>333 km/h	5,992	16%
TOTAL	**36,663**	**100%**

2003

Threshold	Count	Percentage
<333 km/h	7,159	100%
>333 km/h	0	0%
TOTAL	**7,159**	**100%**

2004

Threshold	Count	Percentage
<333 km/h	7,615	94%
>333 km/h	471	6%
TOTAL	**8,086**	**100%**

2005

Threshold	Count	Percentage
<333 km/h	10,982	81%
>333 km/h	2,626	19%
TOTAL	**13,608**	**100%**

2006

Threshold	Count	Percentage
<333 km/h	17,509	99.9%
>333 km/h	23	0.1%
TOTAL	**17,532**	**100%**

2007

Threshold	Count	Percentage
<333 km/h	10,918	99.9%
>333 km/h	7	0.1%
TOTAL	**10,925**	**100%**

2008

Threshold	Count	Percentage
<333 km/h	89	100%
>333 km/h	0	0%
TOTAL	**89**	**100%**

Speed Range of Flights Conducted Within 10 km of Ecuador's Border

YEAR RANGE (mph)	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total by Range	Cumulative Total
0 TO 110										0	
110 TO 120							1			1	110,418 over 110 mph
120 TO 130		1	2	12			64	8		87	110,417 over 120 mph
130 TO 140	31	34	558	268	7		710	159		1767	110,330 over 130 mph
140 TO 150	194	257	4544	735	127	15	1547	515	1	7935	108,563 over 140 mph
150 TO 160	722	1425	7969	751	417	471	1230	716	4	13705	100,628 over 150 mph
160 TO 170	1531	3982	7538	2300	2643	3557	4458	3048	22	29079	86,923 over 160 mph
170 TO 180	1356	2742	4863	2560	3299	3732	7669	5231	55	31507	57,844 over 170 mph
180 TO 190	331	600	1009	483	434	542	1611	1091	7	6108	26,337 over 180 mph
190 TO 200	46	264	948	50	157	474	176	137		2252	20,229 over 190 mph
200 TO 210	208	1237	5526		786	3551	57	18		11383	17,977 over 200 mph
210 TO 220	343	831	3325		207	1168	8	2		5884	6,594 over 210 mph
220 TO 230	68	130	357		7	96	1			659	710 over 220 mph
230 TO 240	8	14	19		2	2				45	51 over 230 mph
240 TO 250		1	5							6	6 over 240 mph
Total by Year	**4,838**	**11,518**	**36,663**	**7,159**	**8,086**	**13,608**	**17,532**	**10,925**	**89**	**110,418**	

Annex 1

Top Ten Fastest Flights Per Year

YEAR	SPEED (MPH)
2000	237.14
2000	236.71
2000	235.55
2000	235.10
2000	234.79
2000	233.56
2000	233.29
2000	231.62
2000	229.77
2000	229.40

YEAR	SPEED (MPH)
2001	246.98
2001	236.94
2001	236.67
2001	236.01
2001	235.43
2001	235.17
2001	234.93
2001	234.64
2001	234.15
2001	233.49

YEAR	SPEED (MPH)
2002	244.7
2002	242.9
2002	242.8
2002	240.7
2002	240.6
2002	239.7
2002	239.5
2002	239.5
2002	239.4
2002	239.2

YEAR	SPEED (MPH)
2003	197.5
2003	195.3
2003	194.8
2003	194.6
2003	194.5
2003	194.4
2003	194.3
2003	194.2
2003	194.1
2003	194.1

YEAR	SPEED (MPH)
2004	231.9
2004	231.8
2004	229.1
2004	227.0
2004	221.3
2004	221.2
2004	220.6
2004	220.3
2004	220.2
2004	219.7

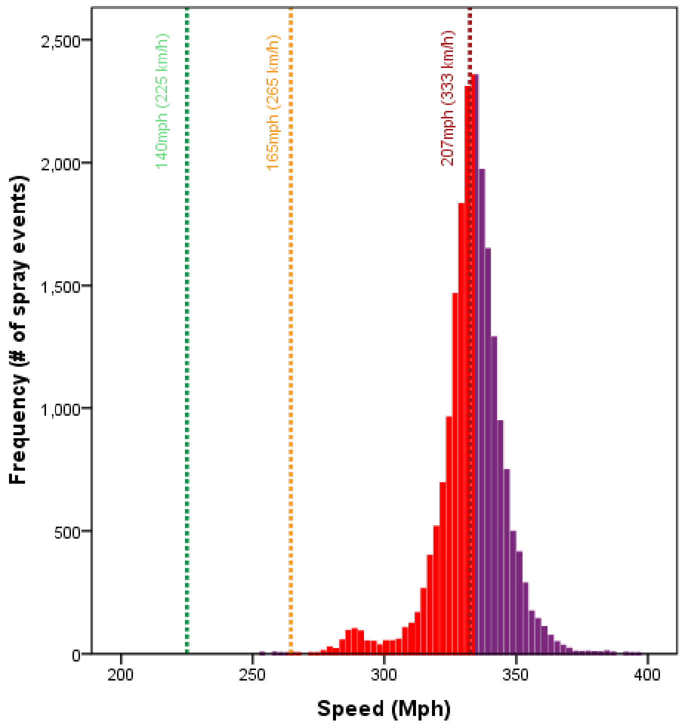
YEAR	SPEED (MPH)
2005	231.2
2005	230.0
2005	229.9
2005	229.9
2005	229.8
2005	227.9
2005	227.5
2005	226.9
2005	226.8
2005	226.5

YEAR	SPEED (MPH)
2006	220.6
2006	213.0
2006	212.2
2006	211.8
2006	211.4
2006	211.4
2006	210.7
2006	210.3
2006	210.1
2006	209.8

YEAR	SPEED (MPH)
2007	213.9
2007	211.2
2007	208.9
2007	208.2
2007	208.2
2007	207.5
2007	207.2
2007	206.6
2007	206.6
2007	205.5

YEAR	SPEED (MPH)
2008	185.2
2008	184.9
2008	182.9
2008	181.9
2008	181.6
2008	181.4
2008	180.8
2008	179.4
2008	179.1
2008	178.1

Speed Distribution of OV-10 Flights Within 10 km of Ecuador's Border (2000 – 2008)



OV-10 Flights Within 10 km of Ecuador's Border Exceeding 140 mph, 165 mph and 333 km/h Thresholds

Threshold	Count	Percentage
< 140 mph	0	0%
>140 mph	20,251	100%
TOTAL	**20,251**	**100%**

Threshold	Count	Percentage
< 165 mph	7	0.03%
>165 mph	20,244	99.97%
TOTAL	**20,251**	**100%**

Threshold	Count	Percentage
< 333 km/h	8,970	44%
>333 km/h	11,281	56%
TOTAL	**20,251**	**100%**

Annex 1

III. Combined Altitude & Speed Analysis

Annex 1

Flights Within 10 km of Ecuador's Border Exceeding Speed and Altitude Thresholds (2000 – 2008)

Threshold	Count	Percentage
< 140 mph & < 25 m	7,279	8%
> 140 mph & > 25 m	85,364	92%
TOTAL	**92,643**	**100%**

Threshold	Count	Percentage
< 165 mph & < 50 m	80,488	87%
> 165 mph & > 50 m	12,155	13%
TOTAL	**92,643**	**100%**

IV. Application Rate & Total Volume of Spray

Annex 1

Flights Within 10 km of Ecuador's Border Exceeding Application Rate Threshold of 23.65 L/ha (2000 – 2008)

Threshold	Count	Percentage
< 23,65 L/ha	**60,806**	**69%**
>23,65 L/ha	27,429	31%
TOTAL	**88,235**	**100%**

Application Rate Statistics by Year: Flights Within 10 km of Ecuador's Border Exceeding 23.65 L/ha Threshold

2002

Threshold	Count	Percentage
< 23,65 L/ha	**26,738**	**69%**
>23,65 L/ha	12,184	31%
TOTAL	**38,922**	**100%**

2003

Threshold	Count	Percentage
< 23,65 L/ha	**4,859**	**68%**
>23,65 L/ha	2,300	32%
TOTAL	**7,159**	**100%**

2005

Threshold	Count	Percentage
< 23,65 L/ha	**10,111**	**74%**
>23,65 L/ha	3,497	26%
TOTAL	**13,608**	**100%**

2006

Threshold	Count	Percentage
< 23,65 L/ha	**12,265**	**70%**
>23,65 L/ha	5,267	30%
TOTAL	**17,532**	**100%**

2007

Threshold	Count	Percentage
< 23,65 L/ha	**6,782**	**62%**
>23,65 L/ha	4,143	38%
TOTAL	**10,925**	**100%**

2008

Threshold	Count	Percentage
< 23,65 L/ha	**51**	**57%**
>23,65 L/ha	38	43%
TOTAL	**89**	**100%**

Note: Data for 2000, 2001 not available; data for 2004 not included due to mixed units (gallons per hectare and gallons per acre)

Total Volume of Herbicide Mixture Sprayed Within 10 km of Ecuador's Border

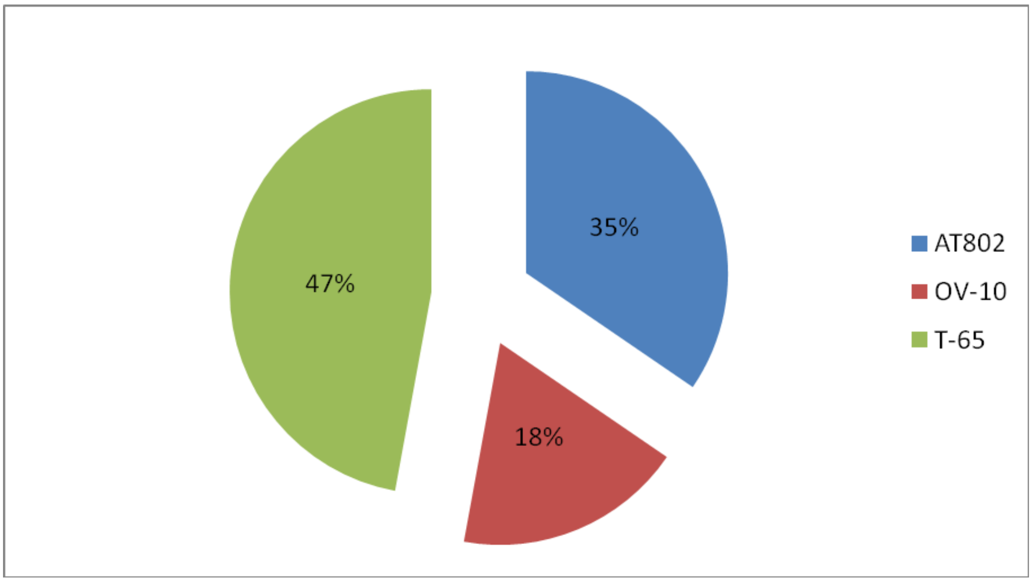
YEAR	# OF TRACKS	GALLONS SPRAYED	LITERS SPRAYED
2000	4,838	14,208	53,783
2001	13,366	38,160	144,451
2002	38,922	111,122	420,643
2003	7,159	20,688	78,313
2004	8,086	11,799	44,664
2005	13,608	33,632	127,311
2006	17,532	56,483	213,811
2007	10,925	40,249	152,359
2008	89	317	1,200
TOTAL	114,525	326,658	1,236,535

Annex 1

V. Type of Aircraft

Annex 1

Aircraft Used Within 10 km of Ecuador's Border (2000 – 2008)



Aircraft Type	Count	Percentage
AT-802	38,142	35%
OV-10	20,251	18%
T-65	52,025	47%
TOTAL	**110,418**	**100%**

VI. Additional Statistics

Annex 1

Statistic[1]	Result[2]
Number of spray events over 140 mph through the end of August 2005.	75,005 spray events
Total volume of spray (in liters) deposited by OV-10 aircraft between 2000 and 2008.	376,329 liters
Number of spray events that can be confirmed to violate all of the following parameters at once: • speed greater than 165 mph; • altitude higher than 50 m; • flying at night (20:00 – 4:00)	2,431 spray events
Number of violations by 1 August 2004: • violations of the speed limit of 165 mph • violations of the height limit of 50 meters • violations of the application rate limit of 23.65 liters per hectare	41,714 spray events over 165 mph 10,815 spray events over 50 meters 14,654 spray events over 23.65 l/ha
Number of violations by 1 December 2006: • violations of the speed limit of 165 mph • violations of the height limit of 50 meters • violations of the application rate limit of 23.65 liters per hectare	54,336 spray events over 165 mph 13,114 spray events over 50 meters 18,871 spray events over 23.65 l/ha
Number of violations by 1 September 2005: • violations of the speed limit of 140 mph • violations of the height limit of 25 meters • violations of the application rate limit of 23.65 liters per hectare	74,984 spray events over 140 mph 56,592 spray events over 25 meters 15,223 spray events over 23.65 l/ha
Number of spray events conducted in December 2006 and January 2007.	22,555 spray events

[1] Unless otherwise noted, all statistics relate to the area within 10 km of Ecuador's border.

[2] Altitude data was not included in 2001 and 2004 due to mixed units (feet and meters). Application rate data was not included for 2001, 2002 or 2004 due to missing data or mixed units (gallons per hectare and gallons per acre).

Number of spray events higher than 30.48 meters between 2000 and 2008.	81,106 spray events
Number of spray events in December 2000 within 10 km of Ecuador’s Sucumbíos Province.	3,276 spray events
Number of spray events in January 2001 within 10 km of Ecuador’s Sucumbíos Province.	8,228 spray events
Number of spray events during December 2001 and January 2002 within 10 km of Ecuador’s Sucumbíos Province.	10,487 spray events
Number of spray events between August 2002 and October 2002 within 10 km of Ecuador’s Sucumbíos Province.	28,121 spray events
Number of violations between August 2002 and October 2002 within 10 km of the Ecuador’s Sucumbíos Province: • violations of the speed limit of 165 mph • violations of the height limit of 50 meters	15,882 spray events over 165 mph 4,533 spray events over 50 meters
Number of spray events conducted within 10 km of Ecuador’s Esmeraldas Province through the end of February 2007.	28,638 spray events
Number of spray events within 10 km of the Cofán-Bermejo Ecological Reserve in 2002.	8,959 spray events
Distance between the community of Salinas, Ecuador and the nearest spraying in 2001.	4.96 km from closest 2001 spray lines
Distance between the community of La Charapa, Ecuador and the international boundary.	8.12 km from international boundary in straight line
Distance between the community of 10 de Agosto, Ecuador and the international boundary.	7.12 km from international boundary in straight line
Distance between the community of Palma Seca, Ecuador and the international boundary.	0.5 km from international boundary in straight line
Distance between the community of Playera Oriental, Ecuador and the international boundary.	0.08 km from international boundary in straight line
Number of spray events in Colombia’s Putumayo department in 2000.	14,214 spray events

Annex 1

Number of spray events within 10 km of Ecuador's border by 1 May 2001.	14,214 spray events
Number of spray events within 10 km of Ecuador's border by 1 July 2001.	14,214 spray events
Number of spray events within 10 km of Ecuador's border by 1 November 2001.	16,061 spray events
Number of spray events within 10 km of Ecuador's border by 1 January 2003.	57,126 spray events
Number of spray events within 10 km of Ecuador's border by 1 June 2003.	60,969 spray events
Number of spray events within 10 km of Ecuador's border by 1 March 2005.	64,285 spray events

Annex 2

Durham K. Giles, Ph.D., *Spray Drift Modeling of Conditions of Application for Coca Crops in Colombia* (Jan. 2011)

Spray Drift Modeling of Conditions of Application for Coca Crops in Colombia

Durham K. Giles

Table of Contents

1. Executive Summary

This report addresses downwind, non-target spray deposition from aircraft applying a glyphosate-based herbicide for eradication of illicit crops in Colombia. The AGDISP model was used to predict the downwind spray deposition, i.e., "spray drift" under a number of scenarios, based on the best data available.

This analysis was based on three critical components: 1) flight records from over 100,000 documented spray events within 10 kilometers of the border between Colombia and Ecuador from 2000 to 2009, recorded by on-board data recording systems, as analyzed by R. J. Hansman and C. Mena (2011); 2) the droplet size spectra of the spray mixture emitted from the aircraft and other spray drift model input parameters reported by A.J. Hewitt, K.R. Solomon and E.J.P. Marshall (2009); and 3) the public domain AGDISP spray dispersion model developed by the United States Forest Service and widely used in risk assessment, regulatory development and spray mission planning.

The flight data revealed that the drift-mitigating limitations on application conditions and aircraft operation that were prescribed by Colombia in the Environmental Management Plan (EMP) and otherwise stated by Colombia were exceeded routinely during operations (Hansman & Mena, 2011). Spray drift is extremely sensitive to these parameters, including aircraft speed and altitude. Higher aircraft speed results in smaller droplets with slower settling velocities and higher release height results in longer droplet travel times, allowing more evaporation and cross wind displacement to occur. The effects of higher aircraft speed and higher height are synergistic and result in significant increases in spray drift. The Hewitt et al. (2009) study assumed values for aircraft altitude and speed much lower than the values reported in the flight path data, resulting in a significant underestimation of spray drift and deposition.

Other factors such as wind speed, atmospheric stability, and canopy height serve to exacerbate spray drift. For example, an increase in wind speed, from the Hewitt, et al. (2009) assumption of 2.57 m/s to a value of 5.14 m/s resulted in ~ 3-fold increases in AGDISP-predicted spray deposition in the far field at 5 to 10 km. With respect to atmospheric stability, Hewitt et al. (2009) assumed unstable, or "weak" conditions, which tend to reduce spray drift. However, the flight data analysis (Hansman & Mena 2011) revealed that 22% of the flights took place during the night time, when stable atmospheric conditions or temperature inversions are more likely. These conditions also increase spray drift. AGDISP predictions of far field (3 – 10 km) spray deposition increased from 4- to 5-fold when the atmospheric conditions were assumed to be stable. With respect to canopy height, Hewitt et al. (2009) assumed a constant tree canopy of 25.91 meters. A lower canopy at any given location, consistent with a clearing for a coca plantation or for agricultural activity, would result in significant increases in off-target spray drift deposition due to the reduced interception of spray drift by the vegetation.

This analysis also considers the cumulative effect of multiple flight lines, which was not considered by Hewitt et al. (2009). The flight path data recorded by the spray planes document the occurrence of dozens of flight lines at numerous locations within 10 km Ecuador-Colombia border (Hansman & Mena, 2011). These multiple flights were typically along parallel paths. In these situations, which are very common in agricultural and forestry aerial spraying, downwind spray drift is produced by each individual flight line. The cumulative effect of multiple flight lines is effectively a multiplicative function in which the far field spray deposition increases approximately proportionally to the number of flights. This study calculated the cumulative downwind deposition from multiple spray lines using the displacement between multiple flight paths recorded in the data set. The effect of multiple flight lines on downwind deposition, especially in the far field, served to further increase the effective non-target deposition. For example, at 1 km downwind, spray deposition from 10 flight lines from the AT-802 aircraft, operating at the 50^{th} percentile value for aircraft speed and the 50^{th} percentile value for height, produced approximately 7 to 8 times the amount of deposition as a single spray line.

The analysis presented in this report, when coupled with the analysis of flight data recorded by on-board the aircraft during spray operations (Hansman & Mena, 2011), establishes that the Hewitt et al. (2009) study significantly underestimated the amounts of spray drift generated by Colombia's aerial spraying program. In contrast, this analysis relies on recorded flight data and thus presents more realistic estimates of deposition generated by actual spray missions. Nevertheless, the flight path data only represents a subset of the actual conditions of operation. There is incomplete data regarding meteorological conditions such as wind speed and terrain conditions such as canopy height. In addition, factors such as the status of equipment and the effect of meteorological phenomena such as temperature inversions are difficult to quantify with spray drift modeling. With more than 100,000 spray events conducted within 10 kilometers of the Ecuador-Colombia border (Hansman & Mena, 2011), each subject to a unique set of operational and meteorological conditions, and operated over slightly different terrain, any number of actual spray drift scenarios are possible. Therefore, while this study predicts spray drift based on the best available data, there is a considerable amount of uncertainty about the amount of spray drift deposited off-target under actual conditions of application in Colombia. Consequently, the actual amount of deposition downwind from any given spray event could be even greater than predicted by the model.

2. About the Author

Durham K. Giles is a Professor of Biological and Agricultural Engineering at the University of California, Davis. Professor Giles received a B.S. in Agricultural Engineering (magna cum laude) from the University of Georgia in 1979. In 1983, he received an M.S. in Agricultural Engineering from the University of Georgia with a thesis title, "Space Charge Deposition of Pesticide Sprays onto Cylindrical Target Arrays" under the direction of National Academy of Engineering Member, Prof. S. Edward Law. The thesis work received an Outstanding Paper Award from the American Society of Agricultural Engineers. Professor Giles was awarded an Edwards Fellowship to Clemson University and received his Ph.D. in Agricultural Engineering (Minor in Mechanical Engineering) in 1987. In 1987, Professor Giles joined the faculty of the University of California, Davis in the department of Biological & Agricultural Engineering. He advanced through Assistant and Associate Professor ranks and was promoted to full Professor in 1997.

At the University of California, Davis, Professor Giles conducts research and teaching in the areas of spray technology and applications, engineering design and development and research methods in engineering. His work in atomization and spray application research and development has resulted in over 75 archival journal publications, 20 issued and pending patents and numerous awards for technical papers and engineering developments. Professor Giles is the Division Editor for the archival journals *Transactions of the American Society of Biological and Agricultural Engineers* and *Applied Engineering in Agriculture* and serves on the Board of Directors of the Institute for Liquid Atomization and Spraying Systems (ILASS Americas). He has also served on the Editorial Board for the journal *Atomization and Sprays*.

Professor Giles consults extensively with industry in the areas of spraying research and development, product development, intellectual property and in-house technical training and holds patents that have resulted in a number of licensed products that are marketed internationally. He also consults with government and nonprofit organizations on regulatory issues related to pesticide application. In addition, he has served as a consultant to the World Health Organization on pesticide application equipment. Prof. Giles is also an instrument-rated, commercial pilot with high-performance aircraft endorsements.

A current curriculum vitae for Professor Giles is attached in Appendix 1.

3. Analytical Methods and Approaches

a. AGDISP Model

A computational model called AGDISP was used to calculate spray deposition and drift. AGDISP was developed by the United States Forest Service and is in the public domain.[1] Version 8.24 of the model was used for this analysis.

The AGDISP model provides for an extensive array of input parameters to characterize the spraying situation of interest. The characterization includes a detailed description of aircraft configuration (weight, engines, propeller speed, etc.), specific flight conditions (altitude, speed, etc.), spray release conditions (droplet size spectra, density, nozzle positions, application rate, evaporation rate, tank mix constituents, etc.), canopy (height, roughness, etc.) and meteorological conditions (wind speed, relative humidity, atmospheric stability, etc.). Where possible, this analysis used model inputs based on actual flight path data recorded by the spray planes in Colombia (Hansman & Mena, 2011) or experimental data measuring droplet size (Hewitt et al., 2009). However, many of the AGDISP model inputs, such as wind speed, relative humidity and atmospheric stability must be assumed because there is no data available documenting actual spray event conditions. Unless otherwise noted, this analysis uses the same assumptions as Hewitt et al. (2009) for parameters that are not recorded in the flight path data. Nevertheless, these assumptions lead to uncertainty in the model results as compared to actual spray runs conducted in Colombia.

Model predictions to 800 m downwind were made using the Lagrangian computations with AGDISP. Predictions beyond 800 m were made using the Gaussian Far-Field Extension capabilities of AGDISP.[2] The model's predictions of deposition have been validated with numerous field tests. (Teske, et al., 2003c; Teske and Curbishley, 2010; Teske and Thistle, 2003; Bird et al., 2002; Teske et al., 1998b). Despite some uncertainty associated with model results, AGDISP is considered a state-of-the art model; it is used extensively to predict deposition and spray drift in the agricultural and forestry sectors, and by several United States government agencies including the U.S. Forest Service and the U.S. Environmental Protection Agency Office of Pesticide Programs.

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[1] The development of AGDISP is described in the User's Manual (Teske and Curbishley, 2010) as follows: "In 1979 Continuum Dynamics, Inc. began developing a Lagrangian model for the dispersal of spray material, utilizing the equations for particle motion first suggested by Reed (1953), and culminating in a model for NASA (Bilanin and Teske 1984) known as AGDISP (for AGricultural DISPersal). This approach included models for aircraft wake effects (vortices, propellers, and jet engines) and evaporation (Bilanin et al. 1989), and subsequently became the near-wake model for FSCBG [an early aerial dispersion model]. Further development and refinement by the Spray Drift Task Force (SDTF) led to its regulatory version AgDRIFT (Teske et al. 2002a), and now to this, the latest version of AGDISP (Teske et al. 2003c). AGDISP origins can be traced to 1981, when the USDA Forest Service contracted with Ketron, Inc. to review the potential for developing and implementing a consistent and inclusive aerial spray model, using as a basis the first released version of FSCBG."

[2] With the Gaussian dispersion computations, the handoff of the computations from the Lagrangian to the Gaussian procedures was done automatically by the AGDISP model. The handoff takes place at the distance downwind where AGDISP determines that the aircraft vortices are no longer a significant contributing factor to the spray movement. The far-field deposition curves presented in Hewitt et al. (2009) indicate that that study also used the Gaussian Far-Field Extension to predict drift.

b. Report Overview

The benchmark modeling described in Section 4 of this report was based on the closely-related work of Hewitt et al. (2009) who applied the AGDISP model to the coca and poppy spraying operations in Colombia. The first step of this analysis involved replicating the Hewitt et al. (2009) results using the input parameters described in that study. Section 5 describes the second step in the analysis, which was to model deposition and spray drift resulting from a single spray line, using the input parameters from Hewitt et al. (2009), with the exception of values for aircraft height and speed. The values for aircraft height and speed come from flight path data obtained from the U.S. Department of State, which record actual spraying operations on coca crops in Colombia between 2000 and 2009 (Hansman & Mena, 2011). As described below, droplet size spectra were derived from relationships with aircraft speed described by Hewitt et al. (2009). Sections 6 and 7 include a sensitivity analysis for aircraft altitude and aircraft speed. Section 8 discusses the effect of the droplet size spectra on spray drift. Sections 9 discusses other factors that affect spray drift and Section 10 presents several illustrative application scenarios. Section 11 describes the cumulative effect of multiple spray lines, consistent with the actual conditions of application in Colombia. Section 12 describes additional factors that affect spray drift, but are not readily captured in spray drift modeling. Finally, Section 13 includes a brief discussion of Colombia's previous spray drift studies and their relationship to the AGDISP analysis.

The input parameters used for each model run are described in each section of the report and are included in a CD submitted with Ecuador's Reply.

c. Spray Tank Mix and Application Rate

In pesticide application, the term "tank mix" is defined as the actual liquid mixture prepared within or loaded into the aircraft tank and dispensed from the spray nozzles. The tank mix used in all model runs was based on the known contents of the spray mixture specified by the U.S. Department of State (2002) and by the Republic of Colombia (2003) in the EMP. The mixture consisted of 44% commercial glyphosate formulation, 1% spray adjuvant (Cosmo-Flux 411F) and 55% water. The commercial glyphosate formulation contained 41% glyphosate salt, 15% surfactant and 44% water.

Unless otherwise noted, the standard application rate used for all model runs was 23.65 L/ha, consistent with the specifications and description by the U.S. Department of State (2002) and the EMP (Republic of Colombia, 2003).

d. Model Output and Units

The AGDISP model output reported in this analysis is the deposition of spray material at various distances downwind from the location of the spray application. Model results were calculated in terms of grams active ingredient per ha, g (a.i.)/ha. Nominally, the active ingredient is the glyphosate isopropylamine salt (the 41% constituent in the commercial formulation). However, glyphosate rates are often expressed in terms of acid equivalent (a.e) which is functionally 75% of the active ingredient glyphosate isopropylamine salt. In this report, deposition is reported as the mass of acid equivalent per unit area, g (a.e.) / ha, consistent with the units used by Hewitt et al. (2009).

e. Droplet Size Spectra

Spray droplets are created through shear forces that develop between a liquid stream and the surrounding air. The shear forces disintegrate the liquid into droplets (Figure 1). The disintegration, and the resulting sizes of the droplets, are controlled by the relative velocities of the liquid and the air, the orientation of the nozzle in the air stream, the characteristic diameters of the streams, the turbulence of the liquid and air streams and the viscosity, surface tension and density of the liquid. The disintegration process, referred to as "atomization," is a complex process that is difficult to predict and therefore often described empirically.

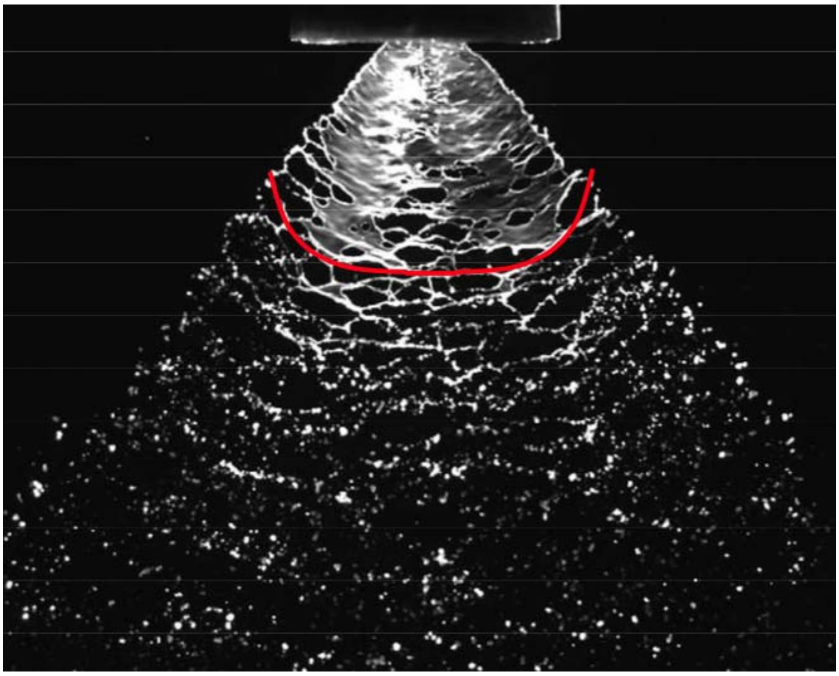
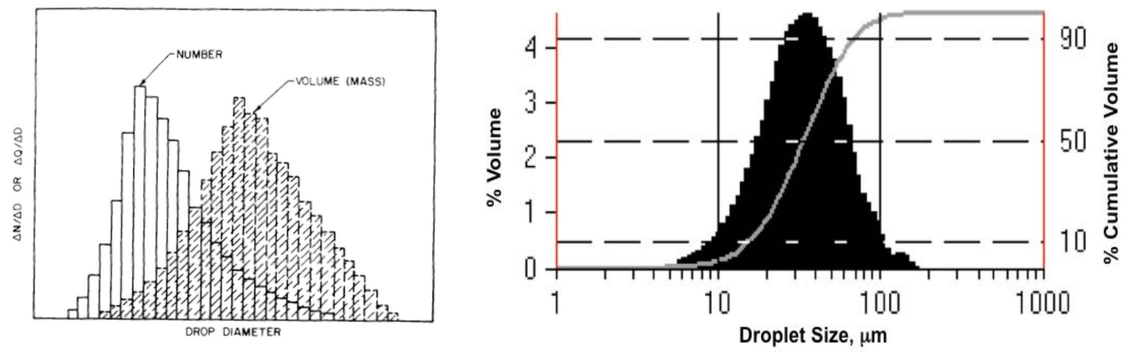


Figure 1. Atomization: the disintegration of liquid into droplets (Source: Cloeter, et al., 2010).

The nozzles used in the Colombian spraying operations and described by Hewitt et al. (2009) are pressure atomization nozzles that pressurize the liquid and propel it through small orifices, where it is released into the high speed airflow past the aircraft. Therefore, the primary mechanism of atomization is the aerodynamic interaction between the liquid streams and the air flow. The atomization process does not produce spray with all droplets of an equal diameter; rather, a range, or spectrum, of droplet sizes is produced. The range, or spectrum, of droplet sizes is a population that can be described statistically. As shown in Figure 2(a), the distribution of droplet sizes can be represented as a histogram. The descriptive histogram can be based on the *number* of droplets within a given size range; however, the more common and useful histogram is based on the *volume or mass* of spray contained in droplets with a given size range. In this manner, the amount of spray liquid within each size range is expressed. As shown in Figure 2(b), the volume-based statistical descriptions can be the actual histogram or a cumulative distribution function calculated from the histogram.



(a) (b)

Figure 2. Statistical representations of examples droplet size spectra; adapted from Lefebrve (1989).

The cumulative distribution, i.e., the ogive curve in Figure 2(b), allows the statistical values of $D_{v0.5}$, $D_{v0.9}$ and $D_{v0.1}$ to be easily extracted from the graphical data. $D_{v0.5}$ is the droplet size, in micrometers (µm, also called "microns"), in which 50% of the spray liquid volume is contained in droplets smaller than the $D_{v0.5}$ value and 50% of the spray liquid volume is contained in droplets larger than the $D_{v0.5}$ value. $D_{v0.5}$ is also known as the volume median diameter (v.m.d.). $D_{v0.9}$ is the droplet size in which 90% of the spray liquid volume is contained in droplets smaller than the $D_{v0.9}$ value. $D_{v0.1}$ is the droplet size in which 10% of the spray liquid volume is contained in droplets smaller than the $D_{v0.1}$ value. These statistical parameters are shown in Figure 2(b) at the intersection of the dotted horizontal lines and the plotted curve of the cumulative distribution.

The size of the spray droplets has important implications for spray drift because it affects the droplet's terminal velocity and rate of evaporation. Smaller droplets have significantly slower terminal velocities and are displaced greater distances by cross winds than larger droplets. Likewise, smaller droplets have higher surface area to mass ratios and the effect of evaporation is to decrease their size more rapidly than larger droplets. As a result of these two factors, smaller droplets are carried greater distances, resulting in greater spray drift.

Hewitt et al. (2009) measured the droplet spectra in a wind tunnel experiment set up to simulate the conditions of application in Colombia. Hewitt used the spray tank mix applied to coca crops, atomized through an Accu-Flo nozzle (0.085 inch concentric orifice diameter) at air speeds of 259, 296 and 333 km/hr. Based on the droplet size spectra gathered from the wind tunnel experiment, Hewitt et al. (2009) developed relationships between the $D_{v0.5}$, $D_{v0.9}$ and $D_{v0.1}$ values and the airspeed of the aircraft. The least-squares (linear) equations developed by Hewitt are shown in Figure 3. Hewitt also calculated the spray droplet spectrum relative span, defined as $((D_{v0.9} - D_{v0.1})/ D_{v0.5})$.

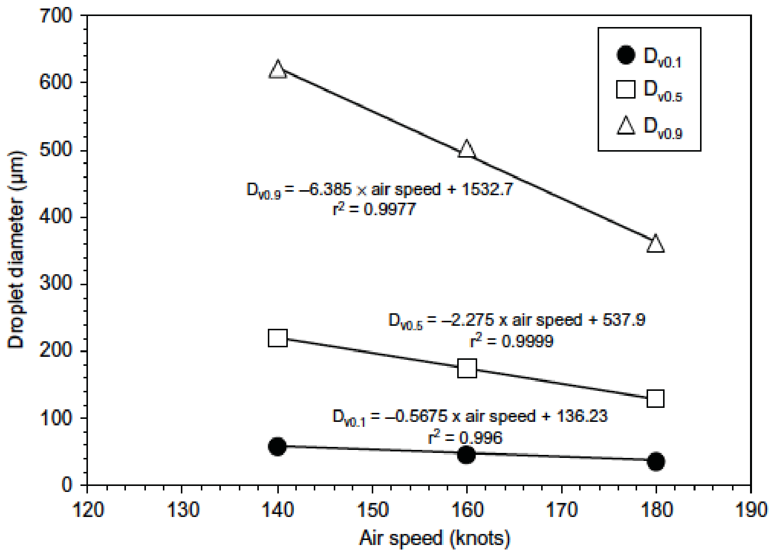


Figure 3. Droplet size spectral parameters as a function of airspeed, shown with least-squares predictive equations for the coca spray tank mix and Accu-Flo nozzle. (Source: Hewitt et al. (2009)).

The droplet size spectra used for the model runs in this report were based on the relationships established by Hewitt et al. (2009) and shown in Figure 3. More specifically, the airspeed and the equations in Figure 3 were used to calculate the $D_{v0.5}$ and relative span values for each model run. These values were used as inputs into AGDISP and the parametric droplet size spectrum generation routine within AGDISP was used to generate a droplet size distribution that was used by the program for drift analysis. The parametric droplet size spectrum generation routine uses the $D_{v0.5}$ and relative span values to calculate a spectrum using the Root Normal approach (Simmons, 1977) as discussed by Teske and Curbishley (2010).

f. Aircraft Type

The aircraft type in the AGDISP model runs for this report were the same aircraft types modeled by Hewitt et al. (2009) and confirmed by the data collected on-board during actual spray operations (Hansman and Mena, 2011). The aircraft types were:

- Air Tractor AT-802
- Rockwell OV-10
- Ayers Turbo Thrush T-65

Aircraft weight, engine, propeller, and performance data were taken as defaults from the AGDISP 8.24 library of aircraft, consistent with the approach reported by Hewitt et al. (2009).

g. Effect of Multiple Spray Passes

Many aerial spraying operations, including those conducted in Colombia, involve multiple parallel flights to cover the target area (Hansman & Mena, 2011). Physically and analytically, each flight is an independent event, i.e., the aircraft wake and the droplets released from one pass dissipate and do not affect the motion of droplets from subsequent passes. Therefore, the total spray deposition at any point downwind from multiple passes is an accumulation of the spray deposition from each individual spray pass.

In order to calculate the total spray deposition from multiple spray passes, the deposition from each individual spray line was added together after translation upwind to account for the spacing between each pass (this technique is called "superposition"). The spacing between passes was set at 51.8 m (170 ft), based on the swath width recorded in the flight path data for the AT-802 and the OV-10 aircraft (Hansman and Mena, 2011).[3]

In contrast to the flight path data recorded by the spray planes in Colombia, which documents the routine occurrence of multiple parallel flights (Hansman & Mena, 2011), Hewitt et al. (2009) evaluated "[o]ne flight line (i.e., single swath applications as used operationally in Colombia)." While analysis of a single pass of an aircraft can be used to determine the relative effects of aircraft configuration and operation, terrain, meteorology or other factors on spray drift, determinations of the actual spray deposition and subsequent biological effects must be based on the actual application scale, i.e., the multiple passes required for the entire treatment. Accounting for the effect of multiple spray passes is an essential step in spray drift modeling for risk assessment because the quantity of chemical reaching a point of interest and affecting non-target areas is the result of multiple spray passes and not a single spray pass. (See e.g., Hewitt et al. 2002). The AGDISP model includes a module that can be used to evaluate the effect of multiple spray passes. Using only a single pass to determine drift deposition when multiple passes were made will significantly underestimate deposition from spray drift.

4. <u>Replication of Previously Reported Model Results</u>

The first step of the analysis presented in this report was to reproduce the drift results published by Hewitt et al. (2009) using the model input parameters reported in that study. Precise direct comparisons are not possible due to the lack of tabulated, numerical data for spray deposition in the Hewitt et al. publication. However, model runs conducted for this analysis using the inputs reported by Hewitt et al. showed relatively good agreement with the published results. Figure 4 shows the drift curves reported by Hewitt et al. Figure 5 shows the drift curves prepared for this analysis based on the inputs reported by Hewitt et al.

[3] Based on the recorded flight path data, the spray lines from the T-65 aircraft have a swath width of 30.48 meters (100 feet) (Hansman & Mena, 2011). The effect of multiple spray lines was not analyzed for the T-65. However, a closer swath width will generally result in greater total deposition at a given point downwind because each individual spray line is closer to the point where deposition is measured.

Annex 2

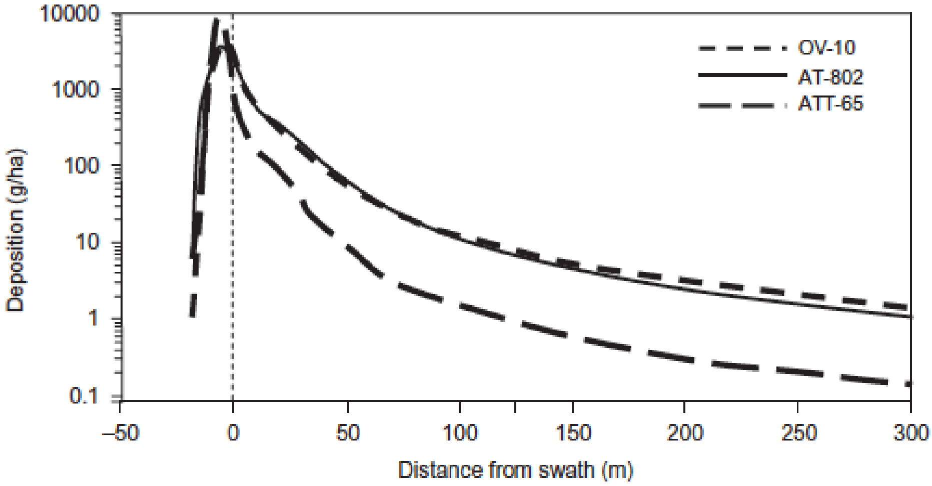


Figure 4. Results of AGDISP modeling of coca sprays applied in Colombia by Hewitt et al. (2009).

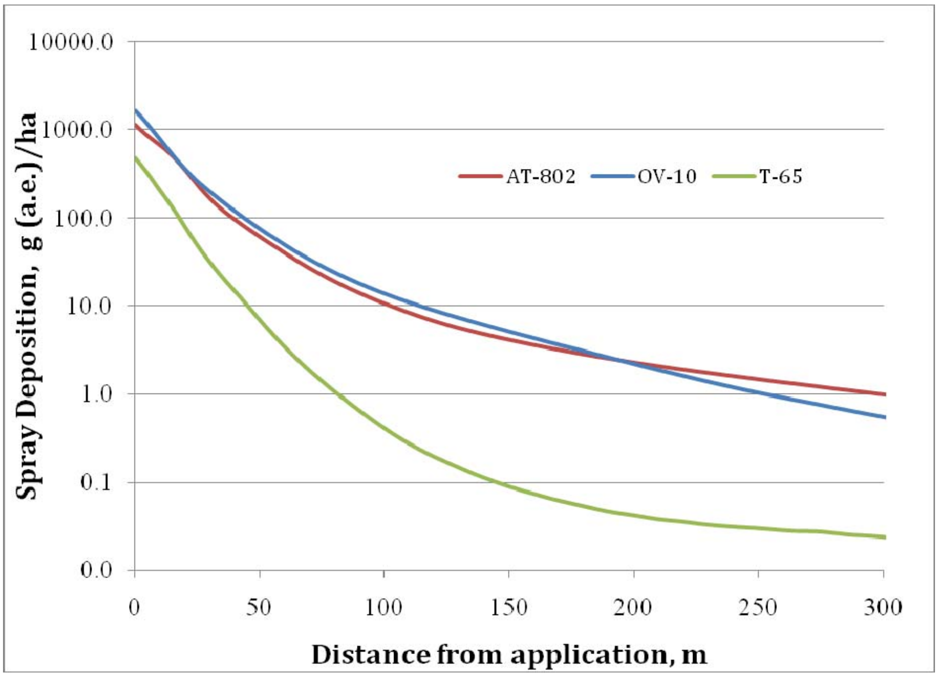


Figure 5. Results from AGDISP modeling of coca sprays prepared for this analysis based in Hewitt et al. (2009) inputs.

5. Baseline Spray Drift Modeling

All model runs and the results reported in this section are based on the input values reported by Hewitt et al. (2009) with the exception of aircraft altitude and speed, which were derived from the flight data recorded on-board during operations, and application rate of the tank mixture which was 23.65 liters per hectare, as discussed in Section 3(c). The droplet size spectra were calculated based on the speed of the aircraft and the equations reported in Hewitt et al. (2009), as described above in Section 3(e). All results reported in this section represent a single spray pass, also consistent with Hewitt et al. (2009).

For each aircraft type, Hansman & Mena (2011) analyzed the flight data records to determine 50, 60, 70, 80, 90, 95 and 99% cumulative occurrences of aircraft altitude (m) and 50, 60, 70, 80, 90, 95 and 99% cumulative occurrences of aircraft speed (mph or km/hr). For example, the 50th percentile value for aircraft altitude represents the median aircraft altitude for the dataset in that ½ the flights were conducted at lower altitudes than the 50th percentile value and ½ of the flights were conducted at higher altitudes than the 50th percentile value. The 90th percentile value for aircraft altitude represents the altitude at which 90 percent of the flights were conducted at a lower altitude and 10 percent of the flights were conducted at a higher altitude. The flight data values used in the baseline modeling are shown in Tables 1-3.[4]

Table 1. AT-802 aircraft flight data used for baseline analysis

Percentile	Altitude (m)	Speed (mph)	Speed (km/hr)	Dv0.5 (µm)	Dv0.1 (µm)	Dv0.9 (µm)	Relative span
Hewitt	30.48	170.25	274.00	200.96	52.18	587.04	2.66
50	40.61	171.20	275.52	199.08	51.71	581.78	2.66
60	42.50	172.60	277.77	196.32	51.02	574.02	2.66
70	44.72	174.10	280.19	193.34	50.28	565.67	2.67
80	47.37	176.30	283.73	188.99	49.19	553.45	2.67
90	51.52	179.50	288.88	182.66	47.61	535.67	2.67
95	55.24	182.30	293.38	177.12	46.23	520.14	2.68
99	64.57	188.60	303.52	164.65	43.12	485.15	2.68

[4] As noted by Hansman & Mena (2011), the altitude values presented in Tables 1-3 most likely underestimate the actual operational altitude of spray aircraft operating in forested areas because the altitude values do not account for the fact that the satellite Digital Elevation Model value used to calculate the terrain elevation measures an apparent height that is above the ground level. This factor is analyzed further in Section 6 of this report.

Annex 2

Table 2. OV-10 aircraft flight data used for baseline analysis.

Percentile	Altitude (m)	Speed (mph)	Speed (km/hr)	Dv0.5 (µm)	Dv0.1 (µm)	Dv0.9 (µm)	Relative span
Hewitt	30.48	206.92	333.00	128.40	34.08	383.40	2.72
50	42.56	207.50	333.94	127.25	33.79	380.17	2.72
60	44.89	208.90	336.19	124.46	33.10	372.34	2.73
70	47.58	210.34	338.51	121.63	32.39	364.39	2.73
80	50.66	212.40	341.83	117.55	31.37	352.96	2.74
90	55.46	215.60	346.98	111.22	29.80	335.19	2.75
95	59.54	218.50	351.64	105.47	28.36	319.04	2.76
99	68.39	225.00	362.10	92.63	25.16	283.01	2.78

Table 3. T-65 aircraft flight data used for baseline analysis.

Percentile	Altitude (m)	Speed (mph)	Speed (km/hr)	Dv0.5 (µm)	Dv0.1 (µm)	Dv0.9 (µm)	Relative span
Hewitt	30.48	140.43	226.00	259.97	66.90	752.67	2.64
50	39.46	162.80	262.00	215.71	55.86	628.45	2.65
60	42.24	166.34	267.70	208.70	54.11	608.77	2.66
70	45.47	169.50	272.78	202.45	52.55	591.24	2.66
80	49.43	172.79	278.08	195.94	50.93	572.95	2.66
90	55.88	177.10	285.02	187.40	48.80	549.00	2.67
95	62.51	180.64	290.71	180.41	47.05	529.36	2.67
99	83.97	188.00	302.56	165.83	43.42	488.46	2.68

It was not feasible to model all of the possible combinations of altitude and speed that occurred in the flight path data set. Therefore, in order to evaluate a range of scenarios for each aircraft type, a model run was conducted at the 50th percentile value for altitude and the 50th percentile value for speed; the 60th percentile value for altitude and the 60th percentile value for speed; the 70th percentile value for altitude and the 70th percentile value for speed, etc. The results from the AGDISP model runs appear in Tables 4-6. Deposition values at the 800 m range are the results of the Langrangian calculations; deposition values at ranges of 1 km to 10 km are from the Gaussian far-field extension results. The deposition values generated from the replication of the Hewitt et al. model runs described in Section 4 are included in Tables 4-6 as a source of comparison.

Table 4. Deposition values for 800 m to 10 km downwind for the AT-802 aircraft operating in the conditions described in Table 1.

Percentile	Deposition 800 m (g a.e./ha)	Deposition 1 km (g a.e./ha)	Deposition 2 km (g a.e./ha)	Deposition 3 km (g a.e./ha)	Deposition 5 km (g a.e./ha)	Deposition 10 km (g a.e./ha)
Hewitt replication	0.10	0.08	0.05	0.03	0.02	0.01
50 altitude 50 speed	5.39	4.91	2.51	1.67	0.91	0.27
60 altitude 60 speed	7.76	6.90	3.49	2.21	1.19	0.36
70 altitude 70 speed	9.89	8.18	4.11	2.48	1.34	0.42
80 altitude 80 speed	10.79	9.65	4.76	2.93	1.57	0.51
90 altitude 90 speed	12.80	11.99	5.67	3.84	1.94	0.66
95 altitude 95 speed	14.36	13.58	6.42	4.25	2.18	0.74
99 altitude 99 speed	16.88	17.69	8.49	5.15	2.74	1.06

Table 5. Deposition values for 800 m to 10 km downwind for the OV-10 aircraft operating in the conditions described in Table 2.

Percentile	Deposition 800 m (g a.e./ha)	Deposition 1 km (g a.e./ha)	Deposition 2 km (g a.e./ha)	Deposition 3 km (g a.e./ha)	Deposition 5 km (g a.e./ha)	Deposition 10 km (g a.e./ha)
Hewitt replication	0.09	0.07	0.03	0.02	0.01	0.01
50 altitude 50 speed	9.93	5.05	2.24	1.42	0.82	0.31
60 altitude 60 speed	11.66	6.02	2.62	1.66	0.92	0.35
70 altitude 70 speed	13.37	7.49	3.19	2.04	1.08	0.41
80 altitude 80 speed	15.05	9.47	3.74	2.26	1.21	0.49
90 altitude 90 speed	17.11	13.56	5.02	2.82	1.48	0.71
95 altitude 95 speed	18.47	15.28	5.75	3.43	1.77	0.77
99 altitude 99 speed	18.49	15.91	5.76	3.26	1.58	0.77

Table 6. Deposition values for 800 m to 10 km downwind for the T-65 aircraft operating in the conditions described in Table 3.

Percentile	Deposition 800 m (g a.e./ha)	Deposition 1 km (g a.e./ha)	Deposition 2 km (g a.e./ha)	Deposition 3 km (g a.e./ha)	Deposition 5 km (g a.e./ha)	Deposition 10 km (g a.e./ha)
Hewitt replication	0.01	0.01	0.01	0.01	0.01	0.01
50 altitude 50 speed	3.17	2.81	1.52	0.97	0.51	0.14
60 altitude 60 speed	5.02	4.67	2.53	1.74	0.91	0.27
70 altitude 70 speed	8.30	7.09	3.69	2.44	1.30	0.38
80 altitude 80 speed	10.19	8.76	4.52	2.74	1.46	0.44
90 altitude 90 speed	12.76	11.04	5.51	3.76	1.91	0.66
95 altitude 95 speed	13.86	12.41	6.29	4.09	2.12	0.73
99 altitude 99 speed	15.80	13.26	7.04	4.54	2.46	0.83

These results, when compared to the results published by Hewitt et al. (2009) (Figure 6), reveal that the Hewitt et al. model predictions significantly underestimate the spray drift that would be expected to result from actual flight conditions. For example, Hewitt et al. report spray deposition at 1 km downwind of approximately 0.1 to 1 g a.e./ha for both the AT-802 and the OV-10 aircraft (Hewitt, et al. original Figure 6) while spray deposition values based on the flight data are at least 2.8 to 5 times higher for the 50th percentile altitude / 50th percentile speed spray conditions and 11 to 13 times higher for 90th percentile altitude / 90th percentile speed conditions. Figure 7 shows the results reported in Table 4 for the AT-802 aircraft as compared to the replication of the Hewitt et al. (2009) model runs for that aircraft.

The under-prediction by Hewitt et al. is most likely not a result of incorrect model use or inaccurate experimental droplet size data. Rather, the under-prediction of spray drift by Hewitt et al. results from assumptions regarding airplane height and speed that do not reflect the flight conditions recorded by on-board data collection systems (Hansman & Mena, 2011). In each case, the actual conditions of application as reflected by the flight path data (i.e. higher altitudes and faster speeds) tend to generate more spray drift. These factors are discussed in greater detail in Sections 6 and 7 below.

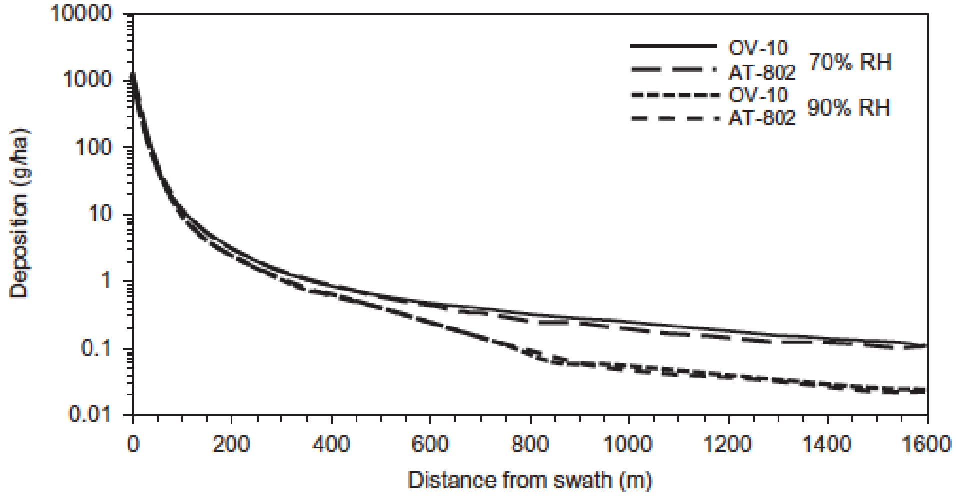


Figure 6. Results from AGDISP modeling of coca sprays applied in Colombia (Hewitt et al. original Figure 6).

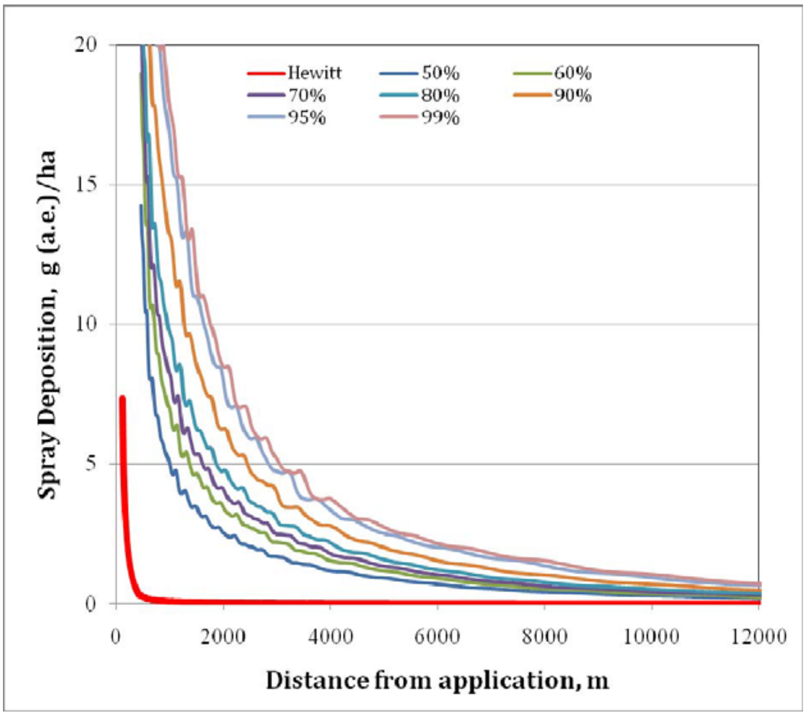


Figure 7. AGDISP results for AT-802 aircraft operating across a range of altitude and speed percentile values as compared to the replication of the Hewitt et al. (2009) model runs for the AT-802 aircraft.

6. Effects of Aircraft Altitude

A critical parameter in the potential for spray drift is the aircraft altitude or height of the application above the underlying canopy. When spray droplets are released, they must travel from the point of release downward to the intended target. Any cross wind that affects the droplets during their downward trajectory will displace them downwind. As the height of release increases, the travel time of the droplets increases correspondingly, allowing a greater horizontal displacement of the droplets to occur. In conventional aerial applications for agriculture, not only is the canopy low and relatively consistent across a field, but the lack of obstructions and ground-based interference with the spray operation allows the aircraft to maintain a low and consistent altitude above the crop. Often the height of application is within 3 m of the crop canopy. Likewise, for commercial applications of herbicides in forestry, the height of the application is kept as low as possible in order to increase target deposition and mitigate potential spray drift; for this reason helicopters are often used in forestry applications.

To determine the effects of aircraft height on the resulting spray drift deposition, a range of application heights were modeled while keeping all other parameters constant. In this analysis, the AT-802 aircraft was used at the 50th percentile flight speed (275.52 km/hr), an application rate of 23.65 L/ha, and the rest of the model inputs as specified by Hewitt et al. (2009). Only the aircraft height was varied over the 50, 60, 70, 80, 90, 95 and 99th percentiles of the flight data, which range from 40.61 meters to 64.57 meters (Table 1). In addition, the 30.48 m value used by Hewitt et al. (2009), the 50 m value from Colombia's EMP (Republic of Colombia, 2003), and a range of altitude values between 30.48 and 40.61 meters were analyzed. The results appear in Table 7.

The results show that downwind spray drift is highly sensitive to the altitude of the aircraft and correspondingly, the release height of the spray material. Given the significant difference between the height of 30.48 m assumed by Hewitt et al (2009) and the actual flight data, the increase in predicted downwind deposition is significant (see Figure 8). At 50 meters above ground, the application limit of the Colombian EMP, the predicted spray deposition exceeded the amount predicted for an application height of 30.48 meters, often by two orders of magnitude.

Table 7. Deposition values for 800 m to 10 km downwind for the AT-802 aircraft demonstrating the sensitivity of spray drift changes in application altitude.

Altitude (m)	Deposition 800 m (g a.e./ha)	Deposition 1 km (g a.e./ha)	Deposition 2 km (g a.e./ha)	Deposition 3 km (g a.e./ha)	Deposition 5 km (g a.e./ha)	Deposition 10 km (g a.e./ha)
30.48 (Hewitt)	0.11	0.09	0.05	0.03	0.02	0.01
32.00	0.16	0.21	0.14	0.07	0.03	0.01
34.00	0.69	0.66	0.44	0.21	0.10	0.03
36.00	2.02	1.76	1.12	0.53	0.26	0.08
38.00	3.38	3.00	1.89	0.92	0.44	0.13
40.61 (50%)	5.39	4.91	2.51	1.67	0.91	0.27
42.50 (60%)	7.61	6.71	3.37	2.20	1.18	0.35
44.72 (70%)	9.76	8.11	4.04	2.57	1.37	0.41
47.37 (80%)	10.23	9.37	4.64	2.89	1.52	0.47
50.00 (EMP)	11.36	11.17	5.57	3.35	1.76	0.55
51.51 (90%)	11.40	11.39	5.69	3.39	1.77	0.56
55.24 (95%)	12.74	13.07	6.58	3.91	2.05	0.67
64.57 (99%)	15.21	17.87	8.87	5.39	2.79	0.96

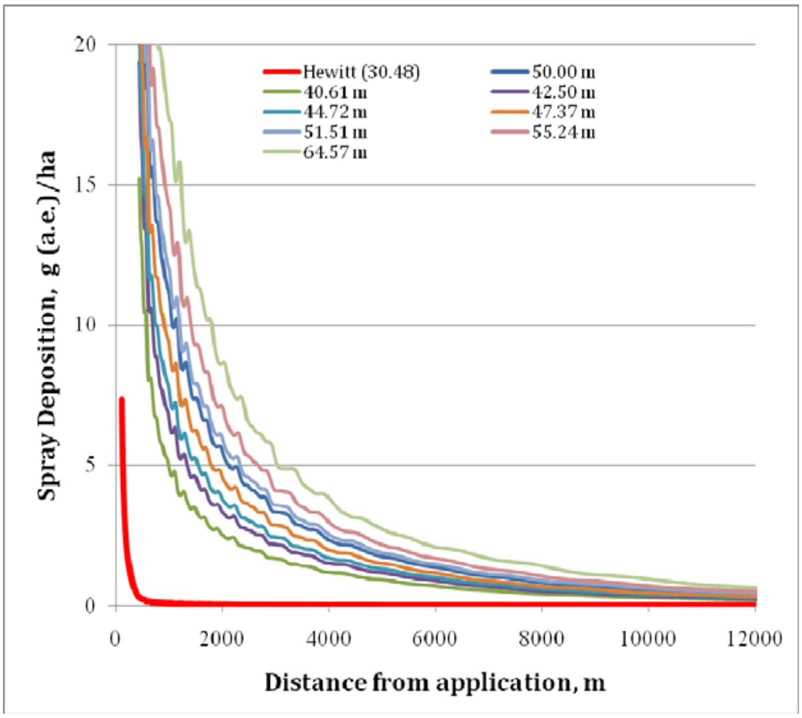


Figure 8. Deposition curves for the AT-802 aircraft demonstrating the sensitivity of spray drift changes in application altitude showing the Hewitt et al. (2009) assumption as compared to the 50th through 90th percentile values for altitude from the flight path data.

As described in Hansman and Mena (2011), the actual height of the spray aircraft may be greater than the values presented in Tables 1 – 3 in areas with rainforest tree canopy. While the actual terrain and exact tree canopy height is variable, a representative value was calculated by Hansman and Mena (2011) to estimate the true altitude of the spray aircraft in areas with rainforest tree canopy. The net effect is to increase the flight data numerical values of aircraft altitude by 17.66 meters.

Tables 8 through 10 below are equivalent to the baseline spray drift modeling described in Section 5, with the exception of the +17.66 adjustment in altitude. Thus, these values assume that the aircraft was flying over a forested area.

Table 8. Deposition values for 800 m to 10 km downwind for the AT-802 aircraft with altitude adjusted for area with rainforest canopy.

Altitude pre	Altitude post	Deposition	Deposition	Deposition	Deposition	Deposition	Deposition
correction	17.66 m correction	800 m	1 km	2 km	3 km	5 km	10 km
(m)	(m)	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)
Hewitt		0.10	0.08	0.05	0.03	0.02	0.01
40.61 (50%)	58.27	14.18	15.81	7.88	4.52	2.42	0.82
42.50 (60%)	60.16	14.61	16.42	8.06	4.94	2.54	0.87
44.72 (70%)	62.38	15.16	17.02	8.24	5.40	2.68	0.93
47.37 (80%)	65.03	16.06	18.14	8.71	5.87	2.91	0.99
51.51 (90%)	69.17	15.89	18.41	9.16	5.69	2.93	0.99
55.24 (95%)	72.90	16.49	17.84	9.37	5.34	2.84	1.04
64.57 (99%)	82.23	17.18	16.06	8.34	5.26	2.81	0.98

Table 9. Deposition values for 800 m to 10 km downwind for the OV-10 aircraft with altitude adjusted for area with rainforest canopy.

Altitude pre correction (m)	Altitude post 17.66 m correction (m)	Deposition 800 m (g a.e./ha)	Deposition 1 km (g a.e./ha)	Deposition 2 km (g a.e./ha)	Deposition 3 km (g a.e./ha)	Deposition 5 km (g a.e./ha)	Deposition 10 km (g a.e./ha)
Hewitt		0.09	0.07	0.03	0.02	0.01	0.01
42.45 (50%)	60.22	17.66	13.78	5.75	3.64	1.89	0.76
44.89 (60%)	62.55	18.27	14.46	5.84	3.59	1.94	0.80
47.58 (70%)	65.24	18.76	15.26	5.79	3.32	1.90	0.86
50.66 (80%)	68.32	18.77	15.14	5.84	3.26	1.76	0.83
55.46 (90%)	73.12	18.44	13.77	5.65	3.44	1.84	0.74
59.54 (95%)	77.20	17.58	13.91	5.18	2.91	1.70	0.78
68.39 (99%)	86.05	16.55	14.72	5.39	3.02	1.98	0.83

Table 10. Deposition values for 800 m to 10 km downwind for the T-65 aircraft with altitude adjusted for area with rainforest canopy.

Altitude pre correction (m)	Altitude post 17.66 m correction (m)	Deposition 800 m (g a.e./ha)	Deposition 1 km (g a.e./ha)	Deposition 2 km (g a.e./ha)	Deposition 3 km (g a.e./ha)	Deposition 5 km (g a.e./ha)	Deposition 10 km (g a.e./ha)
Hewitt		0.01	0.01	0.01	0.01	0.01	0.01
39.46 (50%)	57.12	11.87	11.54	6.02	3.95	2.00	0.62
42.24 (60%)	59.90	12.76	12.86	6.54	4.14	2.12	0.65
45.47 (70%)	63.13	13.34	13.24	7.02	4.09	2.19	0.73
49.43 (80%)	67.09	13.63	12.91	6.70	4.19	2.24	0.79
55.88 (90%)	73.54	14.17	13.00	6.71	4.43	2.30	0.76
62.51 (95%)	80.17	14.80	13.27	7.40	4.28	2.34	0.83
83.97 (99%)	101.63	16.62	15.48	8.12	5.30	3.22	1.04

The results presented in Tables 8 through 10 demonstrate the increase in total deposition that results from an increase in aircraft altitude. For example, an AT-802 aircraft traveling at 50th percentile speed (275 km/hr) and 50th percentile altitude assuming bare ground below the aircraft (40.61 m) would be expected to deposit 4.91 g a.e./ha at 1 kilometer from the application site (Table 4). The same aircraft traveling at the same speed and 50th percentile altitude assuming a forested area below the aircraft (58.27 m) would be expected to deposit 15.81 g a.e./ha at 1 kilometer from the application site (Table 8), roughly a three fold increase under these conditions. As discussed by Hansman & Mena (2011), these increased altitude values are more accurate estimate of the altitude of the aircraft in forested regions. Therefore, the deposition values are also are more accurate estimates based on actual field conditions in forested regions.

7. Effects of Aircraft Speed

Aircraft speed also has a significant influence on spray drift. As discussed in Section 3(e), higher air speeds create greater shear forces on the liquid emitted from the nozzles and produce smaller droplets that are more prone to drift. The aircraft speed also affects the aerodynamics of the aircraft wake and airflow disruption around the spray boom and nozzles. The wind tunnel test data published by Hewitt et al. (2009) and reproduced in Figure 3 of this report clearly establishes the effect of airspeed on the resulting droplet size spectra.

To determine the effects of aircraft speed on the resulting spray drift deposition, AGDISP was used to model the drift from a range of application speeds, with corresponding droplet size spectra, while keeping all other parameters constant. In this analysis, the AT-802 aircraft was used at the 50th percentile flight altitude (40.61 meters, which does not include the 17.66 m correction for areas with rainforest canopy), and application rate of 23.65 L/ha. The rest of the model inputs were used as specified by Hewitt et al. (2009). The aircraft speed was varied over the 50, 60, 70, 80, 90, 95 and 99 percentiles of the flight data (Table 1). Several key thresholds reported by Colombia were also analyzed: 140 mph and 165 mph (Hansman & Mena, 2011). The results appear in Table 11.

Table 11. Deposition values for 800 m to 10 km downwind for the AT-802 aircraft demonstrating the sensitivity of spray drift changes in aircraft speed.

Speed	Droplet size	Deposition	Deposition	Deposition	Deposition	Deposition	Deposition
		800 m	1 km	2 km	3 km	5 km	10 km
(km/hr)	$D_{V0.5}$	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)
225.32 (140 mph)	260.81	2.57	2.93	1.58	0.99	0.49	0.13
265.54 (165 mph)	211.36	4.57	4.56	2.36	1.61	0.83	0.25
275.52 (50%)	199.08	5.39	4.91	2.51	1.67	0.91	0.27
277.77 (60%)	196.32	5.57	5.06	2.57	1.68	0.92	0.28
280.19 (70%)	193.34	5.78	5.24	2.65	1.70	0.92	0.29
283.73 (80%)	188.99	6.20	5.44	2.79	1.71	0.95	0.29
288.88 (90%)	182.66	6.61	5.52	2.73	1.82	0.99	0.32
293.38 (95%)	177.12	7.01	5.57	2.72	1.91	1.01	0.33
303.52 (99%)	164.65	7.93	5.81	2.90	1.88	1.03	0.34

The results show the high sensitivity of downwind spray drift to the speed of the aircraft and correspondingly, the droplet spectra of the spray material. As shown in Figure 9, the higher air speeds, reflected by the actual flight data, in relation to the reported airspeeds of 140 and 165 mph, resulted in greater spray drift.

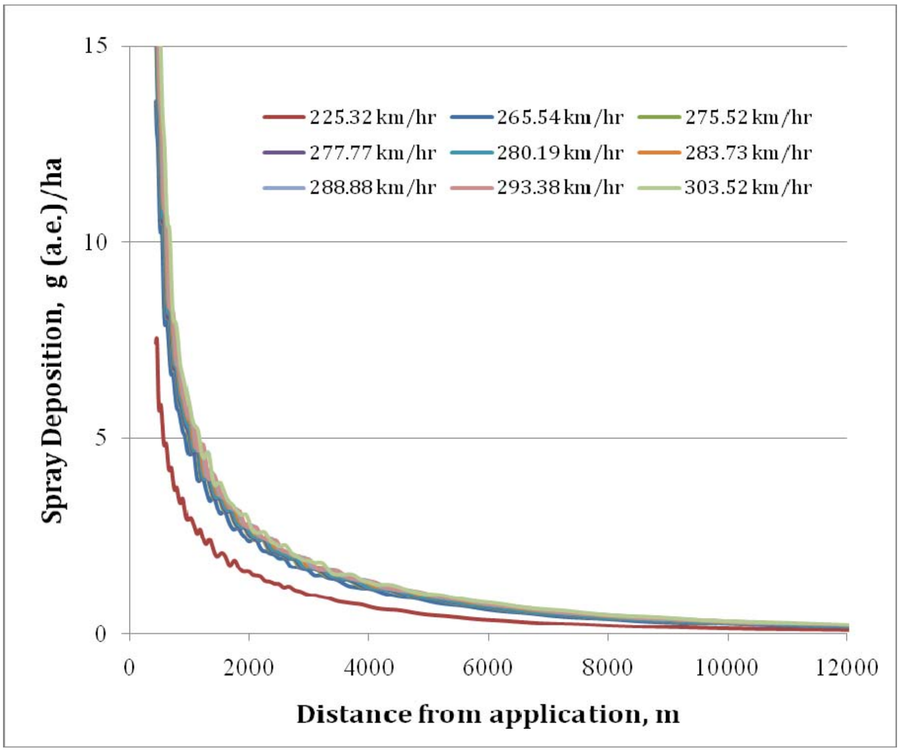


Figure 9. Deposition curves for the AT-802 aircraft demonstrating the sensitivity of spray drift changes in aircraft speed.

8. <u>Effects of Droplet Size</u>

Colombia's EMP states that the permitted droplet size range is 300 to 1,000 microns (Republic of Colombia, 2003). Several other reports indicate that the droplet size is 300 to 1,500 microns (Solomon et al. 2005; Republic of Colombia, 2005). A communication from the Director of Colombia's National Narcotics Commission to the President of the Scientific and Technical Commission of Ecuador on April 14, 2004 stated the average droplet size was 650 microns (Republic of Colombia, 2004). However, as demonstrated by the Hewitt et al. (2009) wind tunnel experiment, these representations significantly overestimate the actual droplet size spectra produced by the spray aircraft. Based on experimental data for aircraft traveling at simulated speeds up to 333 km/hr, Hewitt et al. (2009) reported that the $D_{v0.5}$ (volume median diameter) was 128 microns.

As noted by Hewitt et al., the spray released from the aircraft in Colombia are classified as very fine to fine sprays based on standards established by the American Society of Agricultural and Biological Engineers (i.e., ASABE, formerly ASAE), and accepted by regulatory agencies in many jurisdictions (ASAE, 2009). In contrast, spray droplets with a spectrum of 300-1,000 or 300-1,500 microns, as reported by Colombia, would be classified as larger than extra coarse (the largest size category specified) by the same standards. Figure 10 shows the cumulative size - volume distribution of spray droplets as defined by the ASAE Standard. The droplet size spectrum measured in the wind tunnel by Hewitt, et al. (2009) was smaller than the very fine category in the smaller size portion of the spectrum and classified as fine in the larger portion of the spectrum. Given the importance of the smallest droplets in contributing to spray drift, this reveals that drift estimates based on the Colombian EMP droplet size values would severely under-predict the actual drift.

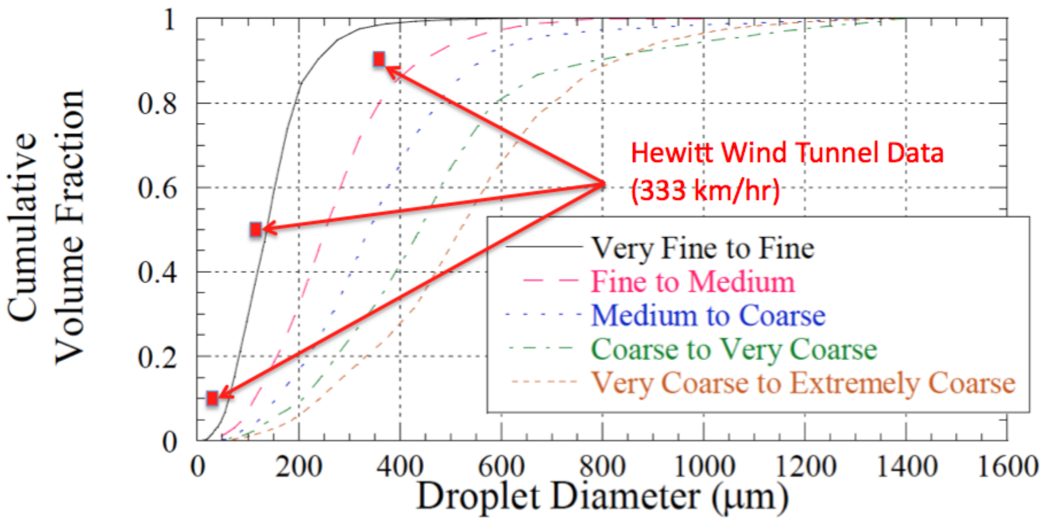


Figure 10. ASABE Standard droplet size distribution classifications (Source: Teske and Curbishley, 2010) shown with $D_{v0.1}$, $D_{v0.5}$ and $D_{v0.9}$ values reported by Hewitt, et al. (2009) for the 333 km/hr air speed.

As discussed in Section 3(e), a decrease in droplet size would be expected to result in an increase in spray drift because the size of the droplet affects its terminal velocity and rate of evaporation. In short, smaller droplets are carried greater distances, resulting in greater spray drift. The very fine to fine droplets resulting from spray operations in Colombia would be expected to be carried significant distances, particularly in cases where other conditions (e.g. application height, wind speed) also favored drift.

9. Effects of Other Spray Application and Model Parameters

As discussed earlier, the spray application process and the associated predictive computations in AGDISP are complex and affected by a number of critical parameters. Accurate modeling of the process requires accurate assumptions about the operational parameters, meteorological conditions, equipment status, and the terrain in the area of application. A sensitivity analysis was conducted for the following parameters: canopy height, spray tank mix application rate, spray tank mix evaporation rate, atmospheric stability, wind speed and relative humidity. This analysis tests the assumptions with respect to these parameters in the Hewitt et al. (2009) spray drift modeling, which are also reflected in the results presented in Sections 5 through 7 of this report.

In all cases, AGDISP was used to model the drift from the AT-802 aircraft, operating at the 50 percentile conditions for altitude (40.61 m) and 50th percentile for speed (275.52 km/hr) and an application rate of 23.65 liters per hectare. All other model parameter values were unchanged, except for the parameter for which sensitivity was being determined.

a. Canopy Height

A key parameter in the spray drift analysis is the height of the canopy of the vegetation underneath the spray application. Taller vegetative cover can reduce spray drift by intercepting the spray droplets sooner and reducing their net vertical travel distance. On the other hand, a lower canopy or a clearing creates more space for the spray droplets to travel vertically, thereby increasing spray drift. The canopy height also affects the wind behavior near the surface and can disrupt the boundary layer of air flow causing spray drift profiles to change. Hewitt et al. (2009) used a canopy height of 25.91 meters, coupled with an aircraft height of 30.48 meters. To determine the sensitivity of spray drift to canopy height, the 25.91 meter canopy height assumed by Hewitt et al. was compared to a canopy height of 4 meters, which reflects of the approximate maximum height of coca plants (Marshall et al., 2009; Collins & Helling, 2002; Ferreira & Reddy, 2000; Ferreira & Smeda, 1997). The results in Table 12 show that the lower canopy height resulted in much greater deposition in the near field (800 m to 1 km) and slightly increased spray deposition further away (2 km to 10 km). Thus, in locations of the Ecuador-Colombia border region where there is a lower canopy, as might be expected in the case of a clearing for coca plants or agriculture, increased spray drift would be expected. The results are depicted graphically in Figure 11.

Table 12. Deposition values for 800 m to 10 km downwind for the AT-802 aircraft operating at two different canopy heights.

Canopy height (m)	Deposition 800 m (g a.e./ha)	Deposition 1 km (g a.e./ha)	Deposition 2 km (g a.e./ha)	Deposition 3 km (g a.e./ha)	Deposition 5 km (g a.e./ha)	Deposition 10 km (g a.e./ha)
25.91	5.39	4.91	2.51	1.67	0.91	0.27
4.00	12.81	8.63	3.67	2.35	1.24	0.37

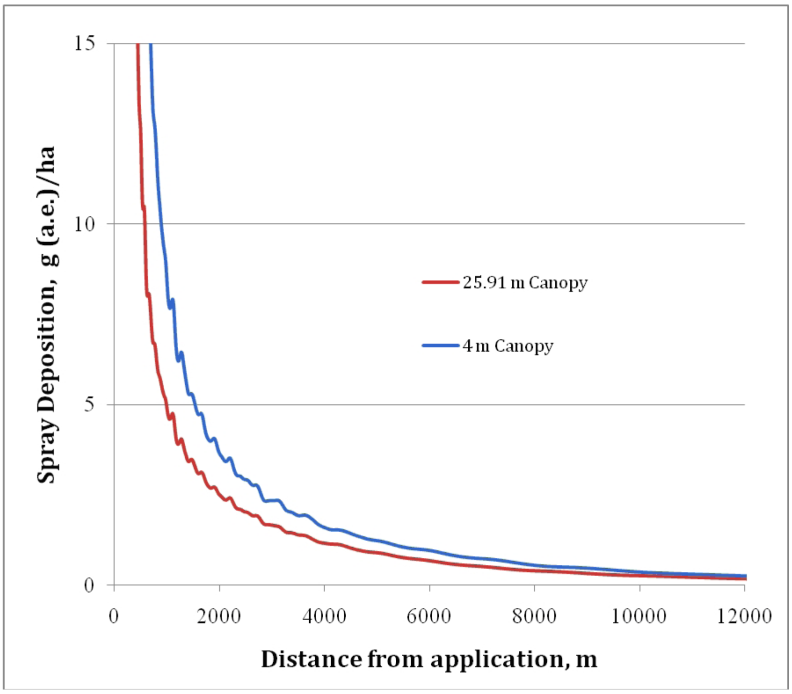


Figure 11. Deposition curves for the AT-802 aircraft operating at two different canopy heights.

b. Application Rate

Application rate has a direct relationship to deposition levels and spray drift. For a given release height, spray droplet size, aircraft configuration, canopy characteristics and meteorological conditions, the greater the amount of the spray tank mixture (active ingredient + carrier + adjuvants) that is released from the spray nozzles at the site of application, the greater the potential for deposition off target.

The application rate used by Hewitt et al. (2009) in their model runs was reported as, "Spray volume rate of 10.4 L/ha (1.11 gallon/acre) total tank mix for coca sprays." This rate is inconsistent with the application rate for the total tank mix of 23.65 L/ha specified by the U.S. Department of State (2002) and in the Colombian EMP (Republic of Colombia, 2003). It is also inconsistent with the application rates recorded in the actual flight data, where application rates sometimes exceeded 23.65 L/ha (Hansman & Mena, 2011). Thus, the 10.4 L/ha application rate reportedly used by Hewitt et al. (2009) is in error. The consequence of using an erroneous 10.4 L/ha rate instead of the correct application rate of 23.65 L/ha would be that the downwind drift deposition estimates published by Hewitt et al. (2009) underestimate drift by a factor of slightly more than 50%, i.e., the values reported by Hewitt et al. would be less than half the actual values.

To determine the sensitivity of spray drift to application rate, the 10.4 L/ha application rate reported by Hewitt et al. (2009) was compared to a range of application rates between 20 and 28 L/ha, including the 23.68 L/ha application rate established in the EMP. The results in Table 13 show that deposition increases proportionally with an increase in application rate. These results also show that when a 10.4 L/ha application rate is used as a drift model input, the deposition is approximately half of the actual values, which are in the range of 23.65 L/ha based on the flight path data. The results are depicted graphically in Figure 12.

Table 13. Deposition values for 800 m to 10 km downwind for the AT-802 aircraft operating at a range of application rates.

Application Rate (L/ha)	Deposition 800 m (g a.e./ha)	Deposition 1 km (g a.e./ha)	Deposition 2 km (g a.e./ha)	Deposition 3 km (g a.e./ha)	Deposition 5 km (g a.e./ha)	Deposition 10 km (g a.e./ha)
10.40 (Hewitt)	2.39	2.14	1.10	0.74	0.40	0.12
20.00	4.55	4.18	2.12	1.41	0.77	0.23
22.00	5.00	4.58	2.34	1.55	0.84	0.26
23.65 (EMP)	5.37	4.91	2.51	1.67	0.91	0.27
24.00	5.45	4.96	2.56	1.69	0.92	0.28
26.00	5.93	5.39	2.75	1.83	0.99	0.31
28.00	6.34	5.78	2.98	1.97	1.07	0.32

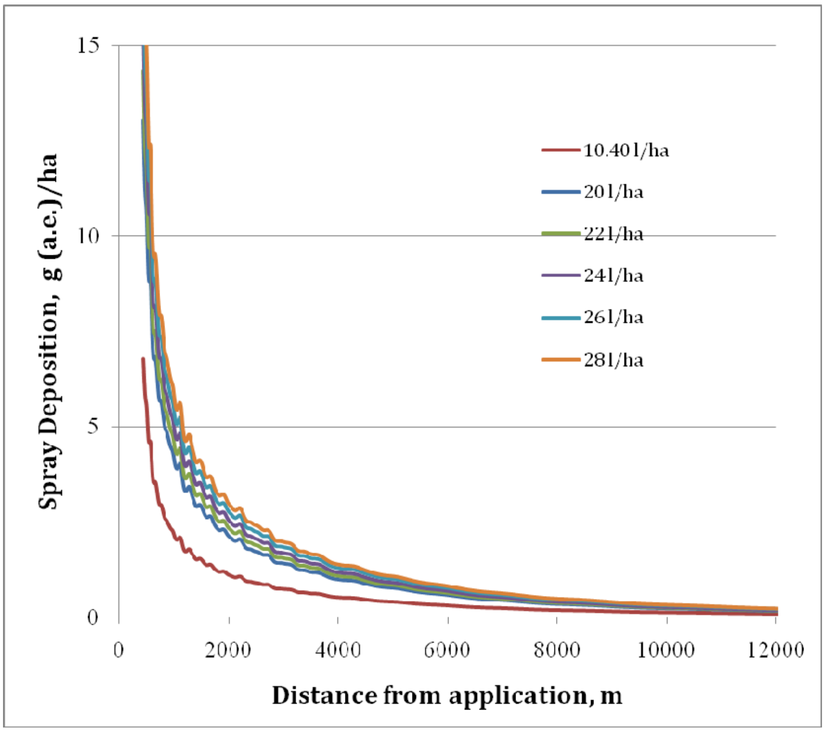


Figure 12. Deposition curves for the AT-802 aircraft operating at a range of application rates.

c. Spray Mix Evaporation

The evaporation rate of the tank mix, coupled with environmental conditions, determines the rate at which the droplet diameter is reduced while in flight. Higher evaporation rates lead to smaller spray droplets with less drag and increased drift potential. Hewitt et al. (2009) used an evaporation rate of 37 μm^2/degC/sec, which was described as "representative of glyphosate products." No additional support was provided for this value. In addition, the effect on evaporation of the adjuvant Cosmo-Flux 411F is unknown.

To determine the sensitivity of the spray drift to evaporation rate, the assumed value of 37 μm^2/degC/sec was compared with the limiting conditions of 84 μm^2/degC/sec (the evaporation rate for pure water), and no evaporation, i.e., 0 μm^2/degC/sec. The results in Table 14 show that higher evaporation rates result in modest increases in deposition rates in the near field (800 m to 1 km). Overall, evaporation rate has a minor effect on spray deposition values under the specific application conditions of this spray situation, however evaporation would be expected to produce more concentrated spray droplets. The results are shown graphically in Figure 13.

Table 14. Deposition values for 800 m to 10 km downwind for the AT-802 aircraft operating at a range of spray mix evaporation rates.

Evaporation Rate (µm2/C/sec)	Deposition 800 m (g a.e./ha)	Deposition 1 km (g a.e./ha)	Deposition 2 km (g a.e./ha)	Deposition 3 km (g a.e./ha)	Deposition 5 km (g a.e./ha)	Deposition 10 km (g a.e./ha)
0 (none)	5.03	4.01	2.12	1.48	0.84	0.36
37 (Hewitt)	5.39	4.91	2.51	1.67	0.91	0.36
84 (water)	5.78	5.18	2.37	1.51	0.78	0.33

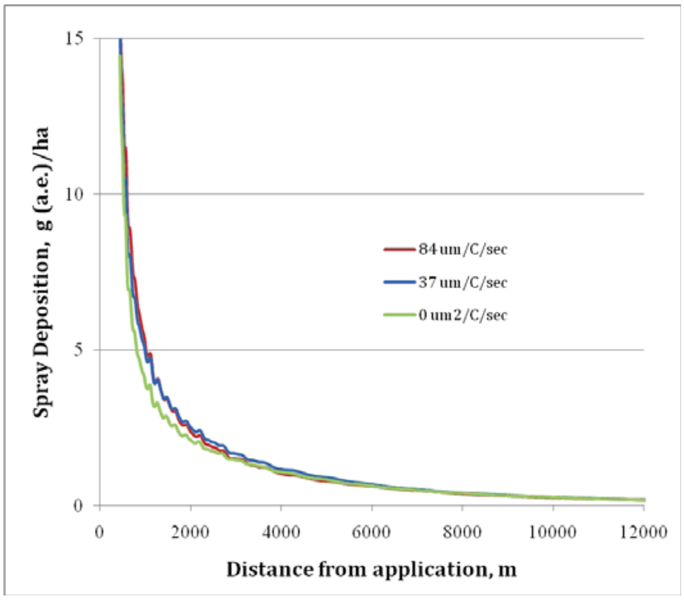


Figure 13. Deposition curves for the AT-802 aircraft operating at a range of spray mix evaporation rates.

d. Atmospheric Stability

The atmospheric stability of the ambient environment into which the spray is released is an important determinant of spray drift. Atmospheric stability is most simply described as the degree of vertical movement of air in the atmosphere near the surface of the ground. When stability is high, vertical mixing is inhibited and small spray droplets do not disperse into the atmosphere as easily as when stability is low, i.e., "unstable" conditions. Stable conditions often generate localized concentrations of droplets in air "packets" that can move in unpredictable ways as compared to more random dispersion of the spray droplets which occurs under unstable atmospheric conditions. Stable atmospheric conditions are most common during the nighttime and unstable atmospheric conditions are more common during the daytime when the ground surface is heating or cooling, causing corresponding vertical air movement.

AGDISP allows the user to specify atmospheric stability conditions. Hewitt et al. (2009) used an atmospheric stability defined as "weak", i.e. unstable atmospheric conditions. To determine the sensitivity of the spray drift to atmospheric stability, weak and strong (i.e. stable) atmospheric stability conditions were modeled. The results in Table 15 show that, for the application conditions for this spray situation, the atmospheric stability has a significant effect on spray deposition values, particularly at downwind distances of 2 km and beyond where deposition rates under strong atmospheric stability conditions are more than double or triple the deposition rates under weak atmospheric stability conditions. The higher drift levels are expected with the strong atmospheric stability due to the lack of random dispersion of the smaller drift prone spray droplets. As show in Figure 14, strong atmospheric stability conditions can lead to atypical spray drift deposition patterns when compared with normal, recommended spraying conditions. Areas of highly concentrated spray drift deposition can occur.

Table 15. Deposition values for 800 m to 10 km downwind for the AT-802 aircraft operating under weak and strong atmospheric stability conditions.

Atmospheric Stability	Deposition 800 m (g a.e./ha)	Deposition 1 km (g a.e./ha)	Deposition 2 km (g a.e./ha)	Deposition 3 km (g a.e./ha)	Deposition 5 km (g a.e./ha)	Deposition 10 km (g a.e./ha)
Weak	5.39	4.91	2.51	1.67	0.91	0.27
Strong	7.06	0.41	6.94	9.26	3.79	1.04

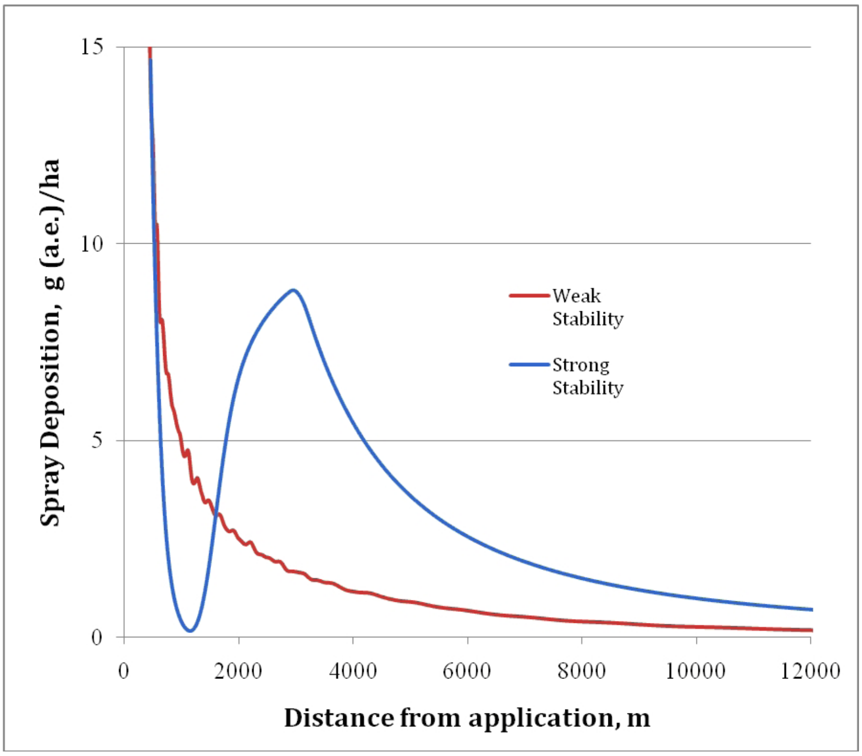


Figure 14. Deposition curves for the AT-802 aircraft operating under weak and strong atmospheric stability conditions.

e. Wind Speed

A critical parameter in the spray drift analysis is the ambient wind speed. While the aerodynamic disturbance of the aircraft is important to spray droplet movement near the point of release, the ambient wind supplies the motive force to displace the droplets away from the application target area. Hewitt et al. (2009) used a wind speed of 2.57 m/s (5 knots) which corresponds to the maximum wind speed in the EMP. However, a range of wind speeds would be expected in the context of more than 100,000 flights conducted within 10 kilometers of Ecuador's border (Hansman & Mena, 2011). To determine the sensitivity of the spray drift to wind speed, the following values were modeled: 2.57 m/s (wind speed assumed by Hewitt et al. (2009) and EMP); 1.28 m/s (half of the assumed wind speed) and 5.14 m/s (twice the assumed wind speed). The results in Table 16 show the high sensitivity of spray drift to wind speed. In particular, if the wind speed is twice as high as was assumed by Hewitt et al. (2009) and as was required in the EMP, the level of deposition increases by a factor of 1.5 to 3.3, depending on the distance from the application site. The flight data evaluated by Hansman & Mena (2011) does not contain meteorological information. Therefore, the actual wind speed during spray operations in Colombia is a significant uncertainty in the spray drift modeling analysis. The results are depicted graphically in Figure 15.

Table 16. Deposition values for 800 m to 10 km downwind for the AT-802 aircraft operating at wind speeds from 1.28 to 5.14 m/s.

Wind Speed	Deposition	Deposition	Deposition	Deposition	Deposition	Deposition
	800 m	1 km	2 km	3 km	5 km	10 km
(m/s)	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)
1.28 (1/2X)	2.08	3.41	1.52	0.86	0.34	0.09
2.57 (Hewitt / EMP)	5.39	4.91	2.51	1.67	0.91	0.27
5.14 (2X)	11.66	9.37	3.77	2.99	2.39	0.88

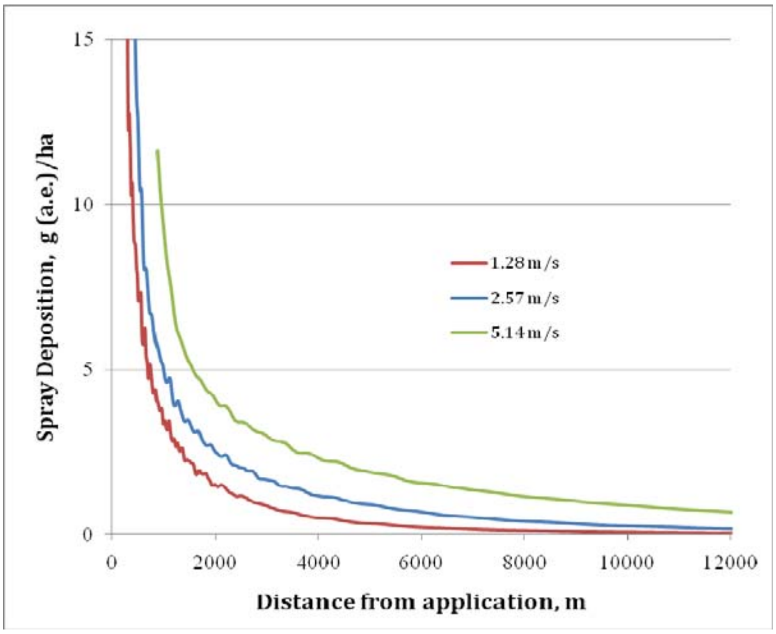


Figure 15. Deposition curves for the AT-802 aircraft operating at wind speeds from 1.28 to 5.14 m/s.

f. *Relative Humidity*

Ambient relative humidity, coupled with the evaporation rate of the tank mix, determines the rate at which the droplet diameter is reduced while in flight. Smaller droplets have less drag and greater drift potential. Hewitt et al. (2009) used a relative humidity of 70% and evaluated the effect of an increase in relative humidity, indicating that the tropical conditions in Colombia could experience higher relative humidity values, up to 90%. To determine the sensitivity of the spray drift to relative humidity, 70% and 90% relative humidity values were modeled. The results in Table 17 show that, for the application conditions for this spray situation, the relative humidity has a minor effect on spray deposition values in the far field (1 to 10 km) as compared to other variables. The increase in relative humidity from 70% to 90% has a very limited effect on spray drift deposition from the high release height conditions of the 50th percentile flight data. The results are depicted graphically in Figure 16.

Table 17. Deposition values for 800 m to 10 km downwind for the AT-802 aircraft operating at relative humidities of 70 and 90%.

Relative Humidity %	Deposition 800 m (g a.e./ha)	Deposition 1 km (g a.e./ha)	Deposition 2 km (g a.e./ha)	Deposition 3 km (g a.e./ha)	Deposition 5 km (g a.e./ha)	Deposition 10 km (g a.e./ha)
70%	5.39	4.91	2.51	1.67	0.91	0.27
90%	5.07	4.21	2.27	1.56	0.89	0.28

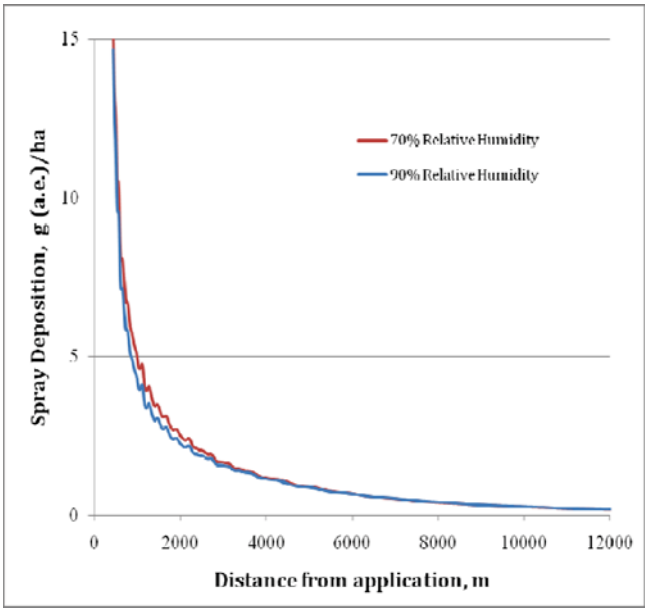


Figure 16. Deposition curves for the AT-802 aircraft operating at relative humidities of 70 and 90%.

10. Illustrative Example Application Scenarios

The analysis of Colombian spray operations in this report was based on over 100,000 flight records describing flights operating at varying operational parameters, over varying vegetative terrain and under varying meteorological conditions. Given the scale and extent of the operation, AGDISP, or any other modeling, can be performed on only a limited number of flights representing the operation. While the flight data (Hansman and Mena, 2011) provide reliable and extensive data on aircraft speed, altitude, application rate, plane type, time of day and certain other factors, data on the actual meteorological and terrain conditions are more limited. In addition, no one of these factors operates in isolation. The purpose of the sensitivity analyses presented in Sections 6, 7 and 9 was to isolate an individual factor and evaluate its effect on spray drift. However, under actual conditions of application, these factors operate together to influence the total amount of spray deposition. It is therefore useful to consider example spray events for several combinations of conditions not previously analyzed in this report.

a. AT-802 Aircraft Spraying Near Low Vegetation With Strong Wind

The first illustrative scenario considers the AT-802 aircraft operating at the 50th percentile condition for altitude (40.6 m), 50th percentile for speed (275.52 km/h) and applying the required application rate of 23.65 L/ha. It further assumes that the aircraft is flying over a typical coca planting with vegetation 4 meters in height and is subject to wind blowing at 5.14 m/s (10 knots, which is 2 times the wind speed assumed by Hewitt et al.). All other conditions are consistent with those used in the analysis by Hewitt et al. (2009).

The results of AGDISP modeling for this illustrative scenario as compared to an AT-802 aircraft traveling at the 50th percentile altitude, 50th percentile speed and the Hewitt et al. (2009) assumptions for canopy height (25.91 m) and wind speed (2.57 m/s, or 5 knots) are shown in Table 18.

Table 18. Deposition values for 800 m to 10 km downwind for illustrative scenarios with the AT-802 aircraft.

Condition	Deposition 800 m (g a.e./ha)	Deposition 1 km (g a.e./ha)	Deposition 2 km (g a.e./ha)	Deposition 3 km (g a.e./ha)	Deposition 5 km (g a.e./ha)	Deposition 10 km (g a.e./ha)
AT-802, 25.91 m canopy, 2.57 m/s wind	5.39	4.91	2.51	1.67	0.91	0.27
AT-802, 4 m canopy, 5.14 m/s wind	12.01	8.63	2.86	1.85	1.08	0.47

As can be seen in Figure 17, the lower canopy height and increase in wind speed contribute to significantly higher deposition levels across the range of deposition distances as compared to the same flight using the assumptions for canopy height and wind speed made by Hewitt et al.

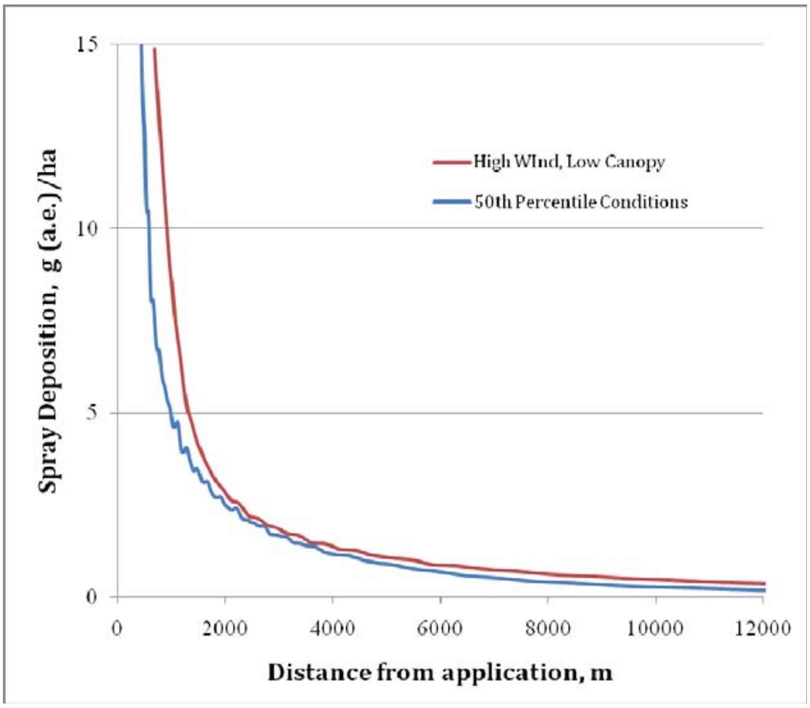


Figure 17. Downwind spray deposition in the far-field, predicted by the Gaussian extension for the scenarios described in Table 18.

b. OV-10 Aircraft Spraying at Increased Height and Speed With Strong Wind

The second illustrative scenario considers the OV-10 aircraft operating at the 95th percentile condition for altitude (59.54 m) and 70th percentile condition for speed (338.51 km/h) and the required application rate of 23.65 L/ha. It further assumes that the aircraft is subject to wind blowing at 5.14 m/s (10 knots). All of the other parameters are consistent with the inputs assumed by Hewitt et al. (2009), including the assumption of a 25.91 m canopy.

The results of AGDISP modeling for this illustrative scenario as compared to an OV-10 aircraft traveling at the 50th percentile for altitude (42.56 m) and 50th percentile for speed (333.94 km/hr), with the Hewitt et al. assumption for wind speed (2.57 m/s, or 5 knots) are shown in Table 19.

Table 19. Deposition values for 800 m to 10 km downwind for illustrative scenarios with the OV-10 aircraft.

Condition	Deposition	Deposition	Deposition	Deposition	Deposition	Deposition
	800 m	1 km	2 km	3 km	5 km	10 km
	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)
OV-10, 50% altitude, 50% speed, 2.57 m/s wind	9.93	5.05	2.24	1.42	0.82	0.31
OV-10, 95% altitude, 70% speed, 5.14 m/s wind	18.02	13.29	4.83	2.97	1.66	0.76

As can be seen in Figure 18, the increase in altitude, aircraft speed and wind speed contribute to significantly higher deposition levels across the range of deposition distances as compared to the OV-10 aircraft flown at 50th percentile altitude and 50th percentile speed, and the assumptions for wind speed made by Hewitt et al.

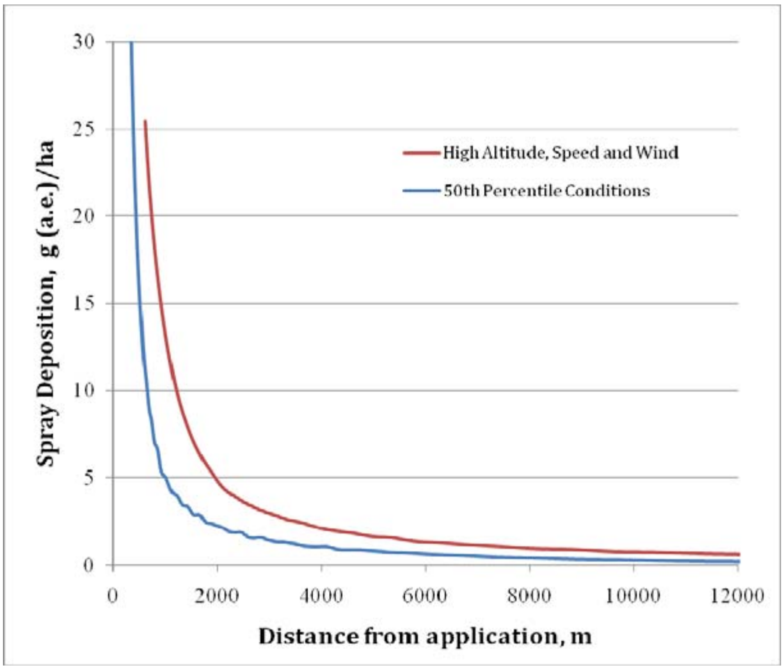


Figure 18. Downwind spray deposition in the far-field, predicted by the Gaussian extension for the scenarios described in Table 19.

These illustrative scenarios show that a combination of factors can interact to result in greater spray drift and deposition. Because there is incomplete data regarding meteorological conditions such as wind speed and terrain conditions such as canopy height at specific spray locations, there is greater uncertainty about the amount of spray drift deposited off-target under actual conditions of application in Colombia. With more than 100,000 spray events within 10 kilometers of the Ecuador-Colombia border (Hansman & Mena, 2011), each subject to a unique set of operational meteorological conditions, and operated over slightly different terrain, any number of actual spray drift scenarios are possible. The results presented in this report are approximations based on the best data available; they do not represent the entire universe of scenarios.

11. Effect of Multiple Spray Lines

Aerial applications of pesticides often involve a sequential series of parallel spray passes to cover a target area. Much like mowing a lawn, each pass covers a "swath" of the target area and multiple passes are required to cover the targeted area. Logistically, the most efficient use of resources (time, fuel, labor, equipment) is achieved when aircraft remain operational in a local area until all desired areas to be treated have been completed. In typical aerial spraying operations, these sequential passes are usually conducted by one or more spray planes within a span of a number of hours. Each spray pass provides an overlapping pattern and produces a relatively uniform application rate across the field. Figure 19 shows a representation of this process. Four spray passes are represented by the aircraft (flying "out of the page") at ~ 50 ft spacings across the field.

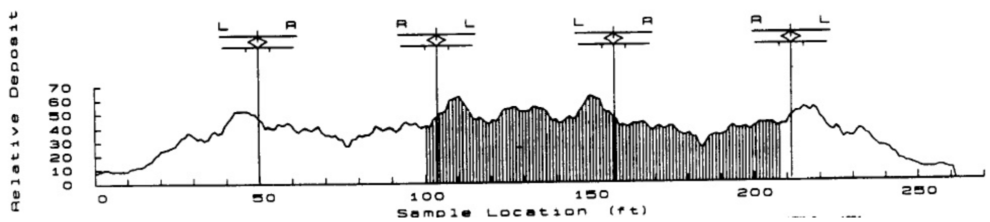


Figure 19. A series of parallel spray passes made to treat a target area; taken from Gardisser and Kulhman (undated).

The analysis by Hewitt et al. (2009) considered only a single spray pass, reporting a model input of "One flight line (i.e., single swath applications as used operationally in Colombia)." However, the flight data records document the routine occurrence of multiple, up to dozens, of parallel flights within a single square kilometer (Hansman and Mena, 2011). As discussed in Section 3(g), downwind spray drift and resulting biological effects accumulate with the incremental drift from each spray pass. Therefore, this analysis evaluates the effect of multiple applications by superposition of multiple spray passes; the spacing between passes was set at 51.8 m for the AT-802 and OV-10 aircraft based on the actual flight data (Hansman and Mena, 2011).

With each spray pass being distinct both temporally and spatially, they can be considered independent events and the resulting spray deposition down wind can be calculated as the sum of the spray deposition from each event. Therefore, the AGDISP calculation can be run for a single spray pass and the results summed, after a linear displacement of each pass equal to the spacing between spray passes. The cumulative effect of 1-10 spray passes on near-field spray deposition is shown in Figure 20.

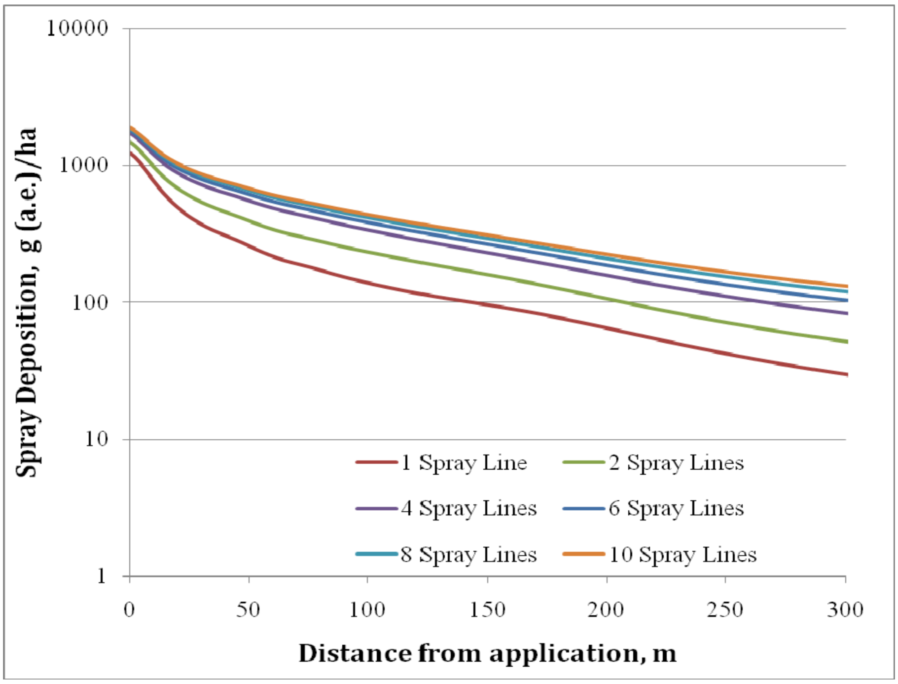


Figure 20. Cumulative downwind spray deposition in the near field (<300 m) from 1 – 10 spray passes.

Cumulative deposition in the far-field (beyond 300 meters) was calculated using Gaussian far-field deposition data from 6 different model runs. As described above, the AGDISP calculation was run for a single spray pass and the results summed, after a linear displacement of each pass equal to the spacing between spray passes. This method was used to calculate the far-field deposition at 800 meters and 1, 2, 3, 5 and 10 km down wind from the point of application (defined as the location of the first spray line). The results for an AT-802 aircraft, operating at 50^{th} percentile height and 50^{th} percentile speed based on the flight path data, an application rate of 23.65 L/ha, and all other parameters as assumed by Hewitt et al. (2009) are shown in Table 20.

Table 20. Deposition values showing the cumulative effect from multiple spray lines for an AT-802 aircraft operating at 50th percentile altitude and 50th percentile speed, 23.65 L/ha application rate; all other input parameters as assumed by Hewitt et al. (2009).

Pass	Deposition	Deposition	Deposition	Deposition	Deposition	Deposition
	800 m	1 km	2 km	3 km	5 km	10 km
(# of spray lines)	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)
1	6.29	4.91	2.51	1.67	0.91	0.27
2	12.08	9.51	4.95	3.32	1.81	0.54
3	17.55	14.27	7.32	4.96	2.69	0.81
4	22.76	18.62	9.71	6.57	3.56	1.08
5	27.57	22.53	12.13	8.12	4.41	1.34
6	32.18	26.55	14.42	9.60	5.24	1.60
7	36.91	30.43	16.58	11.06	6.06	1.86
8	41.06	34.03	18.69	12.51	6.86	2.12
9	44.97	37.46	20.79	13.95	7.65	2.38
10	49.02	40.95	22.84	15.37	8.43	2.64

As can be seen in Figure 21, the displacement distance between each spray pass serves to attenuate the additive effect of each spray pass at closer distances (i.e. each spray pass contributes a bit less to the total deposition because it originates further away from the point of measurement). Therefore, the cumulative effect is not quite linear. Conversely, at far-field distances, the down wind distances are large in relation to the spacing between spray passes, and the cumulative effect becomes increasingly linear, i.e. two spray passes result in approximately twice the amount of deposition as a single spray pass, three spray passes result in approximately three times the amount of deposition, etc.

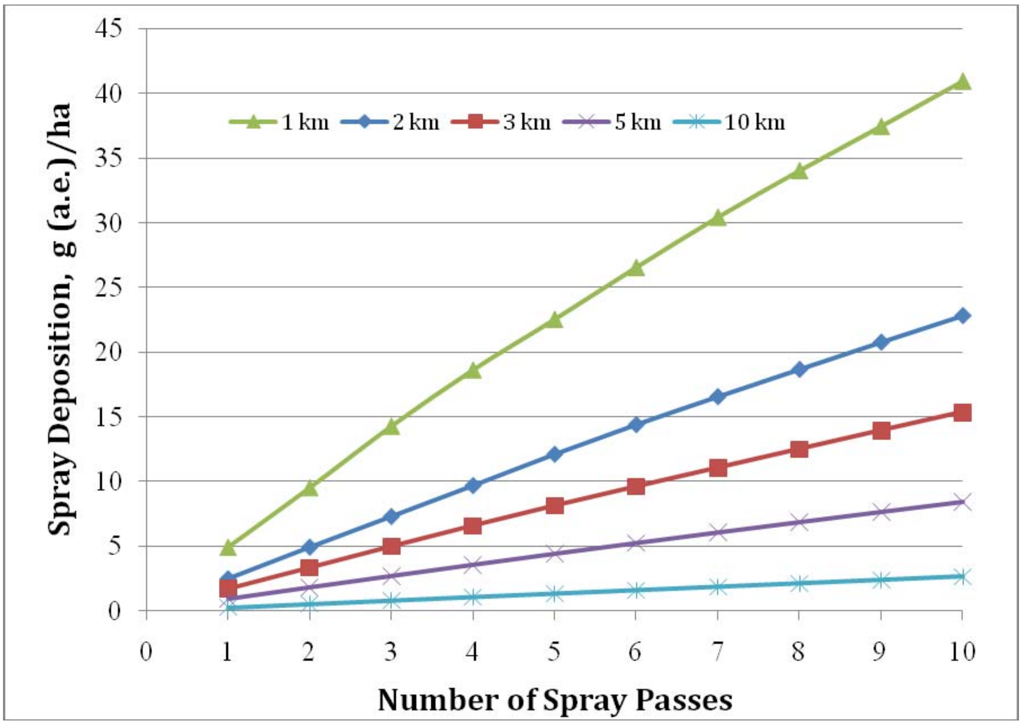


Figure 21. Downwind spray deposition in the far-field at 1, 2, 3, 5 and 10 km as a function of the number of spray passes from an AT-802 aircraft operating under conditions described in Table 20.

The cumulative effect of 1-10 spray passes on far-field spray deposition for five additional model runs is shown in Tables 21 through 25.

Table 21. Deposition values showing the cumulative effect from multiple spray lines for an AT-802 aircraft operating at 90th percentile altitude and 90th percentile speed, 23.65 L/ha application rate; all other input parameters as assumed by Hewitt et al. (2009).

Pass	Deposition	Deposition	Deposition	Deposition	Deposition	Deposition
	800 m	1 km	2 km	3 km	5 km	10 km
(# of spray lines)	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)
1	14.80	11.99	5.67	3.84	1.94	0.66
2	28.68	23.65	11.27	7.60	3.85	1.32
3	42.01	34.75	16.87	11.10	5.74	1.97
4	54.54	44.94	22.44	14.41	7.59	2.61
5	66.43	55.09	27.69	17.63	9.40	3.24
6	78.05	65.18	32.72	20.83	11.19	3.87
7	88.85	74.18	37.64	24.02	12.95	4.50
8	98.91	82.69	42.47	27.21	14.68	5.12
9	109.16	91.39	47.32	30.40	16.39	5.73
10	119.08	99.79	52.17	33.59	18.08	6.34

Table 22. Deposition values showing the cumulative effect from multiple spray lines for an AT-802 aircraft operating at 50th percentile altitude and 50th percentile speed, 23.65 L/ha application rate, canopy height of 4 m, wind speed of 5.14 m/s; all other input parameters as assumed by Hewitt et al. (2009).

Pass	Deposition	Deposition	Deposition	Deposition	Deposition	Deposition
	800 m	1 km	2 km	3 km	5 km	10 km
(# of spray lines)	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)
1	12.56	8.63	2.86	1.85	1.08	0.47
2	23.82	16.53	5.60	3.65	2.15	0.94
3	34.12	23.71	8.24	5.40	3.21	1.41
4	43.42	30.39	10.83	7.12	4.26	1.87
5	51.92	36.45	13.41	8.83	5.30	2.33
6	59.65	41.89	15.96	10.53	6.34	2.79
7	66.69	46.96	18.42	12.22	7.37	3.24
8	73.20	51.78	20.76	13.88	8.39	3.69
9	79.10	56.34	23.00	15.51	9.41	4.14
10	84.46	60.63	25.18	17.10	10.42	4.59

Table 23. Deposition values showing the cumulative effect from multiple spray lines for an OV-10 aircraft operating at 50th percentile altitude and 50th percentile speed, 23.65 L/ha application rate; all other input parameters as assumed by Hewitt et al. (2009).

Pass	Deposition	Deposition	Deposition	Deposition	Deposition	Deposition
	800 m	1 km	2 km	3 km	5 km	10 km
(# of spray lines)	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)
1	6.90	5.05	2.24	1.42	0.82	0.31
2	13.35	9.73	4.44	3.07	1.63	0.61
3	18.81	14.02	6.58	4.71	2.42	0.91
4	23.98	18.15	8.63	6.32	3.20	1.21
5	28.97	22.16	10.60	7.87	3.97	1.50
6	33.54	25.92	12.52	9.35	4.72	1.79
7	37.79	29.44	14.43	10.81	5.46	2.08
8	41.89	32.87	16.34	12.26	6.20	2.37
9	45.85	36.26	18.25	13.70	6.94	2.65
10	49.53	39.45	20.08	15.12	7.67	2.93

Table 24. Deposition values showing the cumulative effect from multiple spray lines for an OV-10 aircraft operating at 90th percentile altitude and 90th percentile speed, 23.65 L/ha application rate; all other input parameters as assumed by Hewitt et al. (2009).

Pass	Deposition	Deposition	Deposition	Deposition	Deposition	Deposition
	800 m	1 km	2 km	3 km	5 km	10 km
(# of spray lines)	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)
1	18.20	13.56	5.02	2.82	1.48	0.71
2	34.95	25.69	9.73	5.50	2.93	1.40
3	50.04	36.70	14.21	8.05	4.35	2.09
4	64.03	47.16	18.56	10.58	5.76	2.77
5	77.29	57.22	22.81	13.11	7.16	3.45
6	89.17	66.63	26.98	15.67	8.55	4.12
7	99.87	75.44	31.06	18.25	9.95	4.79
8	110.22	83.71	35.05	20.80	11.35	5.45
9	120.12	91.73	38.96	23.29	12.75	6.10
10	129.35	99.42	42.77	25.74	14.15	6.75

Table 25. Deposition values showing the cumulative effect from multiple spray lines for an OV-10 aircraft operating at 95th percentile altitude, 70th percentile speed, 23.65 L/ha application rate, wind speed of 5.14 m/s; all other input parameters as assumed by Hewitt et al. (2009).

Pass	Deposition	Deposition	Deposition	Deposition	Deposition	Deposition
	800 m	1 km	2 km	3 km	5 km	10 km
(# of spray lines)	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)	(g a.e./ha)
1	18.01	13.29	4.83	2.97	1.66	0.76
2	34.43	25.66	9.47	5.90	3.30	1.52
3	49.68	37.19	13.95	8.78	4.93	2.27
4	63.81	47.97	18.29	11.61	6.56	3.02
5	76.89	58.05	22.50	14.38	8.18	3.77
6	89.06	67.53	26.61	17.09	9.79	4.52
7	100.41	76.48	30.60	19.75	11.38	5.27
8	111.04	84.97	34.51	22.35	12.96	6.02
9	120.96	93.02	38.31	24.92	14.51	6.76
10	130.28	100.64	42.03	27.46	16.05	7.50

The effect of multiple spray lines can also be calculated using a curve fitted to the Gaussian far-field deposition data (e.g., Figure 22), which facilitates calculations for many spray lines. Figure 21 shows the relationship between the fitted curve and the AGDISP results for the AT-802 aircraft using 50th percentile value from the flight path data for aircraft height and the 50th percentile value for speed, 23.65 L/ha for application rate, and the remainder of the input parameters as reported by Hewitt et al. (2009). Quantitatively, the relationship shows an extremely high correlation with the r^2 value being 0.9827, or approximately a 98.27% accuracy of fit.

Annex 2

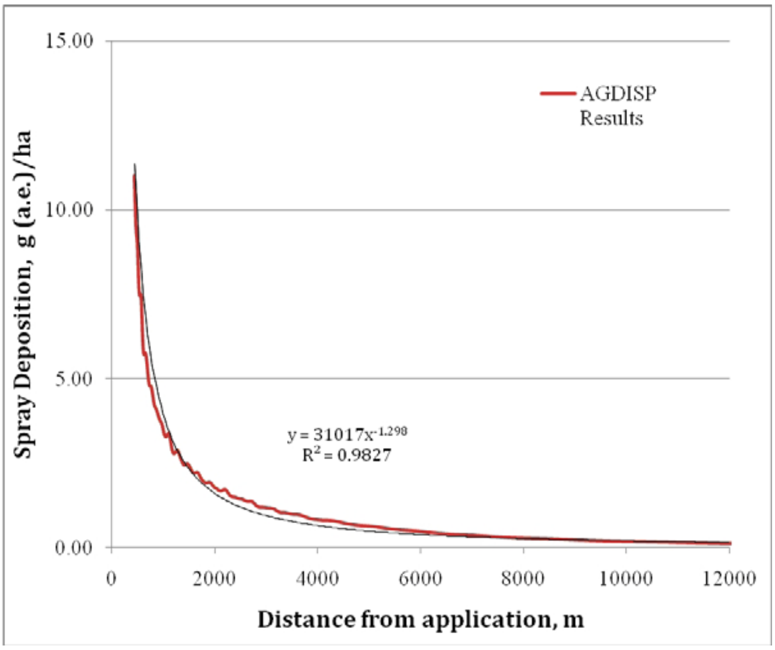


Figure 22. Downwind spray deposition in the far-field, predicted by the Gaussian extension shown with a least-squares fitted equation.

Using this fitted curve, superposition of the individual flight lines, adjusted for the spacing between them, can be used to calculate total deposition. The cumulative effect of 1 - 20 spray passes on far-field spray deposition is shown below in Figure 23.

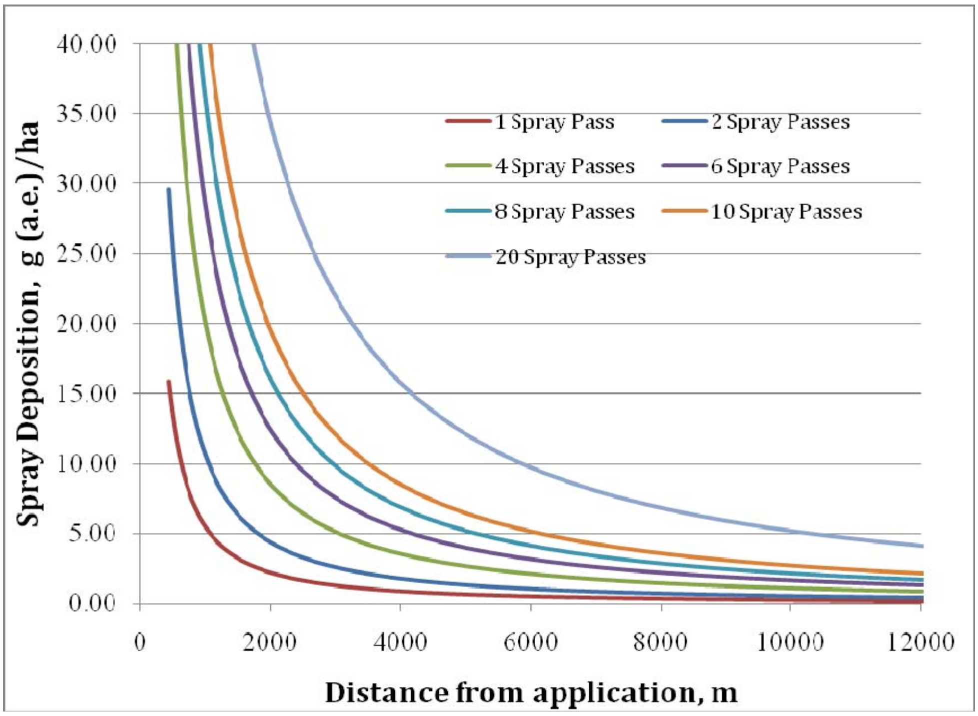


Figure 23. Cumulative downwind spray deposition in the far-field, from 1 – 20 spray passes.

12. Additional Factors that Exacerbate Spray Drift

Many of the contributing factors for spray drift, e.g., aircraft height, aircraft speed, droplet size spectra, wind speed, etc., have been addressed in previous sections of this report. There are, however, additional factors that can affect spray drift that are difficult to quantify with modeling.

a. Nozzle Choice and Damage

The spray nozzles used in the Colombian spray operations and tested by Hewitt et al. (2009) were Accu-Flo™ nozzles marketed by Bishop Equipment Mfg., Inc. of Hatfield, Pennsylvania, in the United States. The nozzles are constructed of concentric rings of hypodermic tubing or "needles," as shown in Figure 24(a). The needles have a long length-to-diameter ratio and are easily damaged in field operations (e.g., tank mix loading and other ground operations) as shown in Figure 24(b). When the nozzles are damaged, the discharge of the liquid streams is disrupted from the normal, desired condition of being co-axial with the airflow past the nozzle. This increased angle results in greater shear forces between the liquid stream and the high-speed air and subsequently, smaller droplet sizes of the spray. Also, misalignment of the spray nozzle needles can result in liquid streams colliding instead of remaining distinct; this further disruption also decreases the droplets sizes. In contrast, the nozzles used in the Hewitt et al. (2009) wind tunnel experiments were unlikely to be damaged or misaligned because they are not exposed to field conditions.

Furthermore, the needle-type nozzles used in the Colombian spraying operations appear to provide no inherent operational advantage over more common, robust, simpler and lower cost agricultural nozzles (i.e. D10 nozzles). Hewitt et al. (2009) stated that:

> "The study included assessments of alternative application systems to the Accu-Flo nozzles currently in use. Accu-Flo nozzles are effective at increasing droplet size for spray applications by rotary wing (helicopter) aircraft, but with their relatively small orifice diameter are less effective at very high aircraft speeds. Large orifice solid stream nozzles such as the D10 (named for its 10/64 in [4 mm] diameter orifice) provide a viable alternative, especially if used at high spray pressures to increase the spray breakup length. At the same spray pressure (2.4 bar), this nozzle increased the *D*v0.5 at 333 km/h from 139 to 168 µm, with a proportional approximate 15% decrease in droplets <150 µm relative to the Accu-Flo nozzle."

(a)

(b)

Figure 24. Accu-Flo™ spray nozzles of the type used in the Colombian spray operations: (a) a nozzle in proper operating condition; (b) a nozzle showing typical damage from field operations. (Source: Bishop Equipment Mfg., Inc.)

b. Atmospheric Stability and Inversion Conditions

The EMP for the spraying operations (Republic of Colombia, 2003) specified a maximum wind speed of 5 knots (2.57 m/s) and a maximum temperature of 35º C for coca spraying. While these conditions are intended for mitigation of evaporation and cross wind driven drift, it is notable that there are not more precise requirements regarding meteorological situations that are consistent with stable atmospheric conditions in the EMP. In particular, there is no limitation on minimum wind speed and only a “recommendation” not to spray when “there is evidence of the phenomenon of inverse currents or clouds near the ground.” (Republic of Colombia, 2003). In addition, the altitude of the inversion with respect to the spraying operations is an important determinant of spray drift; however, Colombia has not reported data on the height of inversions in the border region with Ecuador. As discussed by Hansman & Mena (2011), the absence of meteorological data precludes the validation of compliance with the meteorological parameters in the EMP.

As detailed earlier in the discussion on atmospheric stability, spraying in stable atmospheric conditions, characterized by calm winds and limited vertical mixing and more common during nighttime hours, can result in unpredictable, long range and damaging levels of spray drift. Label language for glyphosate products commonly includes instructions prohibiting application at low wind speeds. For example, the Round Up Pro™ label includes the following application instructions:

Wind

Drift potential is lowest between wind speeds of 2 to 10 miles per hour. However, many factors, including droplet size and equipment type determine drift potential at any given speed. Application should be avoided below 2 miles per hour due to variable wind direction and high inversion potential. **NOTE**: Local terrain can influence wind patterns. Every applicator should be familiar with local wind patterns and how they affect drift.

An extremely undesirable meteorological condition in terms of increasing the risk of significant spray drift is when there is a temperature inversion and associated light and variable wind. In a temperature inversion, vertical dispersion of small spray droplets is inhibited because they remain trapped between layers of air. Thus, spray droplets can remain aloft and often become highly concentrated in relatively small packets or layers of air (Figure 25). During the inversion or as the inversion weakens, the wind can easily displace these high concentrations of suspended small droplets over significant distances and in concentrations greatly exceeding those typical of normal, cross wind driven drift.

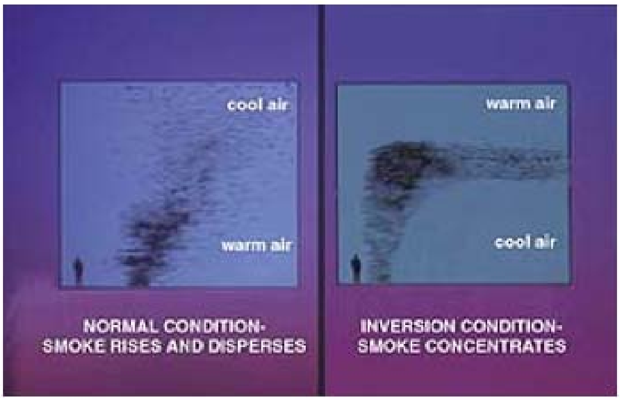


Figure 25. Effects of atmospheric stability on spray application and drift (adapted from Ozkan, 2000).

Label language for glyphosate products commonly includes instructions prohibiting applications during temperature inversions. For example, the Round Up Pro™ label includes the following application instructions:

> **Temperature Inversions**
> Applications should not occur during a temperature inversion because drift potential is high. Temperature inversions restrict vertical air mixing, which causes small suspended droplets to remain in a concentrated cloud. This cloud can move in unpredictable directions due to the light variable winds common during inversions. Temperature inversions are characterized by increasing temperatures with altitude and are common on nights with limited cloud cover and light to no wind. They begin to form as the sun sets and often continue into the morning. Their presence can be indicated by ground fog; however, if fog is not present, inversions can also be identified by the movement of smoke from a ground source or an aircraft smoke generator. Smoke that layers and moves laterally in a concentrated cloud (under low wind conditions) indicates an inversion, while smoke that moves upward and rapidly dissipates indicates good vertical air mixing.

13. Colombia's Spray Drift Studies

A review of the scientific and technical documents associated with Colombia's aerial spraying program reveals that there appear to have been at least three analyses addressing spray drift prior to the Hewitt et al. (2009) study.

a. AgDrift Model Runs – 2002

The first analysis was conducted by the United States Environmental Protection Agency in 2002 at the request of the United States Department of State (U.S. EPA, 2002). The study used AgDrift, a functionally equivalent model to AGDISP, to predict spray deposition up to 300 m downwind. The study concluded that the "highest levels of drift" are bounded by estimates based on model runs with droplet size distributions for "medium sprays" at wind speeds of 10 mph (4.47 m/s, or 8.7 knots). The study also stated that "non-target plants hundreds of feet away may be exposed to a fraction of this glyphosate application" and noted a number of "general uncertainties" with spray drift modeling and with the input parameters used.

The modeling assumed two representative spray droplet size spectra: 1) an ASAE standard "Very Coarse to Extremely Coarse" spectrum and, 2) an ASAE standard "Medium" spectrum. The study noted that, "specific data on droplet size under application conditions was (*sic*) not provided…" and "it is unlikely that very coarse sprays would be achievable due to shearing effects of releasing droplets at high speeds." (U.S. EPA, 2002). The cautionary note on the droplet size assumptions is particularly notable in light of the subsequent publication of more specific droplet size data by Hewitt et al. (2009). For example, the droplet size specta measured by Hewitt et al. (2009) for coca spray mixtures using the Accu-Flo nozzles in air stream velocities of 259, 296 and 333 km/hr indicated that 35, 44 and 57%, respectively, of the spray volume was in droplets less than 150 μm diameter. The ASAE "Very Coarse to Extremely Coarse" standard distribution used by AgDrift assumes only 2.9% of the spray in droplets less than 150 μm diameter. The ASAE "Medium" standard distribution assumes only 14% of the spray in droplets less than 150 μm diameter. Therefore, the use of these droplet size distributions represents a significant underestimation of the most driftable size fraction. Given the high sensitivity of spray drift to droplet size spectrum, especially for the smallest size classes in a distribution, the absence of more accurate data regarding the droplet size spectra resulted in significant underestimation of spray drift in the U.S. EPA (2002) analysis.

Moreover, the U.S. EPA analysis acknowledged the significant uncertainties inherent in the study, particularly, the irregular topography, the potential occurrence of very stable atmospheric conditions, especially temperature inversions, and the release height of the spray. As the flight data analysis of Hansman and Mena (2011) established, the cautions about parameter uncertainties made in the U.S. EPA study were well founded. The release height assumed by the U.S. EPA study was 30.48 meters; the 50th percentile height from the flight data for the AT-802, OV-10 and T-65 aircraft was 40.61, 42.56 and 39.46 meters, respectively. The U.S. EPA study noted that "the AgDrift model is not intended to model spray drift under very stable atmospheric conditions." However, the analysis by Hansman and Mena (2011) shows that 22% of flights occurred during the evening period of 20:00 to 04:00 (8 pm to 4 am) when stable conditions are most likely to occur. With respect to meteorological conditions, the U.S. EPA also noted that AgDrift modeling requires site-specific inputs for meteorology" and that "wind speed, temperature and humidity are measured and the airport which may not be representative of these parameters at the application site." In addition, the U.S. EPA study assumed 4 parallel flight lines "based on video of spraying operations with multiple aircraft." Analysis of the actual flight data (Hansman & Mena, 2011) revealed many fold this number of parallel flight lines at numerous locations within 10 km of the Ecuador - Colombia border.

In summary, lack of *a priori* knowledge about the actual spray operations resulted in significant overestimation in the assumed droplet size spectra and underestimation of the release height, the occurrence of night spraying, the presence of multiple spray lines. As a result, the U.S. EPA (2002) study significantly underestimated the potential spray drift from the coca spraying operations in Colombia.

b. Ballistic Droplet Settling Model – 2004

The second analysis was communicated by the Director of the National Narcotics Commission of Colombia to the President of the Scientific and Technical Commission of Ecuador in an April 14, 2004 Note (Republic of Colombia, 2004). This simple droplet displacement calculation, included in Figure 26 below, was based on three factors: droplet terminal velocity (Vt) for an average droplet 650 microns in size; release height (H), listed as "25 meters in compliance with technical parameters"; and crosswind speed (U), listed as 4.8 km/h (1.3 m/s).

$$\text{Drift} = \frac{H \times U}{Vt} \qquad \text{Drift} = \frac{25\text{ m} \times 1.3\text{ m/s}}{2.7\text{ m/s}} \qquad \text{Drift} = 12\text{ meters}$$

Figure 26. Spray Drift Calculation From April 14, 2004 Note from the Director of the National Narcotics Commission (Republic of Colombia, 2004)

This approach makes inaccurate assumptions made about the input parameters. First, it assumes that the average droplet size is 650 microns in size. However, as demonstrated by the wind tunnel experiment conducted by Hewitt et al. (2009), the median droplet size is on the order of 128-219 microns. Second, it assumes a wind speed of 1.3 m/s (2.5 knots), which is half the wind speed authorized in the EMP. Third, it assumes a release height of 25 meters. This is half of the altitude authorized by the EMP, and as demonstrated in the analysis by Hansman & Mena (2011), the spray planes frequently exceed the 50 meter limit. The approach is also flawed due to the inadequacy of the model. The calculation shown in Figure 26 does not include many of the factors that are included in the AGDISP model such as the significant aerodynamic effects of the aircraft on the droplet motion, (i.e., the turbulent wake and vortex effects of flight) and evaporation of the droplets based on tank mix properties. Additionally, the approach assumes a monodisperse spray droplet size distribution in which all droplets are the 650 micron size, ignoring the significant fraction of the pesticide released in droplets much smaller diameters (down to 10 microns and less). While AGDISP and other more sophisticated drift models have been available since the 1980s, simple ballistic models of spherical particles such as the one described in Figure 26 have not been the accepted standard for spray drift prediction for many decades.

c. Water-Sensitive Paper Study – 2004

A field study of the biological efficacy of glyphosate and a series of candidate spray adjuvants was conducted for Colombia in 2004 (Sociedad Las Palmas, 2004). The study used water sensitive paper as a collector of spray drift droplets and from the stains on the paper, spray drift was estimated. Use of water sensitive paper for spray drift assessment is a marginally reliable method, at best. Water sensitive paper is an optical indicator of droplet deposition and designed for assessment of on-target spray deposition. It is generally a subjective method of visualizing high levels of deposition. The cards typically used are not sensitive to droplets smaller than 70 µm in diameter and the report (Sociedad Las Palmas, 2004) states that "… no stains less than 250 microns were identified on the water sensitive paper cards." Thus, this method would not be expected to capture the many smaller droplets that are characteristic of Colombia's aerial spraying operations, as demonstrated by Hewitt et al. (2009) and is not an adequate technique to measure off-target spray drift.

Despite these measurement inadequacies, the Sociedad Las Palmas report (2004) indicates that a significant amount of spray drift is deposited outside the application site. More specifically, it states that 72.67% of the spray was lost, i.e., not detected in the target area in the testing with the glyphosate formulation and the Cosmo-Flux spray adjuvant. The study attributes these losses to "evaporation, drift and other causes." The general conclusion that a significant amount of the spray mixture is not deposited at the application site is consistent with the results from spray drift modeling conducted for this report.

14. **Conclusions**

This report analyzes the Colombian spray program using extensive spray drift modeling conducted with the best available data and resources: a) flight data, recorded in real time onboard the spray aircraft (Hansman & Mena, 2011); b) published droplet size spectral data collected using the spray tank mix and nozzles used in the spray program (Hewitt et al. 2009); and c) AGDISP, a well accepted computational model for aerial spray application. AGDISP was used to computationally predict and quantify off-target spray deposition downwind from the application site.

Examination of the flight data revealed that aircraft speeds and release heights routinely exceeded the expected and intended limits imposed by the Colombian EMP and otherwise represented by Colombia (Hansman & Mena, 2011). The higher aircraft speeds and choice of nozzle resulted in the generation of spray droplet size spectra that were classified as "very fine to fine" (or even smaller) (Hewitt et al., 2009) instead of the "extremely coarse" size spectra used in previous risk analysis (Solomon et al. 2005; Republic of Colombia, 2005; Republic of Colombia, 2004; Republic of Colombia, 2003; U.S. EPA, 2002). The combination of higher aircraft speeds, and the associated small droplet size spectra, and the high release heights combine to create a situation in which the potential for spray drift is greatly magnified and much more likely to occur.

Previous estimates of spray drift using AGDISP by Hewitt et al. (2009), which assumed compliance with operational parameters, resulted in a significant underestimation of deposition as compared to model runs using the best available data. For example, Hewitt et al. (2009) estimated glyphosate deposition on the order of 0.5 g a.e. / ha for the AT-802 aircraft at a distance of 1 km downwind (see Hewitt et al., 2009, Figure 6). In comparison, AGDISP predictions using typical application conditions based on recorded flight path data, i.e., the 50^{th} percentile aircraft altitude and 50^{th} percentile speed, produced drift deposition amounts of approximately 5 g a.e./ha, a ten-fold higher value. Moreover, the previous analyses considered only a single flight line. The flight data revealed that multiple, parallel spray passes were often made in localized geographic areas. When the drift from multiple flight lines, e.g., 10 spray passes, is considered cumulatively, deposition levels can increase approximately 8-10 fold at distances ranging from 1 to 10 km downwind. When the effect of actual application conditions, based on recorded flight data and the effect of multiple flight lines are combined, the increase in spray drift deposition, compared to previous estimates, can be up to approximately 100-fold. If additional spray lines were considered, the disparity between these estimates of spray drift and deposition would be even greater.

While the analysis using AGDISP, experimental data on droplet size distribution and recorded flight data provides the best possible estimates of spray drift, it is important to note that spray drift, especially at distances far from the application site, is a highly chaotic process. Given the natural spatial and temporal variability in terrain, meteorological conditions and flight conditions, predictions are exactly that, a computational calculation of the aerodynamic and atmospheric transport and trajectory of spray drift from the release point based on a set of assumptions. Therefore, actual spray drift at any specific location could be higher or lower than the estimates. For that reason, this report includes sensitivity analyses illustrating the effects of aircraft height, speed and other meteorological and surface conditions that affect spray drift. As expected, there are a number of factors that can result in greater spray drift downwind.

Given the wide range of operational conditions recorded in the flight data and the extensive scope of the spray program, i.e., over 100,000 flights conducted within 10 kilometers of the Ecuador-Colombia border (Hansman & Mena, 2011), occurrences of conditions that might seem rare, even statistically, would be expected to occur. Given the fact that meaningful quantities of spray drift are predicted to travel distances of 10 kilometers or more, even under typical application conditions in Colombia and the likelihood of more extreme events, expanded buffer zones would be a responsible strategy for mitigating the impacts of off-target spray drift.

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Annex 2

APPENDIX 1

Curriculum Vitae of Durham K. Giles, Ph.D.

Annex 2

January 2011

Durham Kenimer Giles

Professor
Biological and Agricultural Engineering
University of California, Davis

Education

B.S. (Magna Cum Laude) Agricultural Engineering, University of Georgia, 1979.
M.S. Agricultural Engineering, University of Georgia, 1983.
Ph.D. Ag. Engineering, Minor in Mechanical Engineering, Clemson University, 1987.

Academic Career Experience

1979-1983 Research Engineer, Particulate Engineering Lab., Driftmier Engineering Center.
1983-1987 Research Assistant, Agricultural Engineering Department, Clemson University.
1987-present Assistant Professor, Associate Professor and Professor, Biological & Agricultural Engineering Department, Univ. of Calif., Davis.

Selected Awards

1996 Outstanding Paper Award, American Society of Agricultural Engineers.
1997 Engineer of the Year, American Society of Agricultural Engineers, California/Nevada Section.
1998 AE-50 Award for Outstanding Product Design, American Society of Agricultural Engineers.
1998 Outstanding Paper Award, American Society of Agricultural Engineers.
1999 Engineering Concept of the Year Award, American Society of Agricultural Engineers.
2004 AE-50 Award for Outstanding Product Design, American Society of Agricultural & Biological Engineers.
2003 Outstanding Paper Award, American Society of Agricultural & Biological Engineers.
2004 Outstanding Paper Award, American Society of Agricultural & Biological Engineers.
2005 Outstanding Paper Award, American Society of Agricultural & Biological Engineers.
2007 Outstanding Paper Award, American Society of Agricultural & Biological Engineers.

Editorships

Division Editor for *Transactions of the American Society of Agricultural Engineers.*
Division Editor for *Applied Engineering in Agriculture.*
Board of Directors – *Institute for Liquid Atomization and Spraying Systems.*

Patents

Giles, D.K. and D. Needham. 2010. Networked diagnostic and control system for dispensing apparatus. U.S. Patent No. 7,826,930.
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Januray 2011

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Teaching (UC Davis)

EBS 200	Research Methods in Biological & Agricultural Engineering
ABT 233	Advanced Pest Control Methods – Spray Application of Agrochemicals
EBS 170A	Engineering Design and Professional Responsibilities
EBS 170B	Engineering Design: Design
EBS 170BL	Engineering Design: Design Lab
EBS 170C	Engineering Design: Evaluation
EBS 170CL	Engineering Design: Evaluation Lab

Annex 3

Stephen C. Weller, Ph.D., *Glyphosate-Based Herbicides and Potential for Damage to Non-Target Plants Under Conditions of Application in Colombia* (Jan. 2011)

Glyphosate-Based Herbicides and Potential for Damage to Non-Target Plants Under Conditions of Application in Colombia

Dr. Stephen C. Weller

Table of Contents

I. Executive Summary

This report evaluates the potential for glyphosate-based herbicides to cause injury to non-target plants under conditions of application in Colombia. Glyphosate is a non-selective herbicide that has the potential to injure a broad range of non-target plants. Following application, the herbicide moves readily through plant tissues in a process called translocation. Glyphosate's mechanism of action (i.e. the way it kills plants) is by inhibiting a metabolic pathway that is important for plant growth, development, and nutrition. Characteristic symptoms of plants affected by glyphosate include growth inhibition, yellowing and eventual plant death.

Glyphosate is commonly combined with other ingredients that modify or enhance the performance of the spray solution. While the full contents of the spray mixture used to eradicate coca crops in Colombia is not known, it has been reported that the mixture includes at least two surfactants that help increase the penetration of the herbicide through the plant cuticle: polyethoxylated tallow amine (POEA) and Cosmo-Flux 411F. These ingredients are important determinants of the herbicide's efficacy. In particular, Cosmo-Flux 411F has been reported to enhance the efficacy of glyphosate by a factor of four.

Spray drift resulting from aerial application can be a significant problem to non-target plants as well as other organisms in the environment. While plant susceptibility to glyphosate varies, there are many examples of low doses causing severe plant injury. Injury to plants at various distances from the application site can be predicted by comparing spray drift modeling output (i.e. the expected deposition resulting from spray operations) to available dose-response values for glyphosate (i.e. data that represents plant sensitivity to a given level of deposition). Injury to plants caused by glyphosate depends on the total amount of herbicide that enters the plant. Thus, an evaluation of the risk to plants under conditions of application in Colombia must take into account the cumulative deposition from multiple spray passes conducted during a single spray campaign (i.e. over the course of a few hours, or possibly several days or weeks). It is also important to consider the effect of the surfactant Cosmo-Flux 411F, which is not accounted for in the available dose-response values. The results from a range of representative spray drift modeling scenarios based on conditions of application in Colombia indicate that plant injury is expected at distances of at least 10 kilometers from the application site. Because the available dose-response values are not necessarily representative of the ecosystems present in the border region between Ecuador and Colombia, this analysis may underestimate the actual risk to plant species native to Ecuador. In particular, tropical crop plants and other sensitive plant species may face an increased risk as compared to plants for which there is available dose-response information.

Additional factors that are not captured by the spray drift modeling results or the dose-response data may further exacerbate the risk of harm to plants in Ecuador. First, environmental conditions may have significant implications for herbicide efficacy. The spray mixture used in Colombia, which is made up of 74% water, evaporates quickly, making the spray droplets more concentrated. Because the concentration of the spray droplet is a driving force for absorption into the plant leaf, this increases plant susceptibility to injury. In addition, herbicide penetration in plant leaves may be enhanced in humid environments like the Ecuador-Colombia border region. Second, secondary effects caused by glyphosate, including impacts on plant nutrition and susceptibility to disease, may contribute to injury in non-target plants affected by the

herbicide. Third, the spray drift modeling results do not represent actual spray runs, but rather representative scenarios based on a set of assumptions. To the extent that actual conditions differed from model assumptions, greater spray drift may have occurred, leading to greater harm to plants in Ecuador.

II. About the Author

Stephen C. Weller is a Professor of Weed Science in the Horticulture and Landscape Architecture Department at Purdue University. He has a B.S. from Central Michigan University in Biology (1971), a M.Sc. from The Ohio State University, USA, in Horticulture (1976) and a PhD from North Carolina State University, USA in Weed Science (1980). At Purdue University, Dr. Weller is responsible for research, teaching and extension in the areas of weed science, vegetable production and integrated pest management.

Dr. Weller's area of research expertise is in weed science with emphasis in weed management systems, weed biology, mechanisms of resistance in weeds to herbicides and the potential injury to horticulture crops from off-site movement of herbicides including glyphosate, 2,4-D and dicamba. Dr. Weller has conducted and supervised numerous studies regarding glyphosate, including studies related to drift and impacts to non-target plants. He is also an expert on weed resistance to glyphosate, and recently testified before the United States Congress on this subject.

Dr. Weller has over 24 years of experience in international research, teaching, training and extension in pest management and cropping systems development. He has worked in Central America (Guatemala and Honduras), China, India, South Korea, Mexico, Ukraine, Uganda, Kenya and Tanzania. His international projects focus on the implementation of integrated crop and pest management production systems for vegetable crops. Dr. Weller has been an Integrated Pest Management Collaborative Research Support Program (IPM CRSP)-Central America principal investigator for over 15 years working to enhance non-traditional agriculture exports capability and served as Site Chair for Central America for 5 years. Recently, he has served as a principal investigator for vegetable research with African indigenous vegetables in Kenya and Tanzania as part of the U.S. Agency for International Development Horticulture CRSP Project.

Dr. Weller's teaching includes classes in weed management, horticulture production, sustainable agriculture production and study abroad classes comparing organic and conventional agriculture. For 23 years at Purdue University, Dr. Weller coordinated and taught a one-week intensive course entitled "Herbicide Action," designed for representatives of the herbicide industry and focused on the chemical properties and safe and effective use of herbicides.

Dr. Weller is the author of the textbook Weed Science Principles and Practices. He has also written 10 book chapters and over 60 scientific publications, along with over 300 scientific meeting presentations and extension bulletins relating to weed management. He is a Fellow of the Weed Science Society of America and the North Central Weed Science Society.

Dr. Weller's full curriculum vitae is provided in Appendix 1.

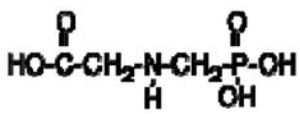
III. Introduction to Glyphosate-Based Herbicide Applications

A. *Glyphosate*

Glyphosate (N-phosphonomethyl glycine) was first developed as an herbicide by Monsanto in 1970 and released onto the commercial market in 1974. Glyphosate is considered a broad-spectrum systemic herbicide because of its general toxic effect on most plants. Unlike damage caused by pests or plant disease, which generally only target a specific species of plant, exposure to herbicide can damage or kill numerous plant species.

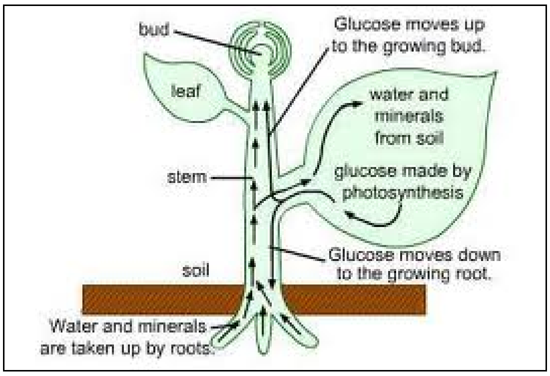
Glyphosate is a crystalline substance that has both a positive (+) and negative (-) charge, making it a polar (i.e. water-loving) compound (see Figure 1).

Figure 1. *Glyphosate structure.*



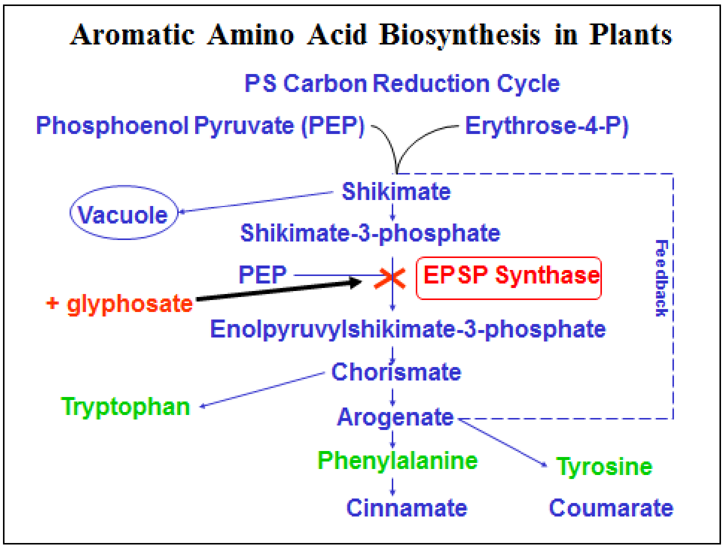
Glyphosate is applied to plant foliage and rapidly absorbed. In general in most plants, approximately 33% of the total applied glyphosate is absorbed within a few hours of application (Schonherr, 2002). The total amount of glyphosate absorbed in specific applications can vary with the commercial formulation used, the surfactants added to the spray tank mixture, the total spray volume applied and environmental factors at the time of application including relative humidity and temperature (Hartzler, 2001). Glyphosate moves readily throughout the plant after absorption via the phloem (plant conducting tissue that carries sugars to rapidly growing areas of the plant) and also in the xylem (plant conducting tissue that carries water and nutrients) (Figure 2). This movement is called translocation. Glyphosate does not kill plants immediately. Instead, plant death takes effect after a number of days. The slow rate of herbicide-induced plant death allows the herbicide to move thoroughly into plants shoots, roots and buds resulting in plant death. This efficient translocation results in glyphosate being an excellent herbicide for control of both annual and perennial plants.

Figure 2. *Translocation pathways in plants includes water uptake by roots and upward translocation in xylem and movement of sugars both upward and downward into rapid growth areas of the plant in phloem. Glyphosate translocates in both the xylem and the phloem.*



The herbicidal activity of glyphosate is primarily attributed to the inhibition of a pathway that is important for the production of aromatic amino acids and precursors for many important pigments, defense compounds, and hormones in plants. More specifically, glyphosate inhibits the chloroplast enzyme 5-enolpyruvylshikimate-3-phosphate synthase, usually called EPSPS (EC 2.5.1.19), in the shikimate pathway of plants (Figure 3). This pathway is important for the production of many secondary metabolites and the essential amino acids tyrosine, tryptophan and phenylalinine. As discussed in greater detail in Section VI, glyphosate's mechanism of action also involves the immobilization of metal co-factors which are important in plant nutrition, and can increase a plant's susceptibility to disease.

Figure 3. *Site of glyphosate inhibition of EPSP synthase in the aromatic amino acid biosynthetic pathway.*



Spray drift from glyphosate can result in plant death, slowed growth, increased susceptibility to disease and other environmental stresses and overall reduced productivity. In general, the first detectable symptom after glyphosate treatment is growth inhibition, followed by a noticeable yellowing (chlorosis) of treated tissue and meristematic regions of the plant (i.e. growth areas such as new leaves, buds and root tips) (Figure 4). Initial symptoms typically take 2 to 4 days to develop (Figure 5), however symptoms may develop at a slower pace depending on weather conditions. After 7 to 14 days, chlorosis begins to turn into necrosis (death of the plant tissue) and the affected plants die. Annual plants will typically die by 21 days while perennial plants die over a longer timeframe depending on whether they are herbaceous or woody.

Figure 4. *Glyphosate injury to pumpkin.*

Figure 5. *Tomato injury (A) 3 days after glyphosate spray, (B) 5 days after spray and (C) 21 days after spray.*

Short of plant death, glyphosate may cause slowed growth or reductions in overall productivity even from low levels of glyphosate exposure. In perennials, plant injury can be long-term and can result in regrowth abnormalities as shown in Figures 6 and 7 for blueberries and coffee, respectively. Additional examples of glyphosate injury are shown in Appendix 2.

Figure 6. *Stunted growth caused by repeated glyphosate application to new shoots of blueberry.*

Figure 7. *Coffee plant exhibiting symptoms of glyphosate injury (left) compared with normal coffee plant (right). Injured plant (left) exhibits strap-like (narrow) and deformed leaves, foliar yellowing and apical region deformity compared to a normal healthy plant (right).*

B. *Formulations and Adjuvants*

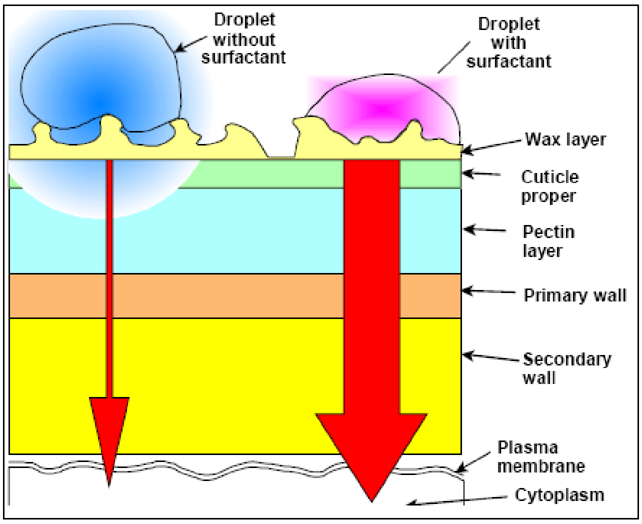
The herbicide glyphosate is sold in a number of different formulations. A formulation is a mixture of the chemical form of the herbicide and various other compounds (called "inert ingredients," "formulants" or "adjuvants") that make up the commercial product. There are many glyphosate products on the market throughout the world. For example, there are hundreds of glyphosate-based products presently registered in the United States; they are marketed with or without an added surfactant (National Pesticide Information Retrieval Service, 2011).

The nature of the formulation can result in variable effectiveness depending on the situation where the product is used. Aquatic formulations do not contain added surfactants while terrestrial formulations usually do contain some surfactant and as noted below herbicidal activity is influenced by formulation ingredients.

An adjuvant is any material added to a herbicide spray solution to modify or enhance the performance of the solution. Adjuvants are used at least twice in most herbicide delivery systems. First, they are an integral part of the herbicide formulation, where they may function as emulsifiers, stabilizers, deflocculants, or surfactants. These adjuvants are also called "formulants" or "inert ingredients." Second, additional adjuvants may be combined with the herbicide formulation in the spray tank to facilitate the delivery of the herbicide mixture. Adjuvants can be divided into two general categories: spray modifiers and activators (Kirkwood, 1994). Spray modifiers are those adjuvants that facilitate or enhance the emulsifying, dispersing, spreading, sticking or wetting properties of liquids. This is primarily accomplished by a modification in the surface tension of the spray solution. Activator adjuvants (sometimes termed accelerator adjuvants) primarily influence herbicide absorption by increasing the herbicide mobility (solubility) in the cuticle (the "skin" of the plant). Adjuvants often determine the effectiveness of the herbicide application because they play an important role in the cuticular penetration of the herbicide. This is particularly true with postemergence-applied herbicides such as glyphosate.

Surfactants (short for "surface active substance") are a common type of adjuvant. Surfactants increase the efficacy of the herbicide by helping it spread out on the plant leaf, increasing wettability and surface coverage by reducing surface tension. Surfactants also play an important role in helping water soluble herbicides such as glyphosate to traverse the waxy plant cuticle. The function of a surfactant is illustrated in Figure 8.

Figure 8. *Penetration of an herbicide such as glyphosate through plant cuticular waxes in the absence (left) and presence of surfactants (right) (Source: Solomon et al., 2005)*



The type of surfactant contained in the glyphosate formulation is a primary driver of both the efficacy and toxicity of the formulation. Some glyphosate formulations do not contain any surfactant (for example, Rodeo and Accord). These formulations are the only type approved for aquatic situations. Most commercial glyphosate products do contain a surfactant, however little information is available concerning the specific types of surfactants or their composition. Often, this information is not available publically because it is considered a "trade secret."

Based on what is known about the spray mixture applied to coca crops in Colombia, the commercial glyphosate product used is formulated with several adjuvants (also known as "formulants") with the primary surfactant being polyethoxylated tallow amine (POEA). An additional adjuvant, Cosmo-Flux 411F (a nonionic surfactant) is combined in the spray tank with the glyphosate-based formulation as part of the final tank mix to increase the activity of glyphosate in control of coca plants (Republic of Colombia, 2003b; U.S. Department of State, 2002; U.S. Environmental Protection Agency, 2002). These specific adjuvants and the manner in which they enhance the efficacy of the herbicide are discussed in greater detail in Section V.C.

C. *Plant Anatomy and Cuticular Interaction with Herbicide Solutions*

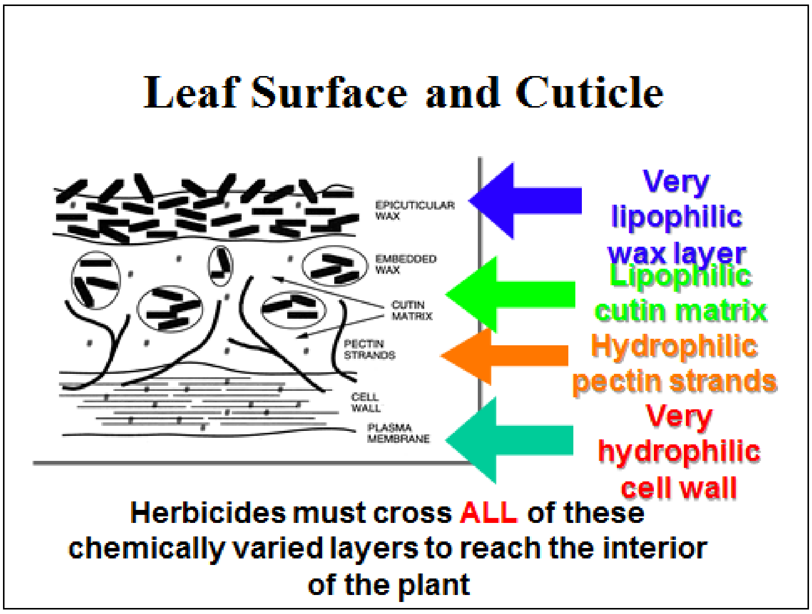
The cuticle is nonliving tissue that covers the surface of the plant leaf. It consists of several components which as a whole make the "skin" of a plant (Figure 9). Cuticular components in most plants consist of (a) epicuticular wax; (b) cutin; and (c) pectin, all of which overlay the walls of underlying cells.

- The epicuticular wax is the outermost layer and poses the single greatest barrier to herbicide penetration. Epicuticular wax is very lipophilic (i.e. it has an affinity for lipids, or fats, and repels water); it impedes penetration by increasing surface tension and contact with the spray droplet. The composition and quantity of epicuticular wax is both genetically and environmentally determined. It varies by species and within species, and ranges from nearly nonexistent to complete coverage of the leaf surface.

- The cutin is the second layer which provides the structural integrity of the plant cuticle. It is a sponge-like matrix with strands of waxy pectin within it. Cutin is generally more permeable to herbicides than the epicuticular wax, although it represents the most continuous barrier to penetration as its structure is still highly lipophilic. This layer can also vary in thickness among species.

- The pectin is the final layer of the plant cuticle prior to the cell wall and is made up of compounds similar to those in the cutin. Nevertheless, this layer has a higher content of hydrophilic (water loving) compounds so penetration of herbicides such as glyphosate through this layer occurs with little impediment as there are many lipo- and hydro-philic paths for movement.

Figure 9. *Leaf Surface and Cuticle.*



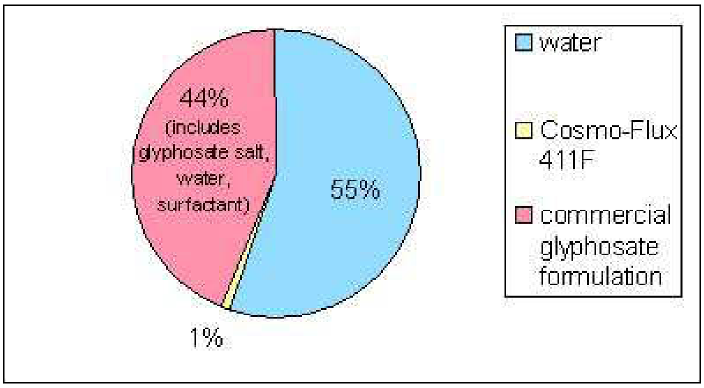
Because cuticular composition varies between plant species, the same herbicide spray, in the same amount, can cause different levels of injury depending on the type of plant that is sprayed. Likewise, different amounts of the same spray can cause different levels of injury to the same plant species. Spray droplets will be more or less compatible with the leaf surface depending on wax thickness, leading to more or less penetration of the herbicide. As discussed in Sections III.B and V.C, the adjuvants used in the spray solution also influence the amount of herbicide that penetrates the cuticle and enters the plant.

Coca leaves have a thick cuticular membrane which makes absorption of a water-based herbicide such as the spray used in Colombia difficult (McWhorter and Outzs, 1994; Ferreira and Reddy, 2000). In particular, the epicuticular layer tends to be continuous and is a major barrier to herbicide penetration (McWhorter and Ouzts, 1994). In contrast, herbaceous species such as tomatoes, corn, and rice, have much more limited epicuticular layer.

IV. Composition of the Spray Mixture Used for Aerial Eradication of Coca in Colombia

Although the full composition of the spray mixture used for aerial eradication of coca is not known, information published by the U.S. Department of State indicates that it contains 44% glyphosate-based formulation (which includes glyphosate in the form of isopropylamine salt, water, and other ingredients), 1% Cosmo-Flux 411F adjuvant and 55% water (Figure 10).

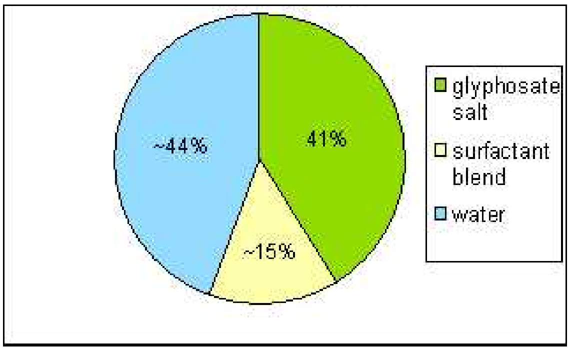
Figure 10. *Composition of the spray mixture used for aerial eradication of coca in Colombia (Source U.S. Department of State, 2002).*



The application rate discharged from the aircraft spray nozzles is 23.65 L/ha (2.53 gallons/acre), which contains 10.4 L/ha of the glyphosate-based formulation (3.7 kg ae/ha of glyphosate), 0.25 L/ha of Cosmo-Flux 411F and 13.0 L/ha of water. (Republic of Colombia, 2003b; Republic of Colombia, 2010). This application rate (3.7 kg ae/ha of glyphosate) is significantly higher than the recommended aerial application rate of 1.5 kg a.e./ha in the U.S. (Monsanto, 2011). In addition, the U.S. EPA (2002) reports that agricultural sites in the United States average "less than 0.75 pounds of active ingredient glyphosate per acre" (equal to 0.63 kg ae/ha) Thus, the application rate of glyphosate used for coca in Colombia is more than 5 times greater than the typical agricultural application rate in the United States.

Based on the information provided by the Republic of Colombia (2003b) and the U.S. Department of State (2002), the glyphosate-based product used for aerial spraying of coca in Colombia contains 41% glyphosate salt and 59% inert ingredients (including water) (See Figure 11). This ratio of active to inert ingredients is formulated as a 4.0 lb a.i./gallon (0.48 kg a.i./liter) isopropylamine salt which is equivalent to a 3.0 lbs a.e./gallon (0.34 kg a.e./liter) glyphosate acid. When data are presented as grams ai/ha this refers to the "active ingredient" or the isopropylamine salt. When data are presented as grams ae/ha this refers to "acid equivalent" or the glyphosate acid. The remainder of this report refers to plant dose-response values in grams ae/ha, which is a more common designation used to refer to the active form of the herbicide within the plant. Hewitt et al. (2009) also presents dose-response values in g a.e./ha, and thus the values in this report are comparable to that publication.[1]

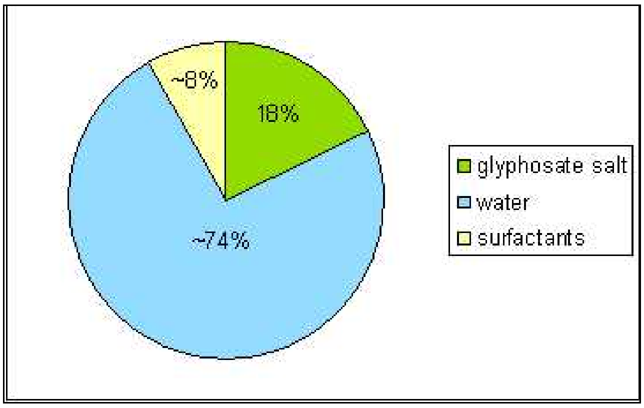
Figure 11. *Composition of the commercial glyphosate formulation used for aerial eradication of coca in Colombia (Source: U.S. Department of State, 2002).*



The final spray mixture (or "tank mix") is composed of 18% active ingredient (glyphosate salt), 8% surfactants (adjuvants, including the surfactants in the glyphosate product and Cosmo-Flux 411F) and 74% water (including water from the glyphosate formulation and water added separately) (See Figure 12). As discussed in greater detail in Section VI.B, the water portion of the tank mix is more volatile than the rest of the spray, and is therefore more prone to evaporation. This means that many of the spray droplets which land on non-target plants have a much higher concentration of glyphosate salt and surfactants than is indicated in Figure 11.

[1]The conversion factor is to divide the acid amount (a.e.) by 0.75 to convert to the salt (a.i) or to multiply the salt amount (a.i.) by 0.75 to convert to the acid (a.e.).

Figure 12. *Composition of the final spray mixture used for aerial eradication of coca in Colombia (Source: U.S. Department of State, 2002).*



V. Damage to Non-Target Plants from Spray Drift

A. *The Problem of Off-Target Spray Drift*

Glyphosate drift can be a significant problem to non-target plants and other organisms in the environment. When drift of glyphosate occurs, damage is likely to be much more extensive and more persistent than with many other herbicides. This is because glyphosate is fairly stable in a plant and is not readily metabolized. As discussed in Section III.A, once glyphosate enters a plant, it translocates (moves throughout the plant) and can be found in plant parts such as roots that were never directly exposed to spray drift. Due to this stability in the plant, glyphosate drift at non-lethal doses can cause persistent injury in perennial plants (plants with a life cycle that lasts more than one year), with symptoms that can last several years (Atkinson, 1985). Plant susceptibility to glyphosate varies widely; however, there are many examples of low doses causing severe plant injury. A good example is the response of wildflowers that are a hundred times more sensitive to low doses of glyphosate compared to many agronomic crops (Breeze, et al., 1992).

Off-site glyphosate movement will vary depending on the type of application. Data show that ground applications can result in 14 to 78 percent of the applied glyphosate moving off-site depending on the environmental conditions at the time of application (wind, humidity, temperature) (Freedman, 1990). Aerial application by helicopter can result in greater than 41 percent of the applied glyphosate moving from the target site (Freedman, 1990). A report by the consulting firm Sociedad Las Palmas Ltda., prepared for the Republic of Colombia, demonstrates that fixed-wing aircraft applications can result in off-target movement of greater than 70 percent of the spray mixture (Sociedad Las Palmas, 2004).

B. *Data on Plant Responses to Glyphosate*

This section presents published data on plant dose-responses to glyphosate. These values are based on studies conducted with pure glyphosate or glyphosate-based formulations and do not take into account the effect of adjuvants such as Cosmo-Flux 411F which are included in the final tank mixture to increase the efficacy of the herbicide. Such increases in glyphosate efficacy and predicted injury to non-target plants are discussed in Section V.C. Section V.D synthesizes this information by comparing these dose-response values to the results of drift modeling analyses based on conditions of application for coca crops in Colombia and taking into account the predicted impact of Cosmo-Flux 411F (Giles, 2011).

The dose-response values evaluated by Hewitt et al. (2009) are presented in Table 1 below as EC_{25} values. EC_{25} is defined variously as the effective concentration of a chemical that is estimated to produce a specific adverse effect in 25% of the test organisms (U.S. EPA, 2009) or the effective concentration that causes a 25 percent effect on the tested species (e.g. inhibition of growth or development) (Boutin et al., 2004). Depending on the plant species, such a reduction in growth or development can seriously impair plant functions (such as reproduction, fruiting, etc.) and viability. Hewitt et al. (2009) report that the EC_{25} values listed in Table 1 are from tests on plants with formulated glyphosate taken from the U.S. Environmental Protection Agency Ecotox database. The species evaluated consist mostly of crop species grown in the northern hemisphere.

Table 1. *Dose-response values analyzed by Hewitt et al. (2009)*

Toxicity Data for Formulated Glyphosate in Plants

Species scientific name	Species common name	EC25 (g/ha)	Effect	Exposure duration (days)
Brassica rapa-rapa	Turnip	36	Development	28
Raphanus sativus	Radish	44	Growth	21
Cucumis sativus	Cucumber	60	Development	28
Glycine max	Soybean	76	Growth	28
Triticum aestivum	Bread wheat	78	Growth	28
Helianthus annuus	Sunflower	78	Development	21
Sorghum bicolor	Broomcorn	78	Growth	21
Beta vulgaris	Beet	87	Growth	28
Abelmoschus esculentus	Okra	90	Growth	28
Raphanus sativus	Radish	100	Development	28
Beta vulgaris	Beet	103	Development	21
Triticum aestivum	Bread wheat	108	Growth	21
Lactuca sativa	Lettuce	111	Growth	28
Zea mays	Corn	117	Development	336
Avena sativa	Common oat	120	Development	28
Allium cepa	Common onion	137	Development	21
Glycine max	Soybean	157	Growth	21
Cucumis sativus	Cucumber	220	Development	21
Cyperus rotundus	Purple nutsedge	372	Growth	28
Pisum sativum	Pea	436	Development	21
Magnoliophyta	Angiosperm	1958	Development	28

Note. Data from (U.S. EPA, 2001).

Using the EC_{25} values presented in Table 1, Hewitt et al. (2009) created a species sensitivity distribution and calculated a 5th centile intercept from that distribution curve equal to 43 g a.e./ha. In other words, Hewitt et al. (2009) estimate that 5 percent of plant species will be injured by a glyphosate dose of 43 g a.e./ha. The authors describe the 43 g a.e./ha dose as a level at which only "sensitive plants" might be affected.

The threshold for injury to sensitive plants calculated by Hewitt et al. (2009) is inconsistent with the threshold calculated by others. Another study, sponsored by the Danish Environmental Protection Agency and Environment Canada, arrives at a much lower value for protecting sensitive plant species (Boutin et al., 2004). The study tested 15 plant species grown in Europe and North America. Like Hewitt et al. (2009), Boutin evaluated EC_{25} values for plants exposed to glyphosate formulations and plotted a species sensitivity distribution. The "hazard dosage," protective of 95 percent of plant species (equivalent to the Hewitt et al. (2009) 5th centile intercept) was 4.1 g a.e./ha. This value is approximately 10 times lower than the Hewitt et al. (2009) value of 43 g a.e./ha.

Boutin et al. (2004) note that focusing only on the northern hemisphere crop plants contained in the EPA database "causes an unacceptable bias with consequences that risk is underestimated." While the selection of plants used in the Boutin et al. (2004) study was considered a preferable measure of environmental risk, the authors noted that even that selection was not necessarily representative of ecosystems affected by herbicide spray. The authors explained that "[i]deally, the tested species should be chosen at random among all species of the target ecosystem they are assumed to represent."

Neither the northern hemisphere crop species tested by Hewitt et al. (2009) nor the plant species tested by Boutin et al. (2004) are representative of the plants in the Ecuador-Colombia border region. In particular, tropical crop plants such as yuca and plantain were not considered in the Boutin et al. study, nor were the non-crop plant species that are present in the region, some of which may be particularly sensitive (Balslev, 2011; Whitten et al., 2011). For example, the effect of glyphosate on epiphytes, which derive water and nutrients from droplets in the air (Balslev, 2011) has not been studied. Therefore, the "hazard dosage" protective of sensitive plant species in Ecuador may be lower than 4.1 g a.e./ha.

Simulated drift research of glyphosate in processing tomatoes by this author (Kruger et al. 2009) showed that glyphosate doses in the range of the 4.1 g a.e./ha "hazard dosage" from Boutin et al. (2004) can cause yield losses in tomatoes. More specifically, loss of flowers, which can lead to loss of tomato fruits, occurred at rates as low as 3 g a.e./ha. The timing of the drift occurrence is critical to this injury. In the Kruger et al. study, drift at the time of flower initiation caused a more significant yield loss at a lower dose than an application shortly after transplanting.

Another study by Ellis et al. (2003) indicates that other crop species may be injured by relatively low doses of glyphosate. For example, in corn, Ellis et al. found significant injury, including yield loss, at rates as low as 26.25 g a.e./ha.

C. *Effect of Surfactants Used in the Colombia Coca Eradication Program*

As discussed above, the main function of a surfactant is to increase the efficacy/toxicity of the herbicide. Therefore, surfactants are of interest to any risk assessment. The spray solution used in Colombia consists of a glyphosate-based formulation containing the surfactant polyethoxylated tallow amine (POEA) and a second surfactant which is added to the glyphosate-based product, called Cosmo-Flux 441F (Republic of Colombia, 2003b; U.S. Department of State 2002; U.S. Environmental Protection Agency, 2002). Both of these surfactants result in greater glyphosate absorbtion into the plant. As discussed in Section III.C, this is particularly important in the case of the coca plant, which has a thick, waxy cuticular membrane and makes the absorption of the water-based spray mixture difficult.

POEA is a nonionic surfactant derived from quaternary fatty amine used as an emulsifier and in formulating emulsifier blends and as a wetting agents, dispersants, stabilizers, sanitizers and defoaming agents. POEA is not a single surfactant but a category of chemicals including fatty acids and tallow (a hard fat consists chiefly of glyceryl esters of oleic, palmitic, and stearic acids in 16-18 carbon chains). POEAs are added to formulated commercial glyphosate products to improve the herbicide penetration of the plant cuticle. POEA helps glyphosate interact with the surfaces of plant cells. It lowers water's surface tension — the property that makes water form droplets on most surfaces — which helps glyphosate disperse and penetrate the waxy surface of a plant. (Relyea, 2005). Although POEAs are often called "inert ingredients" (as opposed to the "active ingredient" glyphosate), POEA type surfactants are not totally inert with no biological activity. For example, research has shown them to be toxic to certain aquatic organisms (Brausch et al., 2007; Brausch and Smith 2007; Relyea, 2005; Flomer et al., 1979).

In coca spray solutions, an additional adjuvant Cosmo-Flux 411F is combined with the glyphosate-based formulation as part of the final tank mix. Cosmo-Flux 411F is a mixture of polyethoxylates, which is a combination of a non-ionic surfactant and isoparafinic oil. The manufacturer of the product, Cosmoagro, states that Cosmo-Flux 411F:

> is a non-ionic stereospecific adjuvant that substantially modifies the biological activity of agrochemicals and permits emulsions and dispersions to remain stable for long periods. Cosmo Flux 411F improves the adherence and uniformity of the emulsified mixture, controlling evaporation and hydrolysis of the active ingredient by completely covering it, which guarantees a uniform concentration of the active ingredient per area unit. Adding Cosmo-Flux 411F to the application of insecticides, fungicides and herbicides prepared in mixtures of mineral or vegetable oil has been shown to have the ability to increase the efficiency of these products. Its effectiveness is four (4) times greater than conventional spraying oils due to synergism between the paraffinic oil and the stereospecific surfactant. (Cosmoagro, 2008).

Cosmo-Flux 411F was selected as the surfactant for glyphosate spray mixtures for coca plant control in Colombia after testing of similar products showed that those products improved glyphosate efficacy on coca by a factor of four (Collins and Helling, 2002; U.S. Department of State, 2002).

This fourfold increase in efficacy is consistent with the properties of nonionic surfactants in general. When added to spray mixtures, nonionic surfactants provide excellent compatibility of the applied spray droplet with the waxy leaf surface of the plant leaves. These properties are especially important for a plant such as coca that has a waxy leaf surface.

Based on the properties of Cosmo-Flux 411F described above, a much greater amount of glyphosate would be expected to enter a plant than an application that uses a glyphosate formulation alone. Therefore, the dose-response figures discussed in Section V.B are likely significant underestimates of plant susceptibility to the spray mixture applied to coca crops in Colombia because they are based on studies of glyphosate formulations and do not consider the effect of Cosmo-Flux 411F. In particular, the Hewitt et al. (2009) study states: "[i]t is recognized that Cosmo-Flux may increase potency of the mixture for plants." However, the Hewitt et al. (2009) study considered only data for formulated glyphosate without the addition of Cosmo-Flux 411F, citing the "lack of data for sensitivity to the mixture in plants other than coca."

The report by Dr. Stuart Dobson (2010), which is included as an Appendix to the Colombia Counter-Memorial also discounts the effect of Cosmo-Flux 411F as part of its argument that the potential for spray drift and injury to non-target crops is low to non-existent. Dobson agrees that the potency of glyphosate used to spray coca in Colombia is increased 4-fold due to the addition of Cosmo-Flux 411F surfactant. Dobson also agrees that the Cosmo-Flux 411F surfactant interacts with the waxy leaf cuticle of the coca plant in such a manner that a greater amount of glyphosate moves through the cuticle and reaches the living cells of the plant where it can cause injury. Dobson also agrees that other plants with a leaf cuticle similar to that of the coca plant will be more susceptible to glyphosate due to the enhanced entry of the herbicide. However, Dobson states that not all plants will be 4-fold more sensitive. He argues that plants with less cuticular protection than the coca plant would show little or no increase in susceptibility due to the addition of Cosmo-Flux 411F since there is essentially no barrier to herbicide entry regardless of whether a surfactant was or was not added to the spray solution. Dobson may be right that any plant with a non-waxy or low wax containing cuticle would absorb enough herbicide to kill the plant in the absence of Cosmo-Flux 411F, and thus the addition of the surfactant has no real effect because a plant can only die once. It is true that if a plant will be killed by exposure to a certain amount of glyphosate, adding Cosmo-Flux 411F will not make that plant any more dead if exposed to the same amount of glyphosate with Cosmo-Flux 411F. However, the important point is that if Cosmo-Flux 411F is added, the same plant will be killed at a much lower dose of herbicide.

Thus, rather than discounting the effect of Cosmo-Flux 411F, as was done in the study by Hewitt et al. (2009) and Dobson (2010), if we assume a four-fold increase in the efficacy of glyphosate — a fair assumption based on statements by the Cosmo-Flux 411F manufacturer and research by Collins and Helling (2002) — even smaller doses of glyphosate than the doses discussed in Section V.B could cause significant injury to non-target plants. The potential implications of Cosmo-Flux 411F for plant injury are discussed in greater detail in Section V.D below.

D. *Evaluation of Spray Drift Modeling Results*

Aerial application of the herbicide used by Colombia can result in significant off-target movement of glyphosate-based sprays (Sociedad Las Palmas, 2004; Giles, 2011), and as discussed above, this drift can lead to significant injury to non-target plants. In a 2002 evaluation of Colombia's aerial spraying program to eradicate coca crops, the U.S. Environmental Protection Agency (2002) stated that "phytotoxicity to non-target plants outside the application zone would be expected, since glyphosate is a broad spectrum herbicide. Given the application method described by Department of State, offsite exposure from spray drift is probable."

The computational model AGDISP developed by the U.S. Forest Service is a well accepted program to model downwind displacement of spray liquid released by aerial spraying of chemicals and in determining if toxic concentrations of a herbicide such as glyphosate could be responsible for injury to non-target plant species. Hewitt et al. (2009) used this model to estimate glyphosate drift in Colombia's coca eradication aerial spray program and concluded that the potential for drift was negligible to off-target sites. The Giles report (2011) also evaluates spray drift and deposition based on conditions of application in Colombia. The results presented by Giles (2011) demonstrate that the level of deposition varies depending on the application parameters (e.g. speed and the height of the aircraft, droplet size), meteorological conditions (e.g. wind speed), terrain (e.g. canopy height) and equipment status, among other factors. All of these factors must be considered when determining how much drift occurs and what amount of herbicide actually moves. In addition, total deposition is influenced by the number of spray passes. Giles (2011) shows that the previously published study by Hewitt et al. (2009) underestimated the drift potential because compliance with operational parameters such as aircraft height and speed was assumed. Nevertheless, even when more appropriate inputs are applied, there is no single deposition scenario, but instead a range of possible scenarios depending on the conditions of application, some of which are unknown.

This section applies a dose-response analysis to several scenarios modeled by Giles (2011). In order to evaluate the potential for injury to plants under a range of potential scenarios, the discussion below evaluates drift model results of flights conducted with two different types of aircraft (AT-802 and OV-10) at the median values for height and speed, as measured by on-board systems in actual spray operations (Hansman & Mena, 2011; Giles, 2011). In addition, scenarios conducted at higher altitudes and speeds are considered. Finally, two additional illustrative scenarios are evaluated, which take into account the additional factors of canopy height and wind speed.

Injury to plants at various distances from the application site can be predicted by comparing the spray drift modeling output presented in Giles (2011) to the dose-response thresholds described in Section V.B. Injury to plants caused by glyphosate depends on the total amount of herbicide that enters the plant. Thus, an evaluation of the risk to plants must take into account the cumulative deposition from multiple spray passes.

Based on the analysis of the flight path data recorded by spray planes in Colombia (Hansman & Mena, 2011), dozens of spray passes may have contributed to off-target deposition at individual downwind locations. As explained by Giles (2011), these spray passes were most likely conducted within a relatively short time frame (within a period of hours or days). Importantly, repeated applications of glyphosate at sub-lethal doses would have a cumulative effect on non-target plants. Even plants that are not initially affected or which show minimal effects can still absorb glyphosate. Therefore, multiple repeated doses within a few hours or a few days would accumulate in the plant up to a point where injury thresholds were exceeded.

Another important factor to consider is the effect of the surfactant Cosmo-Flux 411F. The influence of Cosmo-Flux 411F on glyphosate absorption into test species was not accounted for in the published dose-response values described by Hewitt et al. (2009) or in the other studies described above. In the absence of more specific dose-response information that takes into account the effect of Cosmo-Flux 411F, it is reasonable to assume, based on the statements of the Cosmo-Flux 411F manufacturer and research by Collins and Helling (2002), that Cosmo-Flux 411F would cause a four-fold increase in the efficacy of glyphosate when applied to non-target plants. In effect, Cosmo-Flux 411F can be considered to effect an increase in the glyphosate dosage that enters the plant by a factor of four. Put differently, when Cosmo-Flux 411F is added to the spray tank containing glyphosate, the amount of deposition that will cause injury to a plant is one-fourth the amount that would otherwise be the case. This amount, which takes into account the effect of Cosmo-Flux 411F, is referred to as the "effective dose" or "effective deposition" in the text that follows.

1. Deposition from Spray Aircraft Traveling at Median Height and Speed

A single spray line from an AT-802 aircraft traveling at the median height and median speed deposits 4.91 g a.e./ha of herbicide 1 kilometer from the site of application (Giles, 2011), and thus exceeds the 4.1 g a.e./ha threshold for injury sensitive plants established by Boutin et al. (2004). When the effect of Cosmo-Flux 411F is taken into account, the effective deposition is 19.64 g a.e./ha, which exceeds the Boutin et al. threshold for injury to sensitive plants by a factor of 4.8. The deposition from this single spray line would also be expected to cause fruit loss and flower loss in tomatoes (Kruger et al., 2009). Thus, sensitive plants and crops located 1 kilometer from the site of application would be expected to be injured by a single spray line from an AT-802 aircraft traveling at median height and median speed.

If the effect of multiple spray lines is taken into account, the deposition rates exceed additional plant injury thresholds. For example, 3 spray lines would result in an effective deposition of 57.08 g a.e./ha. This dose is greater than the dose of 43 g a.e./ha reported by Hewitt et al. (2009) to cause injury to plants; it also exceeds the 26.25 g a.e./ha dose reported to cause injury to corn (Ellis et al., 2003). Deposition resulting from 10 spray lines, a realistic scenario under conditions of application in Colombia (Giles, 2011), would result in an effective deposition of 163.80 g a.e./ha of glyphosate at 1 kilometer from the site of application. This dose exceeds the 43 g a.e./ha plant injury threshold reported by Hewitt et al. (2009) by a factor of 3.8.

Based on the Giles (2010) drift modeling results, glyphosate deposition is also likely to injure plants at locations farther afield. At a distance of 10 kilometers from the application site, the effective dose from 4 spray lines from an AT-802 aircraft traveling at median height and median speed is 4.32 g a.e./ha. That amount exceeds the 4.1 g a.e./ha threshold for injury sensitive plants established by Boutin et al. (2004). Thus, plant injury would be expected at a distance of 10 kilometers from the application site under this application scenario. Deposition distance of 10 kilometers from the application site under this application scenario. Deposition from additional spray lines would further increase the risk to non-target plants at this distance. As discussed above, this analysis may under represent the risk to sensitive plants in Ecuador because the available information regarding plant responses to glyphosate is not representative of the crops or the native plant species grown in the region, and thus the "hazard dosage" for sensitive plant species in Ecuador may be lower than 4.1 g a.e./ha.

A similar analysis can be applied to other aircraft used in Colombia's aerial spraying program. For example, the data recorded for the OV-10 aircraft indicates that it tends to travel somewhat higher and faster than the AT-802 aircraft (Hansman & Mena, 2011). As a result, deposition increases both in the near field and the far field (Giles, 2011). A single spray line from an OV-10 aircraft traveling at median height and median speed results in an effective dose of 20.20 g a.e./ha of herbicide 1 kilometer from the site of application. This amount exceeds the Boutin et al. threshold for injury to sensitive plants by a factor of 4.9. Three spray lines would result in an effective dose of 56.08 g a.e./ha, which exceeds the plant injury threshold of 43 g a.e./ha established by Hewitt et. al. (2009). Deposition by the OV-10 aircraft would also be expected to cause plant injury at greater distances. At 10 kilometers from the application site, the OV-10 aircraft traveling at median height and median speed results in an effective dose of 1.28 g a.e./ha. Deposition from 4 spray lines at this distance would result in an effective dose of 4.84 g a.e./ha, exceeding the threshold for sensitive plants reported by Boutin et al. (2004); additional spray lines would create a greater risk for non-target plants.

2. Aircraft Traveling at Increased Heights and Speeds

As described by Hansman & Mena (2011), the aircraft used in the Colombian spray program did not travel at uniform heights and speeds. Glyphosate application from higher altitudes contributes to greater horizontal displacement of spray droplets. Application at higher airspeeds creates smaller droplets that are more prone to drift and also affects the aircraft wake and airflow disruption around the spray boom and nozzles. Thus, herbicide applications at greater heights and speeds result in increased off-target deposition both in the near field and farther from the application site (Giles, 2011).

The effective dose from a single spray line from an AT-802 aircraft traveling at the 90^{th} percentile for height and the 90^{th} percentile for speed releases an effective dose of 47.96 g a.e./ha of herbicide 1 kilometer from the site of application. This amount of deposition exceeds the 43 g a.e./ha threshold for plant injury reported by Hewitt et al. (2009), and exceeds the 4.1 g a.e./ha threshold for plant injury reported by Boutin et al. (2004) by a factor of 11.7. Of course, multiple spray lines would result in even greater levels of deposition, further increasing the risk to non-target plants. Thus, while the effective deposition predicted for a single spray line from an AT-802 flight conducted at median height and speed (19.64 g a.e./ha) would cause injury to plants, there is an even greater risk of injury from the deposition predicted for the same aircraft traveling at elevated heights and speeds (47.96 g a.e./ha).

At a distance of 10 kilometers from the application site, 2 spray lines from an AT-802 aircraft traveling at the 90^{th} percentile height and the 90^{th} percentile speed results in an effective dose of 5.28 g a.e./ha. That amount exceeds the 4.1 g a.e./ha threshold for injury sensitive plants established by Boutin et al. (2004). Thus, plant injury would be expected at a distance of 10 kilometers from the application site under this application scenario. Deposition from additional spray lines would further increase the risk to non-target plants at this distance.

A similar analysis can be applied to other aircraft types. For example, the OV-10 aircraft traveling at the 90^{th} percentile for height and the 90^{th} percentile for speed results in an effective dose of 54.24 g a.e./ha of herbicide at 1 kilometer from the site of application. This amount of deposition exceeds the 43 g a.e./ha threshold for plant injury reported by Hewitt et al. (2009), and exceeds the 4.1 g a.e./ha threshold for plant injury reported by Boutin et al. (2004) by a factor of 13.2. Multiple spray lines would result in even greater levels of deposition and corresponding risk to non-target plants. At a distance of 10 kilometers from the application site, 2 spray lines from an OV-10 aircraft traveling at the 90^{th} percentile height and the 90^{th} percentile speed results in an effective dose of 5.66 g a.e./ha, which exceeds the 4.1 g a.e./ha threshold for injury sensitive plants established by Boutin et al. (2004). Thus, plant injury would be expected at a distance of 10 kilometers from the application site under this application scenario and additional spray lines would create a greater risk for non-target plants.

3. Additional Illustrative Drift Modeling Scenarios

As discussed in Giles (2011), aircraft height and speed are only two of the many factors that influence spray drift. Other factors including meteorological conditions, terrain, and equipment status may increase deposition rates. For example, a single spray line from an AT-802 aircraft traveling at median height and median speed results in an effective deposition of 19.64 g a.e./ha at 1 kilometer from the application site. This drift modeling scenario adopts the assumptions of Hewitt et al. (2009) that the tree canopy is 25.91 meters and the wind speed is 2.57 m/s (5 knots) (Giles, 2011). If this same flight is conducted in a location with a low canopy (4 meters) and a stronger wind (5.14 m/s, or 10 knots), the effective deposition increases to 34.52 g a.e./ha at 1 kilometer from the application site. This value is almost twice the amount of effective deposition from the aircraft operating under the Hewitt et al. (2009) assumed conditions and exceeds the 4.1 g a.e./ha threshold for injury to sensitive plants reported by Boutin et al. (2004) by a factor of 8.4.

Multiple spray lines conducted under these conditions would increase deposition and corresponding risk to non-target plants. A scenario involving a low canopy and a stronger wind would also increase deposition at greater distances. Assuming a tree canopy of 25.91 meters and wind speed of 2.57 m/s, consistent with the Hewitt et al. (2009) analysis, five spray lines from an AT-802 aircraft traveling at median height and median speed results in an effective deposition of 5.36 g a.e./ha at 10 kilometers from the application site. If these same five flights are conducted in an area with a low canopy (4 meters) and a stronger wind (5.14 m/s), the effective deposition increases to 9.32 g a.e./ha at 10 kilometers from the application site. This amount of deposition is nearly twice the amount from the flight under lighter wind conditions and a taller canopy as assumed by Hewitt et al. (2009), and it exceeds the threshold of 4.1 g a.e./ha reported by Boutin et al. (2004) by a factor of 2.2. Thus, a series of spray passes conducted in a clearing at higher wind speeds would be expected to result in even greater risk to non-target plants as compared to the same flights conducted in an area with a rainforest tree canopy of 25.91 meters and a lower wind speed, as assumed by Hewitt et al. (2009).

As another example, an OV-10 aircraft traveling at the 95th percentile for height and the 70th percentile for speed, with a strong wind (5.14 m/s) and a canopy height of 25.91 meters as assumed by Hewitt et al. (2009), deposits an effective dose of 53.16 g a.e./ha at 1 kilometer from the application site. This amount of deposition exceeds the 43 g a.e./ha threshold reported by Hewitt et al. (2009) and exceeds the 4.1 g a.e./ha threshold reported by Boutin et al. (2004) by a factor of 13. At a distance of 10 kilometers from the application site, 2 spray events conducted under these same conditions would result in an effective deposition of 6.08 g a.e./ha, exceeding the 4.1 g a.e./ha threshold reported by Boutin et al. (2004) by a factor of 1.5. Thus, higher, faster flights conducted in the presence of higher winds would result in a greater risk of injury to non-target plants than flights conducted under more routine conditions.

As discussed in Giles (2011), there are many factors that influence spray drift. Drift model results do not represent actual spray runs, rather they are representative scenarios based on a set of assumptions, and only some of the model inputs can be verified against actual data from the spray missions. In addition, some factors that influence spray drift, such as the potential for a temperature inversion, are not captured by the model. Therefore, to the extent that actual conditions differed from model assumptions, greater spray drift may have occurred, leading to greater harm to plants in Ecuador.

VI. Factors That May Enhance Injury to Non-Target Plants Under Conditions of Application in Colombia

A. *Humidity*

As discussed above, the quantity and composition of the plant cuticle is an important determinant of herbicide penetration. In addition to cuticle composition, the level of cuticular hydration can be important. Because the cuticle acts like a sponge with wax on the surface and a pectin layer below, when the cuticle is fully hydrated it expands and there is more space between the embedded wax particles. This allows polar (water soluble) herbicides such as glyphosate to pass through more easily. When the cuticle is less hydrated it shrinks, making passage of polar compounds more difficult. Therefore, herbicide penetration in plant leaves may be enhanced in humid environments like the Ecuador-Colombia border region.

B. *Herbicide Concentration in the Spray Droplets*

Meteorological conditions, such as temperature, humidity, and wind can have a significant effect on droplet size distribution and deposition. As discussed above in Section IV, 74% of the tank mix used to eradicate coca in Colombia is water. Because water is more volatile than the rest of the spray contents, it will evaporate more quickly. Therefore, the further the droplets are carried in the air after their release from the aircraft, the smaller they will become. As a result, the spray droplets that impact non-target plants may be significantly smaller and more concentrated than the droplets that land in the target area.

The concentration of the spray droplet is a driving force for absorption into the leaf. Several studies have shown that a higher glyphosate concentration in the spray droplet increases plant susceptibility to injury (See Box 1). In other words, the same dose of glyphosate is more effective at killing plants when it is delivered in small, concentrated spray droplets than when it is delivered in larger, more diluted ones. The majority of studies reported in the scientific literature referring to plant responses to glyphosate were conducted using ground application spray volumes which have a lower concentration of glyphosate on a g/L basis than those concentrations observed in aerial applications. Therefore, the susceptibility of non-target plants to injury under actual conditions of application in Colombia is likely significantly higher than predicted based on the dose-response analysis above.

Box 1. *Studies Evaluating the Effect of Glyphosate Concentration and Spray Volume on Herbicide Efficacy*

Banks and Schroeder (2002) sprayed sweet corn with 5 different dosages of glyphosate (0.046, 0.092, 0.185 and 0.37 kg/ha). Each concentration was applied either in a constant spray volume of 281L/ha or varying spray volumes of 12, 24, 47 and 94 L/ha. The results showed that when the volume was kept constant at 281L/ha no inhibition of sweet corn growth was observed until the highest dose of 0.37 kg/ha was applied. However, when the spray volume was reduced, injury was observed at 0.092 kg/ha. Thus, the more concentrated spray resulted in plant injury at a much lower dosage. In fact, it took a four-fold higher rate (0.37 kg/ha vs. 0.092 kg/ha) to cause injury in the high volume spray vs. the lower volume spray (281L/ha vs. 93L/ha).

Yerkes and Weller (1996) sprayed two biotypes of field bindweed that varied in their susceptibility to glyphosate with a dose of 1.68 kg/ha in three different spray carrier volumes of 142, 189 or 237 L/ha. The less tolerant biotype showed injury at the lowest volume of 142 L/ha. The results showed that the more tolerant biotype was less injured at spray volumes of 189 and 237 L/ha but had similar injury as compared to the less tolerant biotype at the 142 L/ha spray volume. Data showed a significant improvement of glyphosate activity when spray volume was reduced and a non-ionic surfactant was included in the herbicide mixture.

C. *Secondary Effects of Glyphosate-Based Herbicides*

Exposure of a plant to glyphosate results in a cascade of events that can lead to plant injury, reduced growth, and plant death. Glyphosate exposure can affect a plant's ability to properly function not only biochemically as a result of impared shikimic acid pathway function but also in its ability to absorb and utilize essential plant nutrients from the soil. There is increasing evidence that glyphosate exposure can affect plant nutrient absorption and increase disease susceptibility.

Plant nutrition is influenced in two principal ways. First, within the plant, glyphosate immobilizes metal co-factors such as copper (Cu), zinc (Zn), manganese (Mn) and nickel (Ni), which are important in plant enzyme activity and it can affect the plant's ability to use important macro elements such as magnesium (Mg) and calcium (Ca). Chelation (i.e. immobilization) of Mn and other micronutrients in the plant by glyphosate is related to the initial foliage yellowing (chlorosis) observed after herbicide exposure. The duration of the yellowing relates to the ability of the plant to absorb additional Mn from the soil (Bott et al.; 2008, Gordon, 2007; Reichenberger, 2007). Cakmak et al. (2009) showed that glyphosate treatment resulted in reduced levels of Ca, Mg, Mn and Iron (Fe) in seed and leaves of soybean suggesting that nutrient absorption from the soil by root was also reduced.

Other studies indicate that glyphosate can impact soil health. When glyphosate is absorbed by a plant, it can translocate through the plant and is often exuded from the plant roots (Laitinen et al., 2005) where it can have an immediate effect on soil organisms at the root soil interface (Kremer et al., 2005). Glyphosate is a potent mico-herbicide with toxicity to earthworms, myorrirhizae and many microbes (Kremer and Means, 2009) that are important in soil nutrient cycling and ensuring nutrient availability for plant uptake. Glyphosate has been shown to inhibit soil bacteria important in nitrogen fixation and nitrification, i.e. ensuring the biological availability of nitrogen (Hutchinson, 1995; Eberbach & Douglas, 1983). In addition, glyphosate has been shown to inhibit mycorrhizal fungi associated with plant roots that are important in plant phosphorus uptake (Estok, et al., 1989; Chakravarty & Chatarpaul, 1990; Sidhu & Chakravarty, 1990; Chakravarty & Sidhu, 1987). While glyphosate inhibits some soil organisms, it stimulates others. However, the end result is the same: a reduction in nutrient availability for plants. For example, glyphosate has been shown to stimulate growth of oxidative microbes that immobilize nutrients, making them unavailable for root uptake (Huber, 2010).

In addition to these effects on soil health and nutrient availability, glyphosate also inhibits enzyme activity important in protecting plants from microbial attack (Granson & Jenson, 1988). The chelation of Mn by glyphosate affects many other important enzymes in the shikimic acid pathway that generate products important in plant responses to stress and pathogen defense. The compounds include amino acids, hormones, phytoalexins, phenols (Hernandez et al., 1999) and flavonoids. Without production of these defense compounds, the plant becomes more sensitive to soil borne pathogens such as *Fusarium* (Fernandez et al., 2009), *Pythium, Phytophtera, Rhizoctonia* (Larsen et al., 2006; Smiley, 1992), anthracnose (Johal and Rahe, 1984), and take-all disease in wheat (Mekwatanakarn & Sivassithamparam, 1987). These effects on soil health, nutrient availability, and vulnerability to microbial attack may affect plant health in the long-term in the form of plant injury, stress, stunted growth or reduced productivity.

In addition to this increased plant susceptibility to disease, the growth of several pathogenic organisms in the soil are stimulated by glyphosate (Huber, 2010) (Box 2). Such pathogens include those causing bacterial and fungal root rot, crown and stalk rot and disruption of nutrient uptake (Huber, 2010).

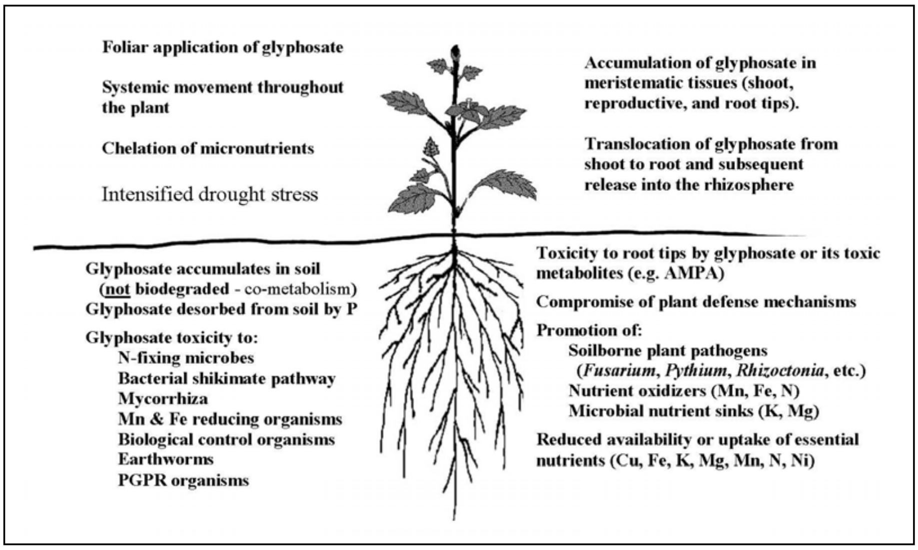
Box 2. *Some plant pathogens stimulated by glyphosate(Source: Huber, 2010)*

Botryospheara dothidea Gaeumannomyces graminis
Corynespora cassicola Magnaporthe grisea
Fusarium species Marasmius spp.
F. avenaceum Monosporascus cannonbalus
F. graminearum Myrothecium verucaria
F. oxysporum f.sp. cubense Phaeomoniella chlamydospora
F. oxysporum f.sp. (canola) Phytophthora spp.
F. oxysporum f.sp. glycines Pythium spp.
F. oxysporum f.sp. vasinfectum Rhizoctonia solani
F. solani f.sp. glycines Septoria nodorum
F. solani f.sp. phaseoli Thielaviopsis bassicola
F. solani f.sp. pisi Xylella fastidiosa
Clavibacter michiganensis subsp. *Nebraskensis* (Goss' wilt)

Due to the factors discussed above, several researchers have suggested that plants exposed to glyphosate may be injured or killed due to pathogenic activity (Joral & Rahe, 1984; Levesque & Rahe, 1992; Johal & Huber, 2009). For example, plants growing in soil containing pathogens are more readily damaged after glyphosate exposure (Peerbolt, 1995).

Consequently, glyphosate — whether sprayed directly onto a plant or through lower-dose exposure from drift — can have significant influences on overall plant growth. These influences include biochemical mechanisms, impacts on the plant-soil environment, microorganism interactions important in nutrient availability and uptake by plants and susceptibility to environmental biotic stresses such as disease (Figure 13). These secondary effects of glyphosate sprayed to eradicate coca crops may contribute to injury to non-target plants in the Ecuador-Colombia border region.

Figure 13. *Schematic of glyphosate interactions in soil (Source: Huber 2010).*



VII. Conclusion

Spray drift resulting from aerial spraying of coca crops in Colombia would be expected to cause plant injury at distances of at least 10 kilometers from the site of application. Thus, aerial applications within 10 kilometers of the Ecuador-Colombia border could cause significant harm to non-target plants in Ecuador. Previous studies of plant dose-responses to glyphosate are not necessarily representative of the ecosystems affected. Therefore, tropical crop plants and other sensitive plant species may face an increased risk as compared to plants for which there is available dose-response information. Additional factors, including environmental conditions and secondary effects caused by glyphosate may further contribute to injury in non-target plants in Ecuador.

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Annex 3

Appendix 1. Curriculum Vitae of Stephen C. Weller

Annex 3

Stephen C. Weller
Department of Horticulture and Landscape Architecture
Purdue University
625 Agriculture Mall Drive
West Lafayette, IN 47907-2010
Phone: 765-494-1333
FAX: 765-494-0391
EMAIL: weller@ purdue.edu

1. **Education**

Degree	University	Field	Year
B.S.	Central Michigan University Mt. Pleasant, MI	Biology	1971
M.S.	The Ohio State University Columbus, Ohio	Horticulture	1976
Ph.D.	North Carolina State University Weed Raleigh, North Carolina	Science	1980

2. **Positions:**
   1980-1985, Department of Horticulture, Purdue University, Assistant Professor
   1985-1990 , Department of Horticulture, Purdue University, Associate Professor
   1990-present, Department of Horticulture and Landscape Architecture, Purdue University, Professor
   Responsibilities: 50% research, 30% teaching, 20% extension in weed science

3. **Honors and Awards**
   ESCOP/ACOP Fellow, 1993
   Fellow, North Central Weed Science Society, 2000
   Fellow, Weed Science Society of America, 2002.

4. **Membership in Professional Societies:**
   American Society for Horticultural Science (Member)
   American Society of Plant Biologists (Member)
   Weed Science Society of America
   North Central Weed Science Society
   International Society of Horticulture Science

5. **Courses:**

   A. **University Credit Courses:**
      HORT 652A. Weed Biology. 1985-1987.
      HORT,BTNY,BIOL 650N. Seed and Bud Dormancy.1986 and1988.
      BTNY 504. Advanced Weed Science,1987.
      HORT 601. Planning and Presenting Horticulture Research,1989-1997.
      HORT 652W. Herbicide Resistance Mechanisms in Plants.1993.
      HORT 401. Horticulture Production Technology, 1994-2007.

Hort 417. Organic Production in Horticulture Crops, 2006-2008.
SA21233 – Comparison of organic and conventional agriculture in Europe, 2005,2007, 2009, Maymester class
Hort 422. Vegetable Production, 2008-present.
Hort 491. Principles of Organic/Sustainable Agriculture, 2011.

B. Continuing Education Courses

'Understanding Weeds – A Practical Course on the Biology of Weeds', Purdue University 1 week intensive short course. 1982 and 1984
'Herbicide Action- An Intensive Course in Herbicide Use', Purdue University, 1 week intensive short course. 1980-2003.
Graduate Student training: 1980 – present, Major Professor of 12 Ph.D. Students, 13 MS Students, 5 Post Doctoral Fellows, committee member on over 50 graduate committees.

6. **Extension Contributions**

A. Duties:

Responsible for weed control recommendations in all horticulture crops in Indiana. Contributor to Production Guides for fruit, vegetable and ornamental crops from 1980 to present. Basic responsibilities are to provide expertise in weed control for extension specialists. The extension program is conducted to accomplish the following goals: 1) provide technical information to the horticulture extension specialists to aid them in advising growers on weed control problems, and 2) write recommendations for growers on how to control weeds with existing herbicides. Other functions include writing extension bulletins or newsletters as needed for special problems, presenting talks at grower meetings and answering questions about weed control and assisting in gaining registrations for new herbicides via Section 18's, 24-C State labels and Section 3 national labels. Dr. Weller has given over 250 extension talks to vegetable, fruit, ornamental and mint producers since 1980.

B. High Impact Programs:

'Understanding Weeds – A Practical Course on the Biology of Weeds' taught during 1982 and 1984 and coordinated by Dr. Fred Warren. I prepared lectures on 'Weed Seed Dormancy, Periodicity of Weed Seed Germination and the biology of Field Bindweed' and coordinated all daily laboratory exercises. This course was taught to 30 weed science professionals each session.

C. Herbicide Action- An Intensive Course in Herbicide Use:

This course has been taught at Purdue University since 1980 and has provided education on how herbicides work and are used in agriculture to professional weed scientists. The course has been attended by over 2000 weed science professionals in the 24 years it was held and provided needed continuing educational training to herbicide company personnel, agricultural crop advisers, university weed scientists and students. This course set the standard for continuing education in weed science and attracted participants from around the world. The course emphasized weed management, herbicide use and their action in plants and issues regarding weed management. Course participants are provided with a notebook of over 800 pages that covers all aspects of herbicides and their use. Dr. Weller was an instructor and assistant to Dr. Fred Warren from 1980 until 1994 and has been the sole coordinator of the course since 1995.

7. Research Contributions:

A. **Mechanisms of glyphosate resistance in Giant Ragweed.** Weed resistance research has been ongoing in Dr. Weller's laboratory his entire career at Purdue University. This research has concentrated on variation in weed populations response to glyphosate and how this relates to their growth biology and herbicide response. The significance of these studies is that they provided evidence that multiple mechanisms are involved in the resistance response of giant ragweed to glyphosate. Mechanisms include growth biology, genetics and numerous physiological and biochemical reactions. Initial studies showed that absorption and translocation of glyphosate could not account for the differences in susceptibility and that the target enzyme of glyphosate, 5-*enol*pyruvylshikimate-3-phospahte synthase (EPSPS) was not altered in the resistant biotype.

B. **Studies investigating non-target site resistance in weeds.** Arabidopsis is being studied as a model plant in relation to how sub-lethal doses of herbicides from various herbicide mode of action families influence expression of genes. Genes involved in the injury response are being identified.

C. **Effects of off-site herbicide movement to vegetable crops.** Studies involve investigating how low-dose application of herbicides, 2,4-D, dicamba and glyphosate and combinations of these herbicides result in growth inhibition and yield effects of vegetable crops.

D. **Alternative approaches to weed management in horticultural crops in organic and conventional production.** Investigations of alternative approaches to weed management in vegetable crops using cover crops have concentrated on the effects of various fall and spring seeded cover crops for use as aids to reduce problem weeds in vegetable cropping systems. Vegetables are at risk crops from a weed control view because there are not a large number of herbicides available for use, weed control costs are high and US consumers are concerned about pesticide inputs and food safety. The objectives of this research have been to develop systems using reduced chemical tools that are effective, practical and have potential for acceptance by commercial vegetable growers. The research has shown that there are several cover crops that have potential in certain situations to provide acceptable weed control while reducing the need for herbicides or mechanical weed removal.

E. **Weed management and crop improvement in mint**. This research is designed to improve methods for managing weeds with chemicals in Indiana mint production fields and has resulted in data to support registration of new herbicides either through emergency exemptions (Section 18) or through IR-4. Research has resulted in assisting with the registration of sethoxydim, haloxyfop, pyridate, clopyralid, sulfentrazone and pendimethalin. In addition to new herbicide registrations, current research includes establishing critical weed infestation periods in row and meadow mint and investigations relating to the *Amaranthus* weed complex found in mint and methods for using GPS for site-specific weed management in mint fields.

As a result of involvement in mint weed research and biotechnology expertise available at Purdue University, in 1990 additional research was funded to develop regeneration and transformation systems for mint crop improvement. This research has resulted in the development of an efficient peppermint regeneration and transformation system that makes it possible to transform peppermint with any gene of interest. This research is critical to the short- and long-term sustainability of the US mint industry. Projects have been completed for inserting herbicide resistant genes into peppermint and current research is investigating the potential for identifying and transforming mint for resistance to *Verticillium* wilt disease and increased crop productivity.

8. International Activities:

Dr. Weller has over 24 years experience in international research, teaching and extension in pest management and cropping systems development, and training in Central America (Guatemala and Honduras), Mexico, Ukraine, Uganda, Kenya and Tanzania. His areas of specializations include: research on and implementation of integrated crop and pest management production systems for vegetable crops; development of tissue culture systems to study plant responses to herbicides; and *in vitro* regeneration and transformation systems for crop improvement. Dr. Weller has been an IPM CRSP-Central America principal investigator for 15 years working to enhance their NTAE (Non-traditional Agriculture Exports) capability; and served as Site Chair for Central America for 5 years. Recently, he has been PI for vegetable research with African Indigenous Vegetables in Kenya as part of the USAID Horticulture CRSP Project.

Specific Activities:

a. 1/2010 -1/2011 Principle Investigator of USAID Hort CRSP project: **Indigenous African Leafy Vegetables (ALV) for Enhancing Livelihood. This project involves evaluating** species including spider plant (*Cleome gynandra*), African *nightshades (Solanum scabrum/S. villosum/S.americanum/S. tarderomotum*) and amaranths *(Amaranthus blitum/A. dubius/A. hybrdus /A. spinosus*)) which are indigenous ALVs that contain higher levels of nutrients than commonly grown exotic species like Swiss chard, kale and cabbage and are rich in proteins, carbohydrates, vitamins and minerals and have medicinal properties. The goal is to establish a base of information and experience for greater production and use of indigenous vegetables that in the long-term will provide a source of food for economic security and improved nutrition, health for Kenyans, especially those afflicted with HIV/AIDs and women farmers. Activities include imparting knowledge on ALV germplasm, establishing/improving local seed banks, providing quality seeds for production, transfer of improved production techniques to stakeholders, organization of self-help groups and farming and market analysis surveys.

Participatory approaches are being to achieve these project goals and impact target groups.

b. 9/2004-5/2005 **Lead Purdue University member** of the Global Horticulture Assessment Team lead by the University of California, Davis with collaborating partners from the University of Hawaii, Michigan State University and Purdue University. The project was funded by USAID. The Global Horticulture assessment was an in depth, analysis of opportunities and challenges for global development of horticulture. This assessment resulted in a list of recommendations to USAID for horticulture research and capacity building in the developing world.
c. 9/1993–9/2004 **U.S. Site Chair,** Central American site (including Guatemala and Honduras), USAID IPM/CRSP Grant, "Participatory IPM: a model for implementing pest management in a global context," Central America. The IPM Collaborative Research Support Program (CRSP) project involves research in non-traditional export crops in Central America. Crops include snow peas, sugar pod peas, broccoli, melons, tomatoes, peppers, and small fruits such as brambles. Primary pests include insects, disease, and weeds. Research goals are to develop integrated pest management production practices that reduce the use of synthetic chemicals in these crops and ensure the crops produced are of high quality and suitable for export to U.S. markets. Primary responsibilities involve research in non-traditional agriculture export (NTAE) crops in pest control, development of integrated and sustainable production systems, and development of pre-inspection programs that would position Central American growers to meet all the sanitary and phytosanitary requirements for NTAE crops imported into the U.S. Research involves various aspects of integrated pest management research and working with grower groups of the Guatemalan and U.S. government agencies (APHIS) to institute pre-inspection programs and to develop regional distribution centers that serve as educational and gathering centers for export crop producers of NTAE crops to assist in providing sustainable markets for small growers in-country, regionally, and internationally.
d. 9/2004 – Present **Co-Principal Investigator**, USAID/IPM CRSP Grant "IPM in Latin America and the Caribbean: Crops for Broad-based Growth and Perennial Production for Fragile Ecosystems". Work focusing on pest management strategies for targeted crops in Honduras and Ecuador.
e. 1982 –1983 USAID Project in Honduras 'Developing Fruit and Vegetable Production in the Camayagua Valley'. Project emphasis was improved tomato production in Honduras and the need for improved weed management of problem annual and perennial weeds. A production guide in Spanish "Guia Technica para la Producion de Tomates en el Valle de Comayagua' by E.C. Tigchelaar, F. Maradiaga, G. E. Wilcox and S. C. Weller, was developed for Honduran farmers was generated and is still used by growers.
f. 1992-1994 Melon Project funded through Purdue University to develop integrated muskmelon production in Monterey Mexico for shipment to Indiana during the off-season. Involvement included improving the overall cultural practices and reducing weed problems.
g. 1998 Lead member of a Participatory Appraisal Team to evaluate agricultural production systems in the Obelisk of Odessa in Ukraine in September of 1998. This team evaluated current production practices and recommended IPM instructional programs that

were subsequently conducted by joint teams of U S and Ukraine scientists during 1999 as part of a USAID IPM program in Ukraine.
9/2003-4/2005

h. Team Member, USAID Global Horticulture Assessment Project to determine the global issues facing the horticulture industry in the developing world.
i. Member of Purdue Assessment team for agriculture assessment of research needs for AMPATH project in Kenya, April, 2008.
j. Member of Purdue Assessment team for Uganda Martyrs University Farm operation and activities, March, 2009.
k. Herbicide Action short course in Honduras for agriculture Technical personnel, Zamorano University, October, 2009.
l. Member of Purdue assessment team for agriculture activities in Jordan and Palestine, March, 2010.

9. Publications:

A. Refereed Papers

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Bordelon B., Weller S.C. 1997. Pre-plant cover crops affect weed and vine growth in first-year vineyards. HortSci 32:1040-1043.

Niu X., Hasegawa P.M., Bressan R.A., Weller S.C. 1998. Transgenic peppermint plants obtained by co-cultivation with *Agrobacterium tumefaciens*. Plant Cell Reports 17:165-171.

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Weller, S.C. and G.E. Sanchez. 2009. Integrated crop management strategies for sustainable production of non-traditional agriculture exports: Snow peas in Guatemala. Chronica Hoticult. 49:19-21.

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B. Book Chapters:

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Weller S.C., Frank J.R. 1989. Paul C. Marth and John W. Mitchell. 1944. 2,4-diclorophenoxyacetic acid as a differential herbicide. Bot. Gaz. 106: 224-232. In, Classic Papers in Horticultural Science, ed. by Jules Janick, Prentice-Hall, Inc., Englewood Cliffs, NJ, pp. 324-336.

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Weller S.C., Owen M.D.K., Johnson W.G. 2010. Managing Glyphosate Resistant Weeds and Population Shifts in Midwestern US Cropping Systems. Chapter 12 in: Glyphosate Resistance in Crops and Weeds: History, Development, and Management, edited by Vijay K. Nandula. John Wiley and Sons, Inc., New York.

C. Books:

Weed Science, Principles and Practices 2002. Thomas J. Monaco, Stephen C. Weller, and Floyd M. Ashton. John Wiley and Sons, Inc., New York.

D. Major Extension and Nontechnical Publications:

Indiana Commercial Tree Fruit Spray Guide, Purdue University, Agricultural Extension Service: Agricultural Experiment Station. 1980-2010. Contributor.

Commercial Small Fruit and Grape Spray Guide, Purdue University, Agricultural Extension Service: Agricultural Experiment Station. 1980-2010. Contributor.

Indiana Vegetable Production Guide for Commercial Growers, Purdue University, Agricultural Extension Service. 1980-2010. Contributor.

Midwest Tree Fruit Handbook.1993. Purdue University Cooperative Extension Service. Contributor.

Midwest Small Fruit Pest Management Handbook. 1997. The Ohio State University, Bulletin 861. Contributor.

10. **Research Funding**.

A. Research Grants/Support: Since 2000)

Mary Rice Grants, 2007-2010: $40,000.
Mint Crop Improvement. 2000-2010, From: Mint Industry Research Council to Purdue University $400,000.
Indiana Mint Market Development & Research Council: 2000-2010: $45,000.
Mid-American Food Processors Association grants from 2000-2010 to support weed management projects in tomatoes: $32,000.
Misc. Industry Gifts to support herbicide research in vegetables - 2000-2010:$ 100,000.

Investigations of Corn Rootworm, Diabrotica spp., and Weed Species within Stacked and Non-Stacked Trait Transgenic Cornfields. $176,400 Monsanto Company 08/2003-07/2005 *(with:* Bledsoe, Larry; Edwards, Richard; Preckel, Paul; Martin, Marshall; Johnson, Bill; Alexander, Corinne)

Participatory IPM: A Model for Implementing Pest Management in a Global Context. $14,000. USAID IPM CRSP. 9/01/03-98/31/04

Integrated Weed Management in Vegetables. $98,110 NC-IIPM. 8/02-7/04. *(with:*Hirst, Peter; Pecknold, Paul; Foster, Rick)

Organic Production Systems for Apples in the Midwest. $63,432 NC-IMP. 4/13-4/06. *(with:* Gibson, Kevin; J. Masiunas)

Glyphosate Resistant Horseweed: Prevalence, Distribution and Areas at Risk in Indiana and Ohio. $37,000 USDA Special Grants Program for Critical & Emersing Pests. *(with*Gibson, Kevin; Johnson, Bill; Jeff Barnes; Mark Loux, John Cardina and Jeff Strachler, The Ohio State University and Ed Luschei, University of Wisconsin)

Weed Community Shifts and Management in the Conversion to Organic Production. $97,492 NC-IPM. 8/02-7/05. *(with:* Gibson, Kevin)

Organic Agriculture Research at Meigs Farm. Experiment Station. $50,000.00 from Purdue Agriculture Research Programs. 1/1/2005-12/31/2005.

Reduced Risk Nightshade Management for Tomatoes. USDA-RAMP - Purdue. $634,830.00. 2001-2004.

Seed Bank Dynamics in Alternative Vegetable Cropping Systems. USDA, NC-IPM - Purdue. $100,000.00. 2002-2004. (*with:* John Masiunas, University of Illinois)

Crops for Broad-Based Growth and Perennial Production For Fragile Ecosystems. IPM In Latin America and the Caribbean: $25,358.00. 10/01/2005-09/30/2006; $24,358,05/06; $25,400, 06/07; $27,000, 07/08; $25,000, 08/09; $45,000, 09/10.

Hi-Tunnel Research Development: Purdue Mission Oriented Grants – Agriculture Research Programs/Extension – $20,000, 4/08.

Site Specific Weed management for Indiana Mint Production – $39,927, 8/02. Specialty Crops Block Grant, State of Indiana.

Glyphosate-Resistant Horseweed: Prevalence, Distribution, Areas At Risk In Indiana And Ohio. Cooperative State Research Service USDA. $37,962.00. 07/01/2004-06/30/2006. (*with:* Barnes, Jeffery, W, Johnson, William, G, Gibson, Kevin, D).

Seed Bank Dynamics in Alternative Vegetable Cropping Systems. Cooperative State Research Service USDA. $100,000.00. 07/01/2003-06/30/2006 (*with:* Gibson, Kevin)

Weed Community Shifts and Management Options In The Conversion To Organic Production Systems. University Of Nebraska. USDA. 93,375.00. 07/01/2002-06/30/2006. (*with*: Kevin Gibson).

Integrated Weed Management Systems In Vegetable Crop Production. Cooperative State Research Service USDA. $27,912.00. 04/01/2002-03/31/2006. (*with:* Kevin Gibson)

Ensuring long-term sustainability of Roundup Ready Cropping Systems, $880,000, Monsanto Company, 2005-2011.

Indigenous African Leafy Vegetables (ALV) for Enhancing Livelihood USAID from University of California, Davis, $150,000, 1-1-2010- 12-31-10,

B. Professional Contributions Outside of Weed Science

1980 to present – Member Vegetable Crops Working Group of American Society for Horticulture Science.

Reviewer for Journal of ASHS and HortScience and Plant Physiology Journal, Weed Science andWeed Technology.

1980 to present – Researcher Member of Mint Industry Research Council and regular contributor to the annual mint growers meetings both nationally and in mint growing states.

Contributor to International Training Program in New Crops: Aromatic and Medicinal, Purdue University, 1997, 1998 and 1999, and 2000; presented talks on Weed Management Systems for Herbs and Molecular Approaches for Crop Improvement.

1985 – 1989 – Member, NC-121 Project 'Integrating Crop Culture, Chemicals and Life Cycles to Control Persistent Weeds', Vice Chair, 1986, Chair, 1987

1989, 1990 & 1991, 2000, 2001 - Panel Member USDA-Competitive Grants Weed Science/Plant Pathology

1990, 1992 – Panel Member Southern Regional IPM

1993 – Panel Manager, 1st Weed Science NRI Competitive Grants Program

2000 – Panel Member, USDA Methyl Bromide Alternatives Panel

2001 – Panel Manager, USDA, Methyl Bromide Alternatives Panel

2007,2008 2009 – Panel member, Western Region IPM Competitive Grants Program

C. Elected or Appointed Offices or Major Posts in National and Regional Weed Science Organizations

1981–1987 Mem ber WSSA IPM Committee

1986–1989 Mem ber WSSA Teaching Committee

1987-1990 Chair, WSSA Necrology Committee

1988–1995 Associate Editor, Weed Science

1989 Chair, WSSA Physiology Section

1988–1992 Chair WSSA Competitive Grants Committee.

1990 Chair of Physiology Symposium 'Recent Advances in Herbicide Mechanism of Action' at WSSA Annual Meeting.

1998 Member, WSSA Research Committee, Chair, 2000- 2003
Invited Speaker at 'Genomics in Weed Science Symposium' at 2000 WSSA annual Meeting.

2007-2009 Member NCWSS Fellows Committee

2008- present Member WSSA Fellows Committee

1982 Chair Horticulture Section

1982 Coach of Purdue University Weed Science Team at the NCWCC Weed Competition

1983 hair Turf and Aquatics Section

1985-1988 NCWSS Board of Directors, Indiana Representative

1986-1988 NCWSS Resident Education Committee
Chair of Graduate Student Poster Competition 1986
Chair of Graduate Student Paper Competition 1987
Committee Chair 1988, Chair, Weed Contest

1998 to present NCWSS Awards Committee
NCWSS Graduate Paper or Poster Competition Judge: 1985, 1989, 1995
1998, 1999, 2009.

Appendix 2. Examples of Glyphosate Injury to Plants.

Annex 3

Figure A. *Glyphosate Injury to strawberry plant.*

Figure B. *Glyphosate injury to almond showing irregular leaf regrowth after exposure.*

Annex 3

Figure C. *Glyphosate Injury to Cosmos plant.*

Figure D. *Glyphosate injury to pepper.*

Figure E. *Glyphosate injury to Redbud.*

Annex 4

Henrik Balslev, Ph.D., *The Vulnerability of the Ecuador-Colombia Border Region to Ecological Harm* (Jan. 2011)

The Vulnerability of the Ecuador-Colombia Border Region to Ecological Harm

Henrik Balslev

January 2011

Table of Contents

Executive Summary

Ecuador's border region with Colombia is comprised of a number of ecosystems rich in biodiversity and environmental resources. The eastern part of the border region is dominated by the lowland Amazon rainforest, a smooth green carpet of vegetation punctuated by emergent trees that reach above the rainforest canopy. Despite the forest's even appearance as seen from above, it harbors a tremendous number of plant and animal species per unit of area. Stepping up in elevation from the lowland Amazonian rainforest are mountain forests and then cloud forests on either side of the Andes. Particularly on the western side of the Andes, these moist mid-elevation ecosystems are amongst the most biodiverse and pristine in the world. The western side of the border region is made up of the lowland Chocó rainforest, which is part of a so called global "biodiversity hotspot" due to its exceptional concentration of endemic species (*i.e.,* those found no where else in the world), many of them threatened with extinction. The border terminates on the west coast with a mangrove ecosystem with both marine and terrestrial life which provides support for human livelihoods. Ecuador has established a number of protected areas in the border region to conserve these environmental resources and to protect vulnerable indigenous groups, including three that are immediately adjacent to the Colombian border: the Cofán-Bermejo Ecological Reserve, the Awá Indigenous and Forest Reserve and the Cayapas-Mataje Ecological Reserve.

The tropical forest ecosystems that dominate the border region are complex, interconnected and vulnerable to environmental stressors. Environmental contamination may affect many species and has a particularly severe effect on sensitive plants such as epiphytes, which derive water and nutrients from droplets suspended in the air rather than from the soil. The border region's network of rivers and creeks maintains the hydrological balance of the border ecosystems but also serves as a transporter of contamination from one area to another. Due to the complex interactions between tropical forest species, when one species dies or becomes weakened, it may produce a chain reaction, affecting other species linked to it through trophic relationships (*i.e.,* the "food chain") or other synergisms. The border region has a high incidence of species that are endemic and threatened with extinction. Therefore, environmental damage may cause the permanent loss of species and some of these changes may even go undetected by science. The most vulnerable parts of a forest ecosystem may be the "edges" created by forest fragmentation or defoliation. The "edge effect" may enhance the sensitivity of the ecosystem to stressors such strong winds, temperature changes and droughts or trigger an increase in invasive or exotic plants. As a result, forest plants may suffer from higher mortality, structural damage, or changes in species composition and these impacts in turn may affect the viability of other species. Tropical forests are subject to continuous natural changes due to events such as tree falls and other physical and biological factors. Thus, human-induced environmental changes influence a "moving target", making the precise impacts on the ecosystem uncertain. In short, even a low level stressor has the potential to cause much greater effects to Ecuador's rich border ecosystems.

I. Information About the Author

Henrik Balslev has an M.Sc. from Aarhus University, Denmark (1978) and a PhD from City University of New York, based on research carried out at The New York Botanical Garden (1982). After graduating, he was director of the herbarium at Pontificia Universidad Católica del Ecuador until 1984 when he returned to his native Denmark to take up a position as associate professor at Aarhus University. He was promoted to Senior Associate Professor in 1989 and to full professor in 1997. He spent a leave from Aarhus as Professor of Botany at Pontificia Universidad Católica del Ecuador from 1995–1997. Henrik Balslev has visited Ecuador every year since and has continued his educational and research activities in close collaboration with colleagues in Quito. He has travelled extensively in Ecuador and other countries in Latin America, especially Mexico, Colombia, Peru and Bolivia. He knows every corner of Ecuador and has often visited and carried out field work in the Colombia-Ecuador border region over the years. His specialty is botany and within that he covers a broad range from taxonomy to floristic studies (inventory), plant community ecology and plant reproductive ecology. Professor Balslev also studies the relationship between humans and plants and has done several ethno-botanical studies among the indigenous communities of Amazonian Ecuador. He is particularly interested in the palm family and has published extensively on palms and palm communities. Professor Balslev has supervised 25 Ph.D. students and 44 M.Sc. thesis students at the universities in Aarhus and Quito, and many of these students are now in academia and research administration. He has published over 150 research papers in international journals and 12 books, apart from many popular science contributions. Seven of his botanical colleagues have honored him by naming new plant species after him (*Centropogon balslevii* Jeppesen, *Phoradendron balslevii* Kuijt, *Parkia balslevii* Hopkins, *Disterigma balslevii* Luteyn, *Cynanchum balslevii* G. Morillo, *Anthurium balslevii* Croat & J. Rodriguez, *Boehmeria balslevii* Friis & Wilmot-Dear). He is a member of the Royal Danish Academy of Sciences and Letters and of the Danish Natural Science Research Academy, he was awarded a Golden Medal by Charles University in Prague (Czech Republic) in 1998 for his contribution to tropical botany, and he was awarded an honorary doctorate by Pontificia Universidad Católica del Ecuador in 2009 for his contribution to Ecuadorian botany. He has served on many national and international boards and committees; currently he is a member of the Danish Natural Science Research Council. Professor Balslev's complete curriculum vitae is attached as Appendix 1.

II. Nature and Complexity of Ecuador's Border Ecosystems

A. An Introduction to Ecuador's Border Ecosystems

The Ecuador-Colombia border reaches from Güepi (0°07'08"S; 75°15'27"W) on the Putumayo River in the western Amazon basin some 430 km to the WNW ending at the Pacific coast at the mouth of the Mataje River (1°28'03"N; 78°52'03"W). Along this stretch the border crosses a number of ecosystems including lowland Amazon rain forest on the western edges of the Amazon basin at 200–700 m elevation, east-Andean mountain forests at 700–2,500 m elevation on the east-Andean slopes, cloud forest from 2,500–3,500 m elevation, treeless tussock-grass páramo vegetation above the timber line, high mountain ecosystems crowned by the Chiles volcano (4,768 m), cloud-forests at 2,500–3,500 m elevation on the western slopes of the Andes, lowland Chocó rain forest on the plains towards the Pacific coast, and mangroves along the coast line. This enormous diversity of ecosystems reaching from steaming tropical forest to barren and permanently frozen mountain tops houses a corresponding diversity of plants and animals; each ecosystem has its own set of species adapted to the special climatic and other ecological conditions in the elevation zones. And the two faces of the gradient from lowland to the highest mountain tops are different. The eastern slopes border the enormous Amazon basin and carry strong Amazon imprints on both their cultural and biological diversity. The western slopes include the coastal mangrove ecosystem and the Chocó rain forest, which is a rare example of a pluvial rain forest that has adapted to climatic conditions in one of the highest rainfall areas in the World. This report focuses primarily on the ecosystems along the border most vulnerable to harm from herbicide drift or direct spray from Colombia's aerial spraying program (Figures 1 and 2). These ecosystems are important not only for their intrinsic natural qualities but also because they provide raw material, food, clean water, a clean atmosphere and many more things to human societies (Calow 1998, Millennium Ecosystem Assessment 2005).

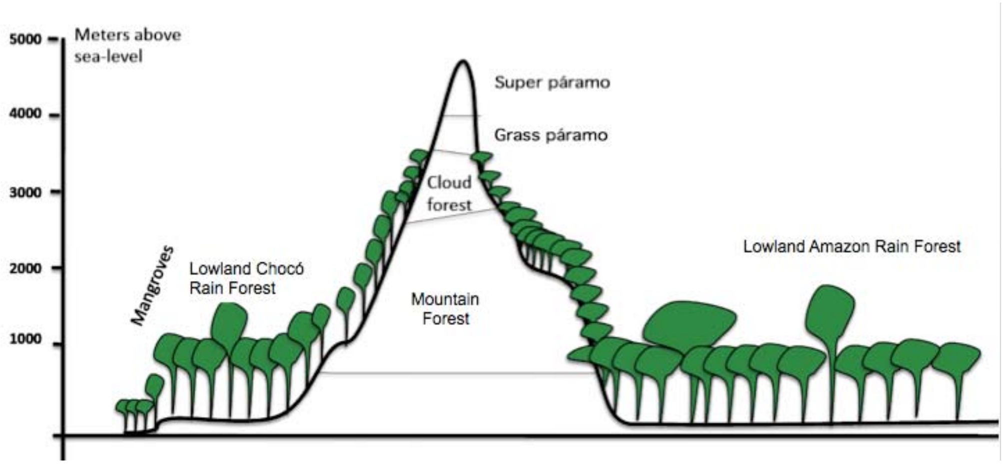

Figure 1. *Altitudinal profile of Ecuador's border ecosystems*

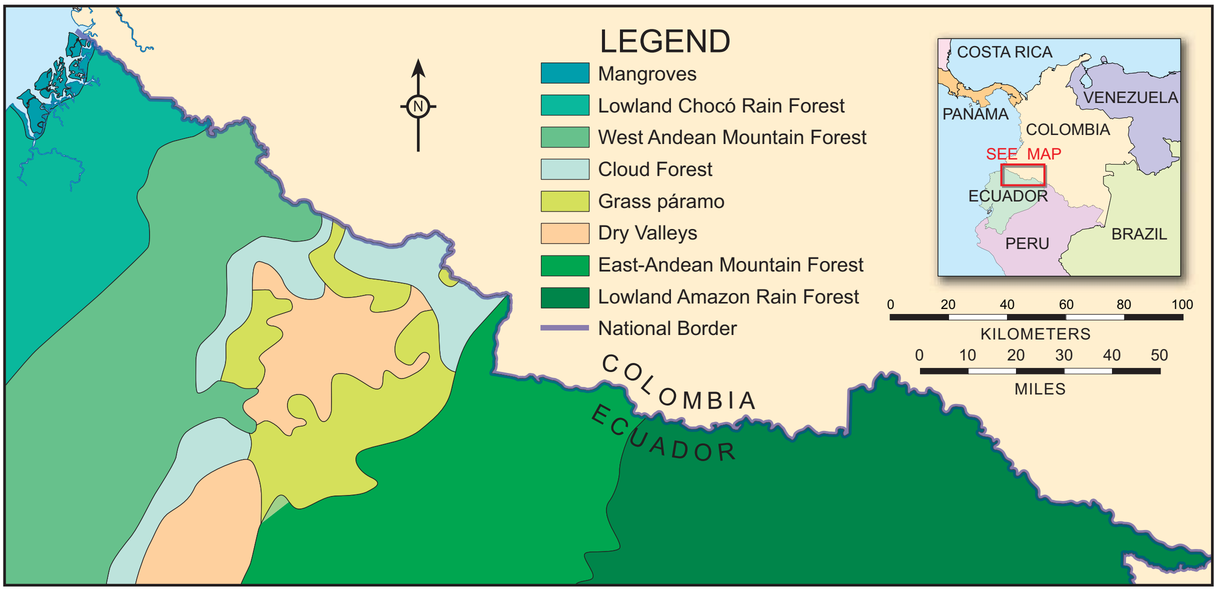

Figure 2. *Location and extent of Ecuadorian border ecosystems.*

1. *Lowland Amazon Rain Forest*

Lowland Amazon rainforests represent the natural vegetation along the greater part (*i.e.,* some 260 km) of the Ecuador-Colombia border. Lowland tropical rainforests are found along the equatorial line in tropical America, Africa and southeast Asia, in areas with high temperatures and rainfall and without or with only very short dry season, *i.e.,* monthly temperatures above 18°C during all months of the year, annual rainfall above 2000 mm, and no month with less than 100 mm rainfall (Richards 1996). The Amazon tropical rain forest covers the entire Amazon basin, from Venezuela in the north to Bolivia in the south and from its western fringe – that include Colombia, Ecuador and Peru – to the east along the Atlantic coast. The Amazon forest of the Ecuador-Colombia border region is on the very western edge of the Amazon basin and is limited by the Andean slopes.

Structurally the tropical lowland rain forest is dominated by large broad-leaved, evergreen trees that usually have huge, straight trunks with a terminal crown that form a dense canopy layer approximately 30-35 meters above the ground (Figure 3). Common tree species of the forest canopy in the region include *Parkia multijuga*, *Hymenaea oblongifolia*, *Schizolobium parahyba*, *Dussia tesssmannii*, *Sterculia colombiana*, *Otoba parvifolia*, *Pseudolmedia laevis*, *Pouteria multiflora*, and *Erisma uncinatum* (Neill 1999). A few trees may be up to 65 m tall and stick out of the closed canopy – they are called emergents (Balslev et al. 1987). *Cedrelinga cateniformis* is a common canopy emergent tree throughout lowland Amazonian Ecuador on well-drained sites; *Ceiba pentandra* is a frequently observed emergent on richer alluvial soils. In a mature forest, the canopy is often so dense that most of the understory has been shaded away, and the forest has the appearance of grandiose construction with a roof supported by pillars. More often however the forest is regenerating after a tree fall or sometimes after blow-downs that have affected a larger patch, and the understory is then filled in with other plants. Sub-canopy palms, especially *Iriartea deltoidea* and *Oenocarpus bataua*, are abundant. The forest floor usually has many shrubs and treelets, and slender individuals of the same species that form the canopy are often found in large numbers as if they are waiting for a tree fall which will give them light enough to grow up into the canopy. Listings of tree species from the eastern lowlands of Ecuador give ranges from 1000 species (Neill & Palacios 1989) to 1200 (Renner *et al.* 1989) to 1356 (Jørgensen & León-Yánez 1999).

Figure 3. *Lowland Amazon Rain Forest in Ecuador, showing the different layers of the forest. (Source: H. Navarrete).*

Apart from the trees, large woody climbers (lianas) are often conspicuous in the lowland tropical rain forest. They are rooted in the ground, attach to a large tree when it is young and then follow it upwards as it grows into the canopy. In that way only the flexible stems, which may be up to 10 cm thick, hang from the canopy, whereas the leafy portion and the reproductive parts of the liana develop within the canopy where light conditions are favorable. The number of liana species in eastern Amazonian Ecuador is estimated at 436 (Jørgensen & León-Yánez 1999). Figure 4 shows a view of the rainforest canopy from above, with lianas in the foreground.

Figure 4. *View of the rainforest canopy from above* (*Source:* Wolfgang Kaehler/Picade)

Epiphytes represent another conspicuous life-form in the tropical rain forest. These are plants that grow on the branches and trunks of trees and use them as substrate, but they do not send their roots into their host-plants so they are not parasites in a strict sense. The epiphytic life-form is mostly represented by mosses, lichens, ferns, orchids, and aroids whereas it is rare for other plants to grow as epiphytes. The epiphytes are most abundant in the canopy and this life-form has developed the capacity to grow on tree branches as an adaptation to environments that have favorable light conditions. At the same time, however, they submit themselves to very dry and nutrient poor conditions because, in the canopy there is no soil to keep the moisture and provide nutrients. Epiphytes therefore have many adaptations that are also found in desert plants; they have thick fleshy tissues that can store water or they have developed special structures that accumulate leaf litter so they build up small deposits of organic matter around their own roots. Epiphytes are represented by 565 different species in Amazonian Ecuador (Jørgensen & León-Yánez 1999). Figure 5 shows just one example.

Figure 5. *Epiphytes in Ecuador's Lowland Amazon Rain Forest.* (*Source:* Wolfgang Kaehler/Picade)

Ground herbs are not abundant in the closed tropical rain forest, but in open areas and along rivers and roads etc., they may be common. Their overall species richness of over 1,000 species is substantial (Jørgensen & León-Yánez 1999). Saprophytes are organisms that take up organic compounds from other organisms*, i.e.,* they are not photosynthetic; there are many saprophytes in lowland tropical rainforest, most of them being fungi and only few (maybe only 15 species; Jørgensen & León-Yánez 1999) of them being plants. Truly parasitic plants that send their roots into the host plant to obtain nutrients etc. also occur in rain forest, but as saprophytes they are not abundant and they are represented with less than 30 species (Jørgensen & León-Yánez 1999). Overall the Amazon region of Ecuador may house over 5,000 species of plants.

A special feature of the lowland tropical rainforest region is that it concentrates very high number of species in relatively small areas. It is said that it has high alpha-diversity. This has been demonstrated in forests very close to the Ecuador-Colombia border. In Reserva Faunistica de Cuyabeno, north of Laguna Grande and less than 40 km from the border with

Colombia, a one-hectare plot had 307 species of trees with stems thicker than 10 cm (Valencia *et al.* 1994). Other one-hectare study plots in Amazonian Ecuador have mostly yielded 200–240 species of trees >10 cm thickness (Balslev *et al.* 1987, Korning *et al.* 1991, Cerón & Montalvo 1997, Palacios 1997). There are only few species counts of other life-forms than trees in small plots, but in the same one-hectare plot mentioned above in Cuyabeno there were 96 species of ground herbs (Poulsen & Balslev 1991), 172 species of epiphytes, 99 species of lianas and 268 species of shrubs and small trees, giving a total of 942 species of vascular plants within an area of 100x100 meters (Balslev *et al.* 1998). In the Parque Nacional Yasuní, some 100 km away from the Ecuador-Colombia border, 1,104 species of woody plants with stems over 1 cm thickness have been documented in a 500x1,000 m plot (Romoleroux *et al.* 1997, Valencia *et al.* 2004a) which is a stunning alpha-diversity of just a single life-form in a single study plot.

Figure 6. *The tropical rain forest near the Colombia-Ecuador border at its eastern extreme near Güeppi (Source: Alverson et al. 2008).*

When flying over the lowland tropical rainforest of the western Amazon basin it appears as a smooth even green carpet (Figure 6). Studies over the past 15 years have however shown that in reality the forest is a mosaic of different forest types growing on a patchwork of soil types and small hills and valleys (Tuomisto *et al.* 1995, 2003, Valencia *et al.* 2004b). The largest distinction is between *terra firme* forest that is never inundated and floodplain forests that become inundated when the rivers overflow their margins in the rainy season. Rivers with so-called white water that is full of sediments and actually creamy-brown from the dissolved clay particles deposit large amounts of fertile mud when they overflow their embankments and inundate the flood plain. Areas flooded by these white water rivers are called *varzea* and such *varzea* floodplain forest often have abundant populations of large palms such as *Attalea butyracea* mixed in with large broad leaved trees (Balslev *et al.* 1987). When the floodplain is inundated with transparent, sediment free so-called black water (which is actually tea-colored from dissolved tannins) we find a different type of forest dominated by a distinctive suite of tree species including *Macrolobium acaciifolium*, the palm *Astrocaryum jauari*, and *Coussapoa trinervia* (Neill 1999). Within the *terra firme* forest there are also several distinctive plant communities, mostly depending on the topography which is created by erosion of a former plateau. The valleys, slopes and ridges have soil and humidity conditions that are different enough to sort the plants. In a study in the Yasuni National Park the ridges were dominated by *Memora cladotricha* and *Cedrelinga catenaeformis*, the slopes were dominated by *Rinoria lindeniana* and the valley bottoms were dominated by *Matisia obliquifolia* (Valencia *et al.* 2004b). These observations agree with the theory that the *terra firme* forest supports a very large number of niches and that each individual species in some way is associated to one or the other niche in this densely packed system. This in turn explains why so many species can grow together in relatively small areas.

The ecosystem services provided by the lowland Amazon rain forest are many and include services both to local indigenous communities and to society at large. The indigenous communities live in close association to the forest ecosystem and depend on it for providing hunting grounds, and for the extraction of very many different plants that they use for medicine, food, construction of houses, for making tools and utensils, and for ritual purposes (de la Torre *et al.* 2008).

2. ***East-Andean Mountain Forest***

On the east-Andean slopes, the Ecuador-Colombia border runs for some 65 km through terrain at elevations of 700–2,500 m. This is the zone of the mountain rain forests; these are very wet with high levels of humidity in the air, and with frequent rains and precipitation coming from mist and fog. The stature of the forest is somewhat lower than that of the lowland rain forest, and the trees often have leaning or bent stems. Another difference from the lowland forest is that mountain forest has many more epiphytes covering the stems and branches. Epiphytes are most commonly represented by mosses and lichens and also orchids, ferns and aroids are commonly epiphytes. The mountain forests are very rich in species and about half of all species in Ecuador are found in mountain forests even though they cover only one tenth of the country's area (Balslev 1988). Density and diversity of vascular epiphytes in the lower mountain rain forest zone are undoubtedly higher than in the lowland rain forest, but quantitative data are lacking (Neill 1999). The high species richness of the mountain forest is less conspicuous when species numbers in small areas is considered. Inventories of trees with a stem thicker than 10 cm in one hectare generally give lower numbers of species with increasing elevation. In lowland Amazonian Ecuador, upwards of 200–240 tree species can be found in a single hectare (Balslev *et al.* 1987, Korning *et al.* 1991, Cerón & Montalvo 1997, Palacios 1997). But at higher elevations the number of tree species per hectare is lower, for example 132 species at 1,200 m near Sumaco and only 45 species near Baeza at 2,000 m elevation (Valencia 1996, Valencia *et al.* 1998). This apparent paradox is due to the fact that mountain forest species have more restricted distribution compared to lowland species, so in a small area of mountain forest fewer species are packed together, but because they have small ranges, they are different from the species found in an adjacent valley some kilometers away. The mountain forests are said to have low alpha-diversity (local diversity) but high beta-diversity (landscape-diversity). Lowland rain forests in contrast have many species packed densely together in small areas (high alpha-diversity) but these species have larger ranges than the mountain forest species, so it is more likely to find them some distance away and the forest therefore (relatively speaking) has low beta-diversity.

A so-called rapid assessment was carried out recently by the Field Museum in the east-Andean mountain forest in Ecuador along the border with Colombia (Vriesendorp *et al.* 2009). The area surveyed is located just south of the Ecuador-Colombia border on the slopes from the summit of the Andean Cordillera delimited to the south by the Cayambe-Coca Ecological Reserve and to the east by the Chingual River. The study group found tremendous biological diversity in the area, so much so that a new reserve has been proposed to protect and conserve this richness for future generations. The results of the rapid assessment are summarized in Box 1.

Box 1. Rapid Assessment Results for the East-Andean Mountain Forest Region (Vriesendorp *et al.* 2009)

- ***Plants:*** In a few weeks of field work, the botanists encountered 850 vascular plants and estimated that an in-depth inventory would reveal 3,000–4,000 plant species. Many of the species identified are endemic and restricted to the forest on both sides of the Ecuador-Colombia border.

- ***Fish:*** 19 species of fish were identified in the rivers in this mountain forest, and four of them were believed to be new to science, i.e. they have never before been studied, and they have not yet been named in the scientific literature. The total fish fauna of the area was estimated to include 25–30 species over the altitudinal range 500–3,000 m.

- ***Amphibians and reptiles:*** There were 36 species of amphibians and six reptiles and the rapid assessment team estimated that the total amphibian and reptile fauna may include 72 and 38 species respectively. The amphibians and reptiles were mostly confined to a single site attesting to the great beta-diversity of the region where closely adjacent areas have different assemblages of species. At the highest elevation intensive searches for frogs demonstrated substantial populations of *Osornophryne bufoniformis* and *Hypodactylus brunneus,* two species that are considered rare in the herpetological literature. This again shows a biodiversity patterns in these forest with rare species with small ranges of distribution, but occasionally with substantial populations at specific sites. At the medium elevation the team encountered the frog *Pristimantis colonensis* which was the first time this frog had been found in Ecuador. The assessment team also found the rare endemic species *Osornophryne guacamayo.* In the lower parts of the mountain forest at 700–800 meters altitude the occurrence of two frogs *Cochranella puyoensis* and *Rhinella dapsilis,* that have hitherto been known only in the lowlands, showed the Amazon imprint on the mountain rain forest herpetofaunas.

- ***Birds:*** The study team encountered 364 bird species in the mountain forests and estimated that a full inventory would include 500 species over the entire range of the transect. If the páramo above the mountain forest were included they estimate that the bird fauna would include some 650 species along this stretch of 60 km border between Ecuador and Colombia. Again the study sites at different altitudes had entirely non-overlapping bird faunas, testifying to the great variation in species along the altitudinal gradients of the border region. The survey revealed the presence of one endangered species (Bicolored Antpitta), four vulnerable species (Wattled Guan, Military Macaw, Coppery-chested Jacamar, and Masked Mountain-Tanager), and nine near-threatened species. This section of east-Andean mountain forest also had 17 species of migrants, including four (Swainson's Thrush, plus Blackburnian, Cerulean, and Canada warblers) that winter almost entirely in the humid Andes.

- ***Mammals:*** The mammalogists confirmed the presence of 40 species in 18 families, and estimated that the mammal fauna of the region includes 50 species. This includes the mountain tapir (*Tapirus pinchaque*) and the spectacled bear (*Tremarctos ornatus*), which was present in healthy numbers. Both species are considered vulnerable or endangered, and threatened with extinction, through most of their range. There were abundant tracks and feeding sites of the little known Mountain Paca (*Cuniculus* [*Agouti*] *taczanowski*), Olive Coatimundi (*Nasuella olivacea*), and an unidentified species of *Coendu* porcupine. At lower elevations there were evidence of *Lagothrix lagothricha, Ateles belzebuth*, and *Alouatta seniculus.* The team's interviews with local people led them to one of the most interesting animals in the region, a giant pocket gopher, *Orthogeomys* sp., that was found four meters underground when a new road was constructed.

The ecosystem services provided by the east-Andean mountain forest are in many ways similar to those provided by the lowland Amazon rain forest. The area is less populated except in its lower elevations which are inhabited by the Cofán indigenous group. Like the indigenous groups in the lowlands, the Cofán have highly diverse uses of the forest and its plant and animal species for food, medicine, construction and much more (de la Torre *et al.* 2008).

3. ***East-Andean Cloud Forest***

Above the east-Andean mountain forest, at 2,500–3,500 m above sea level the ecosystem on the eastern slopes is called cloud forest because that is where the condensation zone is. As their name implies, these cloud forests, which comprise about 60 km of the length of the Ecuador-Colombia border, are usually engulfed in clouds and mist. Because the international border on the eastern slopes of the Andes runs along the deep valley of Chingual River, cloud forests do not occur there, but such cloud forests are found few kilometers away on the higher parts of the slopes. In certain locations where the native vegetation of the inter-Andean valley cloud forest has been deforested, this area now includes fertile agricultural lands that hold a mixture of large *haciendas*, some of which date back to colonial times, and villages inhabited by *mestizos* of mixed racial origin who practice small scale agriculture.

The Spanish term *ceja andina* ("eyebrows of the mountains") is often used for the "elfin forest" near the upper limit of forest (Figure 7). With increase in altitude above sea level, the height of the tree canopy becomes lower, the trees are more twisted and gnarled and tend to be multiple-stemmed, and alpha diversity of trees also decreases (Valencia *et al.* 1998). Mountain forests and cloud forests in many areas of the tropical Andes occur on very steep slopes that are geologically unstable, being subjected to frequent landslides caused by earthquakes and other natural disturbances. Maintaining undisturbed forest-cover therefore is essential for the ecological stability of such areas and to avoid large scale soil erosion caused by the high rain fall and the often times high grazing pressure.

Figure 7. *East Andean cloud forest at Cayambe, Ecuador. (Source: Gunter Ziesler/PhotolibraryUSA)*

4. ***Grass Páramo and Super Páramo***

Straddling the Andes, over a stretch of some 10–20 kilometers of the Ecuador-Colombia border lie the high elevation grass páramo and the super páramo ecosystems. The grass páramo is dominated by grass tussocks and small shrubs. (Ramsay 2001). Even higher is the super-páramo ecosystem, at elevations of 4,000 m above sea level. The vegetation of the super páramo is very sparse with only scattered patches of vegetation amongst the bare soil.

5. ***West-Andean Cloud Forests***

Below the páramo in the zone at 2,500–3,500 m above sea level on the western slopes of the Andes mountains, the cloud forest is well developed in the narrow condensation zone where clouds and mists shroud the forest. On the west-Andean slopes this cloud forest zone barely covers four km of the border because the slopes are very steep. The well developed cloud forest has short, sometimes gnarled trees of low stature and they are covered with heavy loads of epiphytes which thrive on the branches in this zone where the air humidity is very high and hence advantageous to plants of this life-form which are very susceptible to desiccation. The diversity of mosses, lichens, aroids, orchids and ferns that grow epiphytically is very high. The west-Andean cloud forests remain largely untouched and represent a biodiversity heaven with well preserved ecosystems, flora and fauna.

6. ***West-Andean Mountain Forest***

On the west-Andean slopes, the Ecuador-Colombia border runs for some 45 km through forested terrain at elevations of 700–2,500 m. These forests are similar to the east-Andean mountain forests towards the Amazon in their structure and in most ecological features, but the species present are often different, having evolved in isolation during the past 5–10 million years when the Andes mountain chain rose and the altitudinal zones were isolated from each other on the eastern and western side.

The west-Andean mountain forests are inhabited by the Awá, precisely in the border zone between Ecuador and Colombia and this indigenous group has villages on both sides of the international border. The ecosystem services provided by the west-Andean mountain forest are extremely important, not least to the Awá communities inhabiting them. These people depend on the forest for a number of daily amenities. They hunt forest animals and collect grubs and plant leaves, stems and roots for medicine, food, and construction and tools. The importance of the forests' provision of services to this community cannot be overstated. In a larger societal context the forests provide some of the most biodiversity rich areas in Ecuador. The very high precipitation associated with the forests in this region make them so-called pluvial forests and they contain many species found nowhere else in the world. The mountain forests capture large amounts of water which is subsequently filtered in clear rivers trifling down the slopes with water which is, of course, one of the most important resources to all humans.

7. ***Lowland Chocó Rain Forest***

The lowland Chocó rain forest covers about 80 km of the Ecuador-Colombia border on the Pacific coastal plain from sea level near the coast to 700 m elevation at the foot of the Andes. The Chocó rainforest reaches from the Darien region in Panama to northern Ecuador. Structurally the forest is similar to other lowland tropical rain forests, with a dense canopy 30–35 m above the ground and scattered emergent trees that may reach 50 meters height. There is an abundance of lianas and epiphytes and a sparse understory of shrubs, except where a gap in the canopy lets the light penetrate to generate dense vegetation near the forest floor. The forest is rich in palms, especially the oil producing *Oenocarpus bataua* and the stilt-root palm *Iriartea deltoidea,* which is much used in construction. Due to the warm Panamanian sea current along the Pacific coast the Chocó region receives up to 8,000 mm of rain per year, and it is among the wettest areas in the World (Schwerdtfeger 1976).

The Chocó region is one of the World's so-called biodiversity hotspots (Myers 2000) because of the exceptional concentrations of endemic species, *i.e.,* species that occur nowhere else. (Figure 8). The lowland-Chocó rainforest in Ecuador is highly threatened due to the expansion of the agricultural frontier over the past 40 years (Dodson & Gentry 1991). The best preserved parts of this forest are those along the Ecuador-Colombia border.

Figure 8. *Map of north-western South America with indication of the extension of the Tumbes-Chocó-Magdalena biodiversity hotspot, which includes the western part of the Ecuador-Colombia border (Source: Conservation International 2010).*

The Tumbes-Chocó-Magdalena biodiversity hotspot, which includes the Chocó rainforest of the Ecuador-Colombia border region, is characterized by a great number of endemic animal species that, at the same time, are highly threatened (Table 1). The diversity of species in the Tumbes-Chocó-Magdalena hotspot is stunning (Table 2).

Endemic Threatened Birds	21
Endemic Threatened Mammals	7
Endemic Threatened Amphibians	8

Table 1. *Animal species threatened with extinction in the Tumbes-Chocó-Magdalena biodiversity hotspot* (Conservation International 2010).

Taxonomic Group	Species	Endemic Species	Percent Endemism
Plants	11,000	2,750	25.0
Mammals	285	11	3.9
Birds	890	110	12.4
Reptiles	327	98	30.0
Amphibians	203	30	14.8
Freshwater Fishes	251	115	45.8

Table 2. *Diversity and endemism statistics for plants and animals in the Tumbes-Chocó-Magdalena biodiversity hotspot* (Conservation International 2010).

The estimated number of plants in the hotspot is 11,000, of which 5,000 occur in the Colombian part of Chocó which is often mentioned as the floristically richest area in tropical America. The endemism is 25% or, in other words, 2,750 of the plant species found in the hotspot occur no-where else in the world. This is caused by extreme rates of speciation, possibly in connection with the existence of rain forest refugia in the region during Pleistocene glaciations, which elsewhere wiped out large amounts of biodiversity. Another special feature of the lowland Chocó rain forest is that it includes many species that otherwise occur in the mountain forests higher up the slopes; this is connected to the extremely high rainfall. The mountain forest species that descend to the lowlands belong to the genera *Podocarpus, Talauma, Hedyosmum, Meliosma, Brunellia, Panopsis*, and *Ilex*.
The hotspot is also globally important for bird endemism. There are close to 900 species of birds in the hotspot and 110 of them are endemic and found nowhere else, and there are 14 endemic genera of birds. Within the hotspot the Chocó is considered one of the world's most important and critically threatened Endemic Bird Areas (EBAs) (Stattersfield et al. 1998). A new bird species (*Vireo masteri*) was described from there as recently as 1996 (Salaman & Stiles 1996).

There are 285 mammal species in the hotspot, 11 of which are endemic. Many primates are among the flagship species of the hotspot, including spider monkeys (*Ateles* spp.) and tamarins (*Saguinus* spp.) of which the white-footed tamarin (*S. leucopus*) is endemic to the Chocó. Apart from the spectacular endemic mammal fauna, the Chocó also holds many more widespread species of the tropical rain forest, such as the jaguar (*Panthera* *onca*), Baird's tapir (*Tapirus bairdii*), the nine-banded armadillo (*Dasypus novemcinctus*), and the olingo (*Bassaricyon gabbii*).

There are over 320 reptiles, including nearly 100 endemic ones, in the hotspot. This includes colubrid snakes (122 species; 16 endemics), *Anolis* lizards (40 species, 30 endemics). In addition Dahl's toadhead turtle (*Phrynops dahli*) and Dunns mud turtle (*Kinosternonn dunni*) are endemic to the hotspot, and the non-endemic American crocodile (*Crocodylus acutus*) is also found in the hotspot.

Amphibian diversity is also very high in the hotspot with 200 species including 30 endemics. The best known ones are the poison dart frogs (Dendrobatidae). Among these the bright yellow golden poison frog (*Phyllobates terribilis*) is found only in the southern Chocó; it is one of the most poisonous vertebrates in the world. Many of these frogs have very small distribution ranges, sometimes they are found in only a few square kilometers of land, and therefore they are extremely susceptible to forest disturbance, be it deforestation or other effects on the forest such as defoliation. Several species of poison dart frogs have already disappeared from Ecuador in recent years (Saint Louis Zoo, 2008). Another amphibian species found in the Chocó region, the pink-sided leaf frog (*Agalychnis litodryas*) is shown in Figure 9.

Figure 9. *Pink-sided leaf frog (Agalychnis litodryas), photographed in the Chocó Region of Ecuador (Source: Conservation International Ecuador)*

The fish fauna of the hotspot includes some 250 species of which half are endemic.

The ecosystem services provided by the lowland Chocó rain forest are similar to those of the mountain forest found higher up the slopes. The Awá communities extend into the lowland forest and depend on its services as they depend on the services of the mountain forest. The importance of the Chocó forest as a biodiversity hotspot is also of critical importance to the global community because many of the thousands of species found there are endemic to the Chocó, i.e. they are found nowhere else in the world.

8. ***Mangroves***

The 15 westernmost kilometers of the Ecuador-Colombia border runs through the mangrove forest. Mangroves occur along protected coastal areas where the tidal movements of the sea form muddy beaches that are inundated by salt- or brackish water on a daily basis (Tomlinson 1986). These forests may be up 30 meters tall under natural conditions (Acosta-Solis 1959, Little & Dixon 1969) and they are characterized by trees with a dense tangle of arching roots at the base that help anchor them in the unstable substrate. The dominant trees towards the sea side are *Rhizophora mangle* and *R. harrisonii* whereas *Avicennia germinans, Laguncularia racemosa,* and *Conocarpus erectus* are common on the landward edge. The mangroves along the Ecuador-Colombia border are the largest in Ecuador and the only ones where the mangrove tree *Pelliciera rhizophorae* can be found; this is a rare mangrove plant with a very restricted distribution along the Pacific coast from Ecuador to Costa Rica (Neill 1999).

Mangroves are well known for their multitude of ecosystem services. Their position in the tidal zone makes them important for many species of marine life. The tidal zone placement produces a salinity gradient and each zone has its own fish- and invertebrate fauna, so in a very limited space fishermen can find a wide range of different species. Mangrove ecosystems are also important as hatchment areas for larvae of a variety of marine organisms, including shrimp and lobster. Many of these species, including oysters, crab, lobster, shrimp and many types of fish are important to local human diets. Mangroves also provide an important habitat for a variety of bird species, many of which are residents of the Cayapas-Mataje mangrove protected area along the Colombian border. Mangroves have even been used as a source of building materials.

B. Biodiversity

In Ecuador's three provinces bordering Colombia there are 2,333 species of vascular plants in Esmeraldas, 2,911 species in Carchi and 1,888 species in Sucumbíos (Table 3). Since some of the species occur in more than one of the provinces the total number of registered vascular plant species in the three provinces is 5,444, representing more than one third (36%) of the total Ecuadorian biodiversity which includes 15,900 species of vascular plants (Jørgensen & León-Yanez 1999). The three provinces together cover 13% of Ecuador's land area.

	Esmeraldas	Carchi	Sucumbíos
Esmeraldas	**2333**	0.30	0.19
Carchi	793	**2911**	0.21
Sucumbíos	393	503	**1888**

Table 3. *Number of vascular plant species in Ecuador's Esmeraldas, Carchi and Sucumbíos provinces. The numbers in bold type indicate the total number of vascular plant species in each province; the lower left part of the table has the number of overlapping species between the three provinces; and the upper right part of the table has the Sørensen's Similarity Index between the species assemblages in the three provinces. This index varies from zero (0=no shared species) to one (1=all species are the same).*

The overlap between the species assemblages of the three border provinces is 19–30% attesting to a very large variation in plant species along the Ecuador-Colombia border region (Table 3).

The dominant plant families in the Ecuador-Colombia border region are the orchids, the aroids and the melastomes (Table 4). The two first of these are predominantly epiphytes, *i.e.,* plants growing on the branches and stems of other plants using them for support but without truly parasitizing them (Figure 10). The shrubs are largely plants that fill the undergrowth of the forest. Herbs are non-woody plants growing on the ground – the high number of grasses (family *Poaceae*) in the Carchi province is because this plant family is particularly diverse in the grass páramo ecosystems found there. While Table 4 represents the most dominant species, the families listed in the table represent only a fraction of the many plant species present in Ecuador's border provinces.

Plant family	Life form	Esmeraldas	Carchi	Sucumbíos
Orchidaceae	epiphytes	331	501	295
Araceae	epiphytes	137	82	49
Melastomataceae	shrubs	101	104	82
Piperaceae	shrubs	73	85	-
Bromeliaceae	epiphytes	71	-	-
Gesneriaceae	epiphytes	69	81	-
Rubiaceae	shrubs	66	91	69
Dryopteridaceae	herbs	63	-	-
Poaceae	herbs	60	118	43
Asteraceae	shrubs	-	173	-
Solanaceae	shrubs	-	74	60
Moraceae	trees	-	-	57
Mimosaceae	trees	-	-	54
Arecaceae	trees	-	-	42
Ericaceae	shrubs	-	-	41

Table 4. *Number of species of vascular plants in the most diverse families in Ecuador's three provinces bordering Colombia. The column* Life form *indicates the most common growth form for the species in each family (Data from Jørgensen & Yanés-León 1999).*

Figure 10. *Epiphytes belonging to the orchid and bromeliad families sharing their habitat with mosses and ferns on the branches of rain forest trees. (Source: Mongabay.com)*

The Ecuador-Colombia border region is not only rich in plant species. The distribution of mammal species diversity in the Americas shows that the Ecuador-Colombia border region lies right in the maximum diversity area with as many as 274 species (Schipper et al. 2008).

Likewise, the distribution of South American bird species is highly centered around the Andean Cordillera, and precisely the Ecuador-Colombia border area is the richest in bird species of all bird areas in the Americas (Rahbek & Graves 2001) (Figure 13).

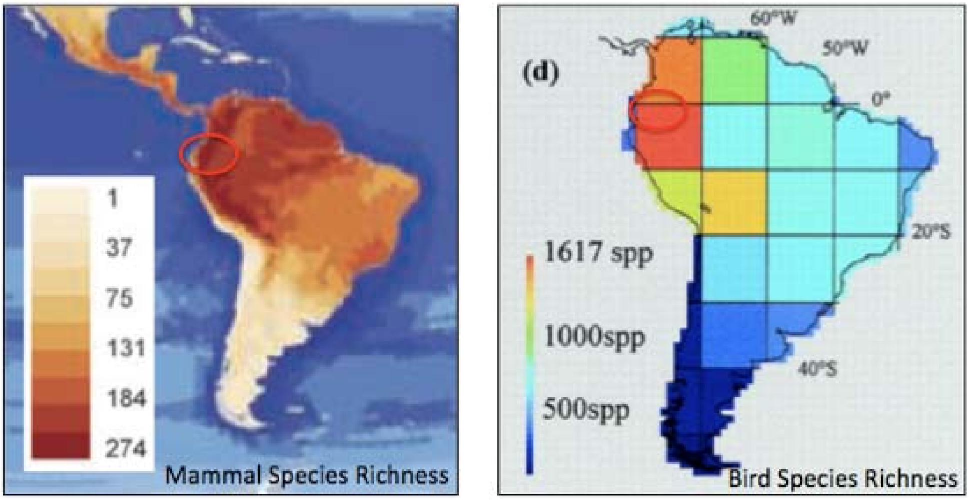

Figure 11. *The distribution of mammal (left) and bird (right) species richness in the Americas. The Ecuador-Colombia border region (circled) stands out as the richest region for both mammals with close to 300 species and birds with over 1500 species (Source: Schipper et al. 2008; Rahbek & Graves 2001).*

Given their uniqueness and tremendous biodiversity, a significant investment of research time and funding has been dedicated to the study of Ecuador's ecosystems. For example, a well studied 50 hectare plot is located in the 1.6 million hectare Yasuni National Park and Huarani territory some 100 kilometers south of the Colombian border and 230 meters above sea level. In that plot all trees with stems more than one centimeter thick have been inventoried, marked and mapped and they are being censused at regular intervals to follow the growth of trees, the mortality, the diversity and the distribution along ecological gradients. The forest in Yasuni is evergreen lowland wet rainforest with a canopy 30–35 m tall with some emergent trees reaching 40 meters or occasionally 65 meters in height. The largest trees are over 2 m in diameter, for instance in *Ceiba pentandra* (Figure 12) and *Tessmannianthus heterostemon*.

Figure 12. Ceiba pentandra *is one of the emergent species in the lowland Amazon rainforest. (Source: Mongabay.com)*

The forest where this plot is located is in a building phase and appears to not have been disturbed for centuries. The forest is the home to a rich fauna, including harpy eagle, macaws, guans, and a good puma population. There are also giant ant eaters, white-lipped peccaries, tapirs and jaguars. There are 11 primates in the forest around the plot, including woolly monkeys (Valencia *et al.* 2004a, Figure 10a).

Yasuni stands at the cross roads of diversity of many groups of organisms (Figure 13). The area has outstanding global conservation significance due to its extraordinary biodiversity and potential to sustain this biodiversity in the long term because of its large size and wilderness character, its intact large vertebrate assemblage. Yasuni National Park is classified in the World Conservation Union (IUCN) system as a level-II protection area which means that it is a large natural area set aside to protect large-scale ecological processes, along with the complement of species and ecosystems characteristic of the area (www.iucn.org).

Figure 13. *The Yasuni National Park, just south of the Colombia-Ecuador border region (blue line) lies in the exact overlap zone of maximum diversity of four major groups of organisms (plants, mammals, birds, amphibians). (Source: Adapted from Bass* et al. *2010).*

C. Protected Areas in the Ecuador-Colombia Border Region

Ecuador has a number of protected areas along its international border with Colombia (Figure 14).

The Vulnerability of the
Ecuador-Colombia Border Region to Ecological Harm

Figure 14. *Protected areas and indigenous reserves along the Ecuador-Colombia border region include the Cuyabeno Faunistic Production Reserve, the Cofán-Bermejo Ecological Reserve and Indigenous Territory, the El Angel Ecological Reserve, the Awá Indigenous and Forest Reserve, and the Cayapas-Mataje Ecological Reserve.*

1. ***Cayapas-Mataje Ecological Reserve***

Established in 1995, this 51,300 hectare reserve, located south of the Mataje River along the Ecuador-Colombia border at the Pacific coast, is covered by mangrove forests, estuaries, marshland, dry forest and shoreline and inhabited by a range of species adapted to tolerate salt-water. The most notable plant in this mangrove may be *Pelliciera rhizophorae* (Figure 15). This species was widespread in the Caribbean and in Central America in the Tertiary period (65–2 million years ago), but has disappeared from many of its former localities where it has been documented in the pollen record. Nowadays only few and scattered populations are left in the mangroves along the Caribbean coast of Central America and some sites along the Pacific coast of South America. The population in the Cayapas-Mataje Ecological Reserve represents the southernmost extension of this rare and beautiful species (Jiménez 1984).

Figure 15. Pelliciera rhizophorae, *a rare mangrove tree with a relict population in the Cayapas-Mataje Ecological Reserve.*

2. ***The Awá Indigenous and Forest Reserve***

The Awá Indigenous and Forest Reserve (*Reserva Étnica y Forestal Awá* in Spanish), established in 1998, straddles the border between the Esmeraldas and Carchi provinces and covers a total of 120,000 hectares. The reserve is matched by a reserve with the same name on the Colombian side of the border which is 280,000 hectares in size. The Awá territory has 65% coverage of well-conserved primary forest and stretches from the lowland Chocó rain forest to humid mountain- and cloud forests at the highest elevations. Its status as an indigenous and forest reserve provides good protection of these forests. The Federation of Awá centers within the reserve are currently carrying out a project with the purpose of establishing a management plan for the conservation and sustainable use of the biodiversity in the Awá indigenous territory.

Within the reserve, 170 species of birds have been registered; including species that are threatened with extinction and others that are endemic to the Chocó hotspot such as the Banded Ground-cuckoo (*Neomorphus radiolosus)*, the Baudo Guan (*Penelope ortoni*), and the Yellow-green Bush-tanager *(Chlorospingus flavovirens)*. (BirdLife International 2010).

Among other important animal species found in the reserve are: the Brown-Headed Spider monkey (*Ateles fusciceps)*, the Ecuadorian Sac-Winged Bat (*Balantiopteryx infusca)*, the Bush Dog (*Speothos venaticus)*, Baird's Tapir (*Tapirus bairdii)*, Jaguar (*Panthera onca)*, Central American Woolly Opposum (*Caluromys derbianus)*, Oncilla (*Leopardus triginus)*, Neotropical Otter (*Lontra longicaudis)*, Bushy-Tailed Olingo (*Bassaricyon gabbii)*, Greater Long-tailed Bat *(Choeroniscus periosus)*, Hairy Little Fruit Bat *(Rhinophylla alethina)*, Northern Naked-tailed Armadillo *(Cabassous centralis)*, Pacarana *(Dinomys branickii)*, Mountain Paca *(Agouti taczanowskii)*, Crab-eating Ra *(Ichthyomys hydrobates)* and Spectacled Bear *(Tremarctos ornatus)* (Figure 16).

Figure 16. *The Andean Bear* (Tremarctos ornatus), *one of the flagship species found in the west-Andean montane forest for instance in the Awá Indigenous and Forest Reserve (Source:* Lincoln Park Zoo)

There are also several timber tree species including Chanul (*Humiriastrum procerum*), Ceibo (*Ceiba pentandra*) (Figure 17), Anime (*Protium ecuadorense*), Sande (*Brosimum utile*) and Copal (*Dacryodes occidentalis*). This tremendous rich fauna and flora is a testimony to the original state of the lowland Chocó rain forest and the mountain- and cloud forests that covers the western section of the Ecuador-Colombia border in this region.

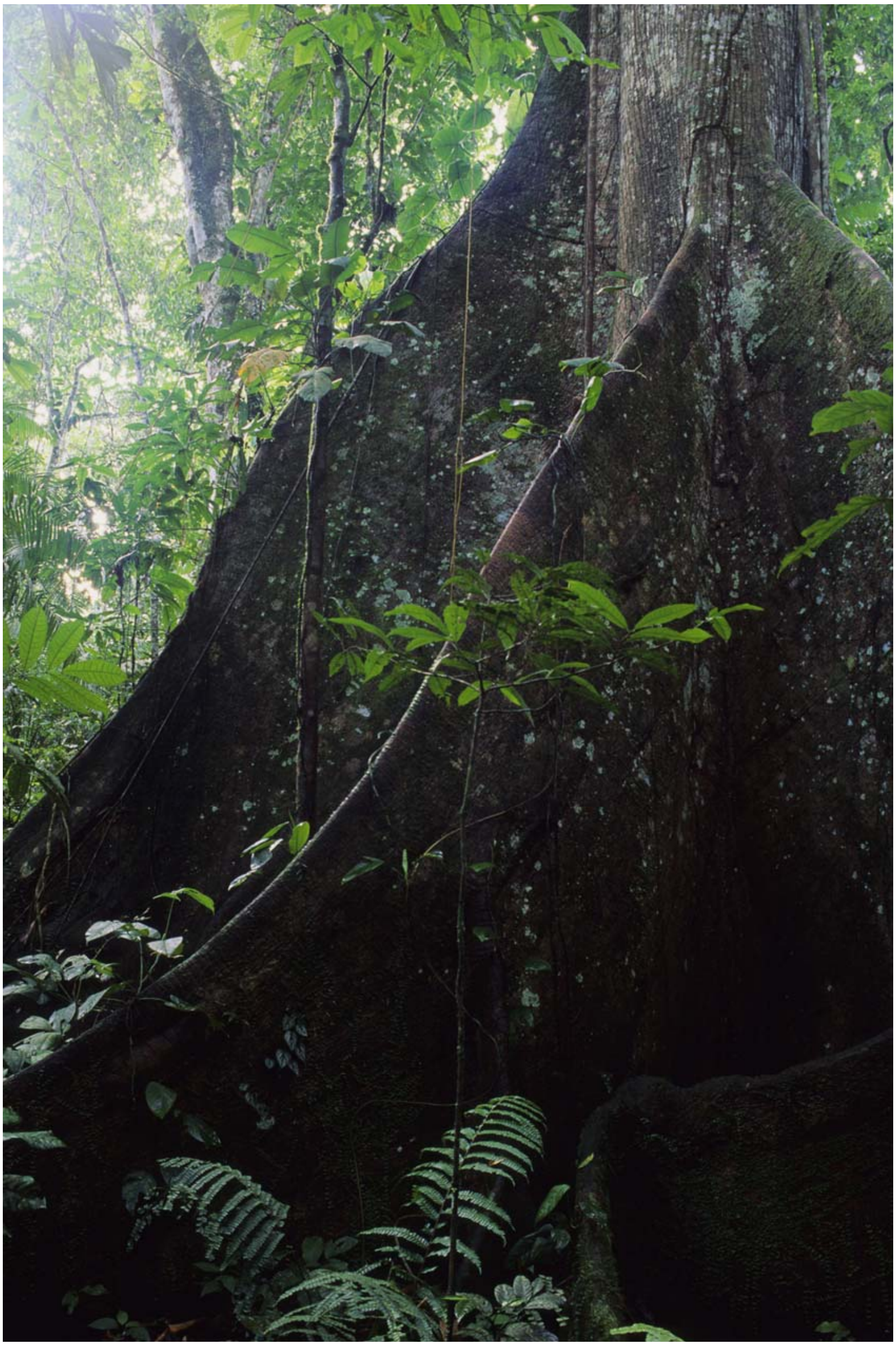

Figure 17. *Ceibo tree in Northern Ecuador (Source: Wolfgang Kaehler/Picade).*

3. *El Angel Ecological Reserve*

The flora and fauna of the Chiles Volcano and its surrounding páramos are protected in a 15,715 hectare large ecological reserve established in 1992 (Coello 1994). The most conspicuous species in this reserve is without doubt the giant rosette plant *Espeletia pycnophylla* in the dandelion family, a species endemic to the páramos on each side of the Ecuador-Colombia border. The genus *Espeletia* with some 130 species is distributed in the páramos from Venezuela to southern Colombia. A single species, *E. pycnophylla* drops over the border into Ecuador, and it also has a relict population further south in the Llanganates páramos east of Baños and Ambato.

4. *Cofán-Bermejo Ecological Reserve*

This reserve covers 55,451 hectares of tropical lowland rainforest in northeastern Ecuador along the border with Colombia. The reserve was created in 2002 and the Cofán people were entrusted with the sustainable management of the area (Abbey *et al.* 2009).

The forests of the Cofán-Bermejo Ecological Reserve have been inhabited for centuries by the indigenous Cofán people, who now live in four small communities along the Aguarico, Bermejo, and Chandia Na'e Rivers. The Cofán are indigenous to the Aguarico and San Miguel watersheds of northeastern Ecuador and southern Colombia. Their language is linguistically unique, with no close living relative, though it shares some features with the Chibchan languages of central Colombia and western Ecuador. The Ecuadorian Cofán number about 1,200 native speakers in 13 isolated communities in the Andean foothills and Amazonian lowlands (Cepek, per. com.). Nearly a third of these — about 320 people — live in the Cofán-Bermejo Ecological Reserve. Given the tiny "footprint" of these four communities and the immensity of the forests surrounding them, most of the foothills remain wilderness, with a regional population density of less than half a person per square kilometer. Due to their knowledge, use, and historical residence of the area, and their growing involvement in conservation initiatives, the Cofán are critical players in the long-term conservation of the region. The largest and most accessible Cofán community in the region is Soquié, located along the San Miguel River. Cofán park guards patrol a large segment of the reserve, under an agreement with the Ecuadorian Ministry of the Environment. Most of the day-to-day activity in Cofán communities is still devoted to small-scale agriculture, hunting, fishing, and craft-making for tourism. These activities are complemented by the harvest of medicinal forest products like *uña de gato* (the liana *Uncaria tomentosa*, Rubiaceae) and *sangre de drago* (the tree *Croton lechleri*, Euphorbiaceae).

The forests around Bermejo have remained exceptionally well-preserved. They are marked by an extremely diverse and complex plant community, due to the fact that two of the largest floras on Earth — the Amazonian and the Andean — converge in this area. During July and August of 2001 a Rapid Inventory team assessed the biodiversity in what was to become the Cofán-Bermejo Ecological Reserve (Pitman *et al.* 2002). Among other findings, at least 15 of the plant species that the rapid assessment team registered during its inventory are endemic to Ecuador. Perhaps the best example of a species with a very restricted range in the Cofán-Bermejo Ecological Reserve is a shrub in the guava family, *Calyptranthes ishoaquinicca* (Myrtaceae), that was previously used by Cofán communities for coming-of-age ceremonies, and the Cofán confirmed that the plant had never been found anywhere but a small area in the vicinity of the community of Sinangoe. A more complete summary of the rapid assessment results is found in Box 2.

Box 2. Rapid Assessment Results for the Cofán-Bermejo Ecological Reserve (Pitman *et al.* 2002)

- ***Plants:*** The rapid assessment team registered over 1,000 species out of an estimated regional flora of 2,000–3,000 species. Nearly all plant families and genera found in the lower parts of the area are shared with Amazonian forests. In a canopy tree transects, the team recorded nearly 60 different species in a sample of 100 trees. Palms are a dominant family, along with legumes, Myristicaceae, Vochysiaceae, Meliaceae, and several others. The most common tree here, as in most of eastern Ecuador, is the palm *Iriartea deltoidea.* In Bermejo, as much as 20% of the canopy at the higher elevations was taken up by *Billia rosea* (Hippocastanaceae). Several of the ridges were topped with stunted vegetation and a flora characteristic of acidic soils. On one such site in Bermejo, the team collected *Purdiaea nutans* (Cyrillaceae), a treelet previously known only from the acidic mountains in southern Ecuador. Orchids, ferns, and aroids were very abundant and very diverse. The rich herbaceous community was especially apparent on the 2,275-meter summit just south of Sur Pax, where the low, open, and disturbed forest is buried under an extravagance of epiphytic mosses and wildflowers.

- ***Amphibians and reptiles:*** The herpetological team registered 31 species, including 17 frogs and toads, six species of snakes, a caecilian, a salamander, and six lizards, including an apparently undescribed species in the genus *Dactyloa*. They found a lizard *Cercosaura ocellata*, a species never before recorded in Ecuador. As in other amphibian communities around the world, population declines and disappearances have been recorded just south of the Serranías Cofán and may be spreading through the apparently pristine areas. The situation appears particularly critical for several species of glass frogs (Centrolenidae) and poison-arrow frogs in the genus *Colostethus*, which have disappeared from some streams and waterfalls in the Cayambe-Coca Ecological Reserve over the last decade (F. Campos, pers. obs.).

- ***Birds:*** The rapid assessment team registered significant range extensions, for many bird species, and many rare birds were frequent and abundant in the area including large populations of *Campylopterus villaviscensio* (Napo Sabrewing), *Phylloscartes gualaquizae* (Ecuadorian Tyrannulet), and *Snowornis subalaris* (Gray-tailed Piha). The team recorded 399 bird species and estimated a regional total of 700. Perhaps the most notable sighting was of the Foothill Elaenia, *Myiopagis olallai*, a bird described so recently by scientists (Coopmans & Krabbe 2000) that it does not even appear in *The Birds of Ecuador* (Ridgely & Greenfield 2001). Although *M. olallai* had been known from just three localities in Ecuador and Peru, this new register, less than 10 km from the Colombian border, almost guarantees that the species eventually will be recorded in that country as well. Just as significant was a sighting of the Black Tinamou, *Tinamus osgoodi*, previously known only from one site in Colombia and another in southern Peru. Although ornithologists never had recorded this species in Ecuador before the team saw and heard it on the Shishicho ridge, and the Cofán accompanying the team reported having seen the same species as far south as the San Rafael falls. Throughout the area the team encountered large populations of showy bird species that are typically vulnerable to hunting, including the Military Macaw (*Ara militaris*), Salvin's Curassow (*Crax salvini*), and the Wattled Guan (*Aburria aburri*). The implication is that the Cofán foothills may be an important sanctuary for species whose populations are declining over large areas elsewhere in eastern Ecuador.

- ***Mammals:*** The rapid assessment team found a very diverse, intact mammalian fauna, including 12 species of monkeys and large populations of several globally threatened species. Perhaps the most significant individual sighting was of the rare Shorteared Dog, *Atelocynus microtis*, at the highest elevation (1,200 m) recorded for the species. The team confirmed the presence of 42 species of large mammals in the area, more than half of these globally threatened or rare. Twenty five species on the list are included in CITES Appendices I (globally threatened) or II (potentially threatened), including the 12 species of monkeys. Many of these vulnerable species are abundant in the area. Especially common were spectacled bears (*Tremarctos ornatus*), tapirs (*Tapirus terrestris*), woolly monkeys (*Lagothrix lagothricha*), and collared peccaries (*Tayassu tajacu*). It is worth noting, as an example of how poorly known the area remains, that one of the favorite food plants of the spectacled bear on Cerro Sur Pax, a terrestrial bromeliad it strips for the tender leaf bases, is itself an undescribed species.

Figure 18. *Examples of the fauna in the Cofán-Bermejo Ecological Reserve.* ***A.*** Enyalioides cofanorum. ***B.*** *A bushmaster* (Lachesis muta) *at Shishicho.* ***C.*** Hyla phyllognatha*, a species of upper hill forests, lives in Shishicho.* ***D.*** *Giant earthworms, over a meter long, inhabit the forests around Cerro Sur Pax (Source: Pitman et al. 2002).*

5. ***Cuyabeno Wildlife Reserve***

This reserve was established in 1979 in Ecuador's Sucumbíos province, in the very eastern part of the country, with its northern limit some 10–20 km south of the Colombian border and reaching south to close to the Napo River. It is covered by humid tropical lowland rainforest. The reserve includes a system of black-water and white water rivers, lakes, and flooded igapó forests. The reserve has very high diversity of both plants and animals. The highest number world wide of trees over 10 cm diameter was found in one hectare within the Cuyabeno Reserve (Valencia *et al.* 1994)**.** The enormous plant richness is a reflection of the area's position at the cross roads of two extraordinarily rich floras, the rich-soil flora of the Yasuni and the poor-soil flora of the Loreto province in Peru. The Cuyabeno Reserve together with the National Park La Paya in Colombia and the Zona Reservada Güeppi in Peru form a conservation corridor that covers the easternmost part of the Ecuador-Colombia border region. The three protected areas were studied by a Rapid Inventory team in October 2007 and they found tremendous and in many cases un-explored biological diversity in the region (Alverson et al. 2007), summarized in Box 3.

Box 3. Rapid Assessment Results for the Cuyabeno-Güeppi conservation corridor which includes the Cuyabeno Wildlife Reserve and the eastern part of the Ecuador-Colombia border region (Alverson *et al.* 2008)

- ***Plants:*** In this tri-national conservation corridor (Ecuador-Colombia-Peru) the team documented a rich plant community of 1,400 species out of an estimated total flora in the region numbering 3,000–4,000 species. In the Cuyabeno Wildlife Reserve the team found a new genus in the violet family (Violaceae) which was a large fruited tree, in addition to 11 other species that were new to science. They also found four genera and five species that were know elsewhere but had never been seen in Ecuador.

- ***Fishes:*** Commercially important species such as *paiche, arahuana,* and *tucunaré* were easily observed in the rivers. The team collected two fish species that were new to science (*Characidum* sp. and *Tyttocharax* sp) and 17 fish species that had never been observed in Ecuador. In total they registered 184 fish species of the 260–300 species expected in the region.

- ***Amphibians and reptiles:*** The Cuyabeno Wildlife Reserve housed a frog that had previously been known only in the Tigre and Corrientes watersheds in Peru (*Pristimantis delius*), and there were 19 species of amphibians and reptiles that were recorded for the first time in the Wildlife Reserve. In addition the team observed healthy populations of hunted reptile species such as the Black Caiman (*Melanosuchus niger*), the White Caiman (*Caiman crocodilus*), the River Turtle (*Podocnemis unifilis*), the Yellow-footed tortoise (*Chelonoidis denticulata*) and the Arboreal Boa (*Corallus hortulanus*). The team documented 59 amphibians and 48 reptiles in the region out of the expected totals 90 amphibians and 60 reptile species.

- ***Birds:*** There were records of 437 bird species and the team estimated that the total bird fauna would be 550 species. In the Cuyabeno Wildlife Reserve there were healthy populations of the hunted species Salvin's Curassow (*Mitu salvini*), Guans (*Penelope* and *Pipile*) and Gray-winged Trumpeter (*Psophia crepitans*). They also found seven species that are endemic to northwestern Amazonia, abundant herons of the genera *Agami* and *Cochlearius*, and they sighted a Harpy Eagle (*Harpia harpyja*) and a Sigsag Heron (*Zebrillus undulates*).

- ***Mammals:*** The team documented a high diversity of medium and large mammals totaling 46 species, divided between 11 carnivores, 10 primates, seven rodents, seven edentates, five ungulates, three marsupials, two cetaceans, and one sirenian. In the Cuyabeno Wildlife Reserve the presence of the critically endangered giant otter (*Pteronura brasiliensis*) was of special interest. The presence of manatees (*Trichechus inunguis*) that is critically endangered in Ecuador was also noteworthy. The same is true for the healthy populations of Woolly Monkeys (*Lagothrix lagotricha*) and Tapirs (*Tapirus terrestris*). The rarely observed Pygmy Marmoset (*Cabuella pygmaea*) was also seen.

III. Vulnerability of Ecuador's Border Ecosystems to Ecological Harm

Tropical rain forests are among the richest ecosystems on Earth, yet their stability depends on the maintenance of a number of physical and biological factors. This section discusses the complexity of tropical ecosystems and their vulnerability to environmental perturbations.

A. Vulnerability to Environmental Contamination

Environmental contamination may affect tropical forest ecosystems through a number of pathways. First, airborne contamination is a concern, as it may come into direct physical contact with many species. The epiphytes that dominate the ecosystems along the Ecuador-Colombia border region are particularly sensitive to wind and rain borne substrates because rather than drawing minerals and nutrients from the soil, they feed on water which is brought to them through rain and mist and on nutrients dissolved in the rain water. Thus, material transported through the air is likely to affect Ecuador's characteristic epiphytes even more severely than other life forms (Figure 19).

Figure 19. *Large branches of emergent tree in tropical Amazon rain forest covered with epiphytic ferns, aroids, orchids and other groups. These plants are all isolated from the ground and depend on the rain water and mist for nutrients and humidity.* (*Source:* Wolfgang Kaehler/Picade)

Second, contaminants may enter the ecosystem through the hydrological cycle (Figure 20) and in that way also affect other life forms in the tropical rain forest. Tree canopies will intercept air borne particles, which are subsequently washed off by rain and fog and finally reach the undergrowth and forest floor as through-fall or stem-flow. Once on the forest floor, water will move into streams and rivers as surface run off, or it will percolate through the soil layers to the ground water or move into streams as subsurface water movement. This movement will distribute any dissolved substances, including contaminants, through the ecosystems, allowing it to reach and affect a variety of plant and animal life.

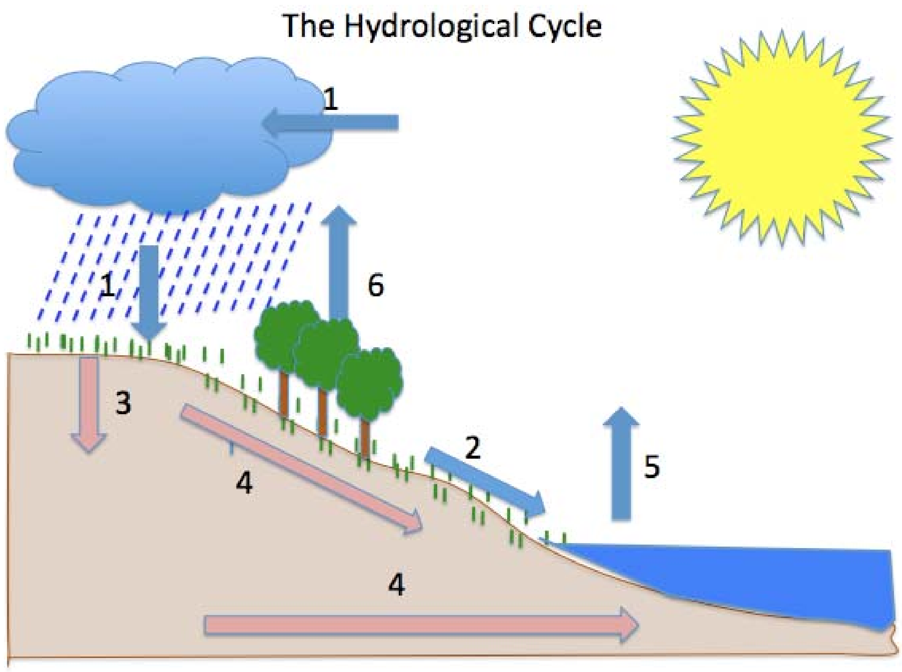

Figure 20. *A schematic view of the hydrological cycle, showing the transport of water from rain (1) into the ecosystem and its subsequent movement as surface run-off (2) or infiltration into the soil (3) and movement with the ground water (4) to reach a river or lake from which evaporation (5) returns water to the atmosphere. Some of the water that is taken up from the soil by the plants returns to the atmosphere through evapotranspiration (6).*

The Ecuador-Colombia border region is crossed by numerous streams and rivers that drain large amounts of water from the precipitation, which is excessive in places. The Chocó region is one of the wettest areas in the world; it receives 8–10 meters of rainfall per year, and it rains more than 300 days per year (www.britannica.com), which translates into a myriad of streams and rivers that flow through the area all year round. Consequently the hydrological cycle in the Colombia-Ecuador border ecosystems is very dynamic and large amounts of water are transported through these systems. The most important river on the western side of the Andes is San Juan River, that becomes the Mataje River in the lowlands; both these rivers coincide with the border (Fig. 21). The east Andean slopes, though receiving less rain, likewise remain wet throughout the year and have a similar richness of water ways rushing down the slopes and reaching the slow flowing meandering rivers of the

Amazon lowland. Here the main rivers are San Miguel River on the eastern slope and the near Andean lowlands, and Putumayo River in the Amazon lowlands further away from the Andes (Fig. 21).

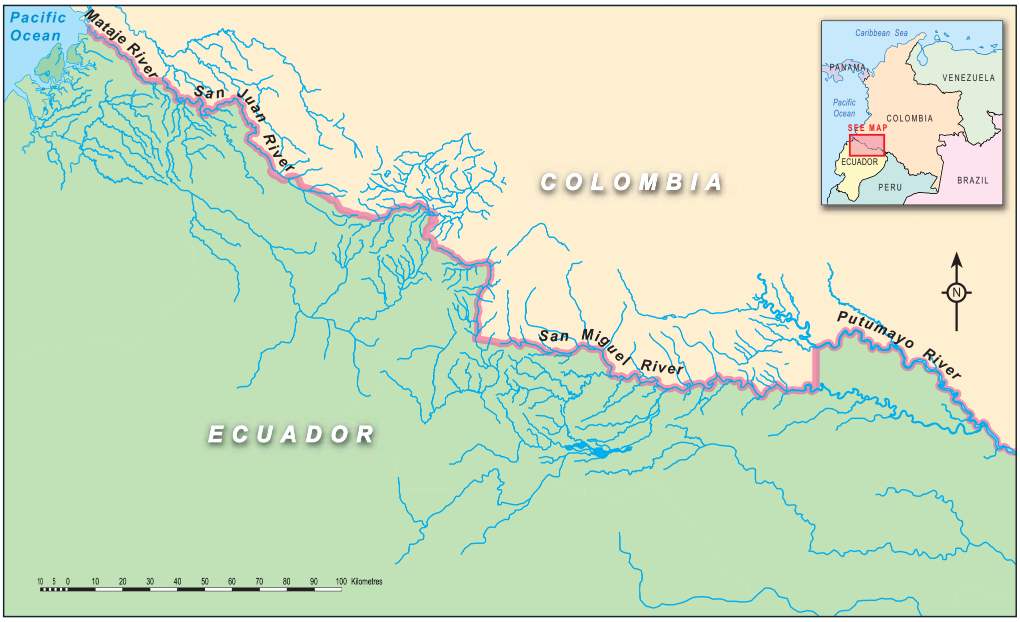

Figure 21. *Sketch of rivers and streams in the Colombia-Ecuador border region. The border follows the larger Mataje River and San Juan River on the western lowlands and slopes and the San Miguel River and Putumayo River on the eastern slope and the Amazon lowlands. These larger rivers are fed by a myriad of smaller streams.*

Rivers are not only waterways and transporters of minerals and contaminants but also the habitat for a rich biodiversity. Just like other ecosystems along the Colombia-Ecuador border, the aquatic ecosystems house many different species. The Tumbes-Chocó-Magdalena biodiversity hotspot which is transected by the San Juan River and Mataje River houses 251 species of freshwater fish of which almost half (115) are found only there, that is they are endemic to that area (Table 2; Conservation International 2010). The rapid inventory team estimated that the Chingual River and San Miguel River had a fish fauna of 25–30 species at the elevations between 500–3,000 meters (Vriesendorp *et al.* 2009; see Box 1), and in the Güeppi area surrounding the easternmost part of the Colombia-Ecuador border, the they recorded 184 fish species and estimated a total fish fauna of 260-300 species (Alverson *et al.* 2008; see Box 3). The rivers of the Colombia-Ecuador border region in the lowlands Amazon also house several species of large mammals such as the giant otter (*Pteronura brasiliensis*), the Amazonian manatee (*Trichechus inunguis*), the pink river dolphin (*Inia geoffrensis*) and the grey dolphin (*Sotalia fluviatilis*) which are all endangered or even critically endangered according to the Red List of mammals of Ecuador. These large mammals depend on high quality of uncontaminated water for their survival.

B. Food Webs, Trophic Levels, Pollinator Networks and Cascading Effects

The interconnectedness of tropical ecosystems also contributes to their vulnerability to environmental perturbations. An ecosystem functions as a food web where primary producers (plants) convert carbon dioxide and water into organic compounds, especially sugars, using the energy of sunlight. The primary producers then serve as food for primary consumers (herbivores) which in turn serve as food for secondary consumers (carnivores). In tropical rain forests with their thousands of species such food webs — organized in trophic levels — may be very complicated because the food chains (described above) are not isolated sequences but form interwoven networks in which one species may feed on several species or one species may serve as food for several species. In addition there may be all sorts of intermediates between the basic trophic levels (primary producer, primary and secondary consumers) because some species feed on both plants (primary producers) and animals (primary consumers). For example, the spectacled bear (*Tremarctos ornatus*) is mostly vegetarian but about 5% of its food consists of small animals (Ward & Kynaston 1995). Such complex relationships between organisms belonging to different species are pervasive in tropical rainforests. Thus, when one species is removed from the ecosystem it produces a chain reaction. Another example of inter-species dependence that involves a "food chain" or trophic web has four trophic levels: the first trophic level (producer) consists of small trees of the *Piper* genus, which are eaten by various small insect herbivores (herbivores are all plant eating animals, from the smallest insects to the largest ungulates), which are in turn consumed by ants, which are eaten by beetles (Letourneau & Dyer 1998). The functioning of such a system is intricate and sensitive to even small disturbances, which may cause trophic cascades where the survival of one species depends on that of another in the system. These disturbances may cause top-down as well as well as bottom-up trophic cascades, that is, the effects may be caused by disturbances in either end of the food chain. A top-down cascade would involve the removal of a predator which in turn causes excessive growth of the herbivore population because it is not eaten by the predator; the increase in herbivore populations would then negatively affect the primary producer population. A bottom-up cascade would involve removal or reduction of the primary producer which, in turn, would affect the populations of primary and secondary consumers. In such complex systems the overabundance of one species could also affect competitor species that compete for the same resources.

Interdependence of tropical forest species also occurs in cases where some species are dependent upon other species for their habitat. For example, certain frogs use the wallow ponds of peccaries (medium sized mammals related to pigs), and when the peccaries are driven away from forest margins frogs also disappear (Laura Naranjo 2005).

Complex interactions in tropical rainforests also involve reproductive biology. Many rain forest plants are pollinated by insects and have evolved close relationships with the species of insect that pollinates them. Orchids, which are prevalent in the Ecuador-Colombia border region, provide many examples of these close dependencies between species. For example, orchids such as species of the genus *Cattleya* have so-called “gullet flowers” in which the pollinating insect enter a chamber where the pollen is deposited on its back (Dressler 1981). This means that the particular species of orchid can only be pollinated if its mutualistic species of insect pollinator is present.

Other complex mutualistic relationships involving several species are found in so-called pollinator-networks where many species interact. Some plant species may be pollinated by several species of insects or several species of insects may pollinate the same plant. Such pollinator networks are very sensitive to disturbance and removal or introduction of species that are not part of them may profoundly affect the reproductive success of the involved species (Padrón *et al.* 2009).

Tropical rain forests such as those found along the Colombia-Ecuador border region are characterized by very high biological diversity. One consequence of that high biodiversity is that populations of individual species in many cases are very thin, in other words, different individuals of the same species may be far removed from one another. This has prompted other intricate plant-animal interactions such as trap-lining where one insect individual will fly a specific route that may be several kilometers long every day and visit flowers of individual plants that as a response produce one mature flower per day (Ohashi & Thomson 2009).

Intact forest ecosystems are important for yet another mutualistic relationship: the dispersal of fruits by animals. Plants must disperse their fruits away from the plant that generated them, in order to maintain viable populations. This is achieved by fruit and seed dispersal by a number of agents of which the most important are vertebrate animals. It has been shown that defaunation of a tropical rainforest (a reduction in animal species, particularly vertebrate animals) may reduce the species richness of plant seedlings by as much as 60% (Webb & Peart 2008).

Ecuador is ranked third in amphibian diversity worldwide with 415 described species (Ron & Merino 2000). Only Brazil and Colombia have more species than Ecuador. According to conservative estimates, the populations of at least 26 species of Ecuadorian frogs have declined. The precise reasons for this biodiversity crisis are not clear however it is likely caused by multiple factors (Ron & Merino 2000). A detailed study of amphibian decline in Ecuador (Bustamante et al. 2005) show that at six out of seven sites studied in Ecuador there was a significant reduction in species richness and 56 of the 88 populations had lower populations at the time of the study than in the past. It was especially amphibian species with aquatic larvae that had declined. The regional scale of their study demonstrate that the declines are not isolated losses but are part of a more generalized process and that there is a general decline in the health condition of Ecuadorian amphibian populations. 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.

All these examples show that even small effects on one species can have serious effects on other species in the tropical rainforest ecosystem and can have implications far beyond the initial damage created by the introduction of a contaminant or by other disturbances.

C. Threatened and Endemic Species

The vulnerability of Ecuador's border ecosystems is exacerbated by the fact that they house a tremendous number of threatened and endemic species. Therefore, damage caused by a contaminant or other abiotic influence could mean increasing the threat of extinction, or even the loss of an entire species.

There are over 4,011 species of vascular plants that are endemic to Ecuador (Valencia *et al.* 2000). This means that out of Ecuador's 15,900 species of native plants one in four does not occur anywhere else in the World. Of the 4,011 endemic species 33% are orchids and 9% belong in the dandelion family (Asteraceae). Herbaceous epiphytes account for 36% and terrestrial herbs for 22% of all endemic plants in Ecuador. Woody shrubs and sub-shrubs account for 22% and the remaining 16% are shared between woody climbers (lianas) trees, hemi-epiphytes and others. The Amazon lowlands of Ecuador house 453 of the species that are endemic to Ecuador, the coastal lowlands towards the Pacific house 743 endemics and the Andes region houses 2,965 species that are endemic to Ecuador (Valencia *et al.* 2000). These numbers reflect the fact that the tropical rain forest of the Amazon lowlands of Ecuador are connected to similar vegetation in Colombia and Peru without any barriers to dispersal of plant species so Amazonian Ecuador will share many species with Colombia and Peru in this type of vegetation. The slightly higher number of endemics on the coastal plain lowland forests is because this zone has a much narrower connection to the neighboring countries and dispersal opportunities are much more limited, so more species tend to be restricted to Ecuador. Finally the very high number of Ecuadorian endemics that are found in the Andes region is due to the high beta-diversity of the forests on the Andean slopes. Due to the landscapes that are highly dissected by steep valleys and isolated mountains, dispersal is much more limited and the species that evolve in the ecosystems there tend to be limited to very narrow ranges, giving a tremendously high number of species restricted to the zone.

As to endemism in the Ecuador-Colombia border region, of the three provinces that reach the border Esmeraldas houses 341 of Ecuador's endemic species, Carchi 388 and Sucumbíos 142 (Valencia *et al.* 2000). The endemic species of Ecuador are, in general, very rare. More than one quarter of them are known only from the original collection on which the description of them was based, and they have never been seen again since their original discovery. One third of Ecuador's endemic vascular plants are known from only one population, but may have been collected there several times, and more than half of the endemics are known from less than 10 populations (Pitman *et al.* 2000).

According to the system established by the World Conservation Union (IUCN), 2960 species (74%) of the Ecuadorian endemic plants are threatened with extinction. More specifically, 1835 species are classified as vulnerable (facing a high risk of extinction), 828 are endangered (facing a very high risk of extinction), and 296 are critically endangered (facing an extremely high risk of extinction) (Pitman *et al.* 2000). Of the Ecuadorian endemics only 15% are not threatened (and 11% cannot be evaluated in the IUCN system). Twenty-two percent or 871 of these endemic plant species grow in the three provinces of Ecuador that share the border with Colombia. While there is no study further pinpointing their locations, many of these vulnerable species likely occur in the Ecuador-Colombia border region.

From the section on Biodiversity of this report (above, Figure 13) it is evident that the Ecuador-Colombia border region is the most species rich part of tropical America for mammals and birds, and one may presume that this is also true for other animal groups and that the high species richness is generated by the presence of high numbers of endemic animal species.

D. Forest Fragmentation and Edge Effects

Forest fragmentation — a process that may be caused by defoliation, felling trees, reducing forest cover, and dividing forests into disconnected fragments — has significant impacts on both the flora and fauna that inhabit Ecuador's border ecosystems. Fragmentation of tropical rainforests strongly affects their dynamics. Often, the most significant effects are along the edges of a fragmented forest. This suggests that processes along forest edges have significant consequences for biodiversity, including in areas remote from the edge. Not only herbs and shrubs, but also trees are strongly affected and this translates to the rest of the plant and animal communities in the forest because the trees largely determine the architecture and microclimatic conditions in the forest. Intact tropical rain forests are buffered from harsh external conditions by a dense canopy cover, but this buffering breaks down near forest edges and may lead to higher mortality of plant species that are sensitive to drought. The effect of strong winds are also much more severe along the forest edges than in the interior of the forest and the edges therefore experience higher incidences of wind-throw and structural damage to the forest. The forest edges are prone to increased growth of vines, lianas and secondary growth species and exotic plants may invade the forest along the edges (Laurance *et al.* 1998). In a study using 66 Amazonian rainforest plots mean mortality rates increased from 1.27% in the interior to 2.40% at 60–100 meters from the edge and 4.01% within 60 m from the edge. Damage rates increased from 1.48% in the interior to 1.96% at 60–100 meters from the edge and 4.10% within 60 meters from the edge. Finally turnover rates increased from 1.15% in the interior to 2.055% at 60–100 meters from the edge and 3.16% within 60 meters from the edge (Laurance *et al.* 1998). This demonstrates that edges of tropical rainforest are very sensitive to any external influence, and that mortality and turnover are significantly affected far away from the edges. The same study actually detected affects, but less pronounced up to 300 meters from the edge.

Plant death or damage caused by herbicides along forest edges would be expected to reduce leaf cover and thus increase light penetration. This could cause changes in the microclimate of the forest, particularly along its edges. As demonstrated by the study described above, however, this damage would not necessarily be limited to the immediate forest edge, but could reach several hundred meters into the mature interior of the forest.

Forest fragmentation not only impacts plant species but may affect animal species as well. For example, fragmentation is detrimental to the movement of animals that depend on mature forest, which in turn affects seed dispersal and in some cases also pollination. With increasing fragmentation home ranges of animals may be disrupted or the sizes of the forest fragments may become too small to include viable populations of larger animals.

E. Tropical Forest Gap Dynamics and Stand Level Dynamics

Tropical forests are in a state of continuous flux driven in part by tree falls, that create “gaps” in the forest that trigger further change, including changes in species composition. Thus, human-induced environmental changes influence a “moving target”, making the precise impacts on the ecosystem uncertain. Rain forest trees germinate, grow up and die over 50–1,000 years (Korning & Balslev 1994a, Martínez-Ramos & Alvarez-Buylla 1998). A tree may die standing due to old age or disease, its trunk may snap if it is hit by a lightening, or it may fall over due to strong winds. Trees may die individually or in groups in a domino effect caused by storms. Dead trees leave gaps in the canopy that are the beginning of the classic forest growth cycle that go through a building phase to reach a mature phase that reverts to the gap phase and the forest cycle will start over again. The forest is therefore made up of a mosaic of patches in gap-phase, in building-phase and in mature-phase (Yamamoto 1992). In gaps, increased amounts of solar radiation reach the forest floor, causing higher temperatures and drying of the soil and growing conditions that are much different from the mature forest phase and gaps are therefore inhabited by different sets of species. Gaps are dominated by light-demanding species with small seeds that grow faster than other rain forest trees and compete strongly with each other for light, and die when other species overtop them and put them in shade. These light-demanding species constantly move from gap to gap and cannot germinate in their own shade – they are nomads in the forest in constant search for new patches where they can survive.

The dynamic nature of tropical forests is illustrated by a study conducted in a two-acre plot in the Reserva Faunistica Cuyabeno, just 40 km south of the Colombian border (Korning & Balslev 1994b; See Box 4).

Box 4. *Study of Tropical Forest Stand Dynamics in the Reserva Faunistica Cuyabeno* (Korning & Balslev 1994b).

Tropical rainforest dynamics is estimated by measuring tree diameter and re-measuring after some time to calculate growth of individual trees. If this is done for many trees that grow together in one forest, then the measurements can be added up to give stand-level dynamic information.

The trees were first measured in May 1998, when there were 697 trees with stems over 10 cm diameter. Two years and seven months later there were 734 trees. Eighteen trees had died and 55 trees had been recruited. The basal area of the trees (the area of a cross section of the tree at a height of 130 cm above the ground) had increased from 27.2 m^2 to 28.9 m^2. This means that 1.04% of the individuals had died each year (mean annual mortality rate), and half the stand would disappear in 67 years if no new recruits were added (stand half-life). The mean annual recruitment rate was 3.09% which means that it would take 23 years to double the number of trees if none of them died. Overall these numbers show that the forest plot at Cuyabeno was in a building phase during the 2 years and seven months between the measurements in the late 1980s.

Another three plots, measured at Añangu some 60 km further south were close to reaching the mature phase or had reached it, and one plot was in the break-down phase were more trees were dying than growing into the forest. These numbers show just how dynamic the forests along the Ecuador-Colombia border are, and also that they are comparable in this respect to 11 other tropical American forests where stand half-life had been measured to be 23–66 years, and doubling times to be 22–11 years.

Although the typical expression of forest growth cycles are easy to describe, the actual situation is one of continuous change and broad overlap between the phases. Similarly, rain forest trees represent a spectrum from light-demanding to shade-tolerant species, accompanied by a gradual change from small- to large-seeded species. Artificial gaps in the forest canopy, created for instance by aerial spraying with herbicides, may increase light penetration and temperatures, and release of the seed bank in the soil that is mostly made up of seeds from fast growing pioneer species. Nevertheless, the precise effects on the ecosystem would be difficult to predict. Impacting the forest with external factors is impacting a highly dynamic “moving target” which leads to uncertainty about the effects that may be caused by environmental perturbations.

IV. Previous studies

The report by Solomon and collaborators (2005) reviews existing literature concerning possible adverse effects of the use of glyphosate. It reviews many aspects of the toxicity of this chemical compound, which is used in weed control in many countries, and in Colombia to spray illegal poppy and coca plantings using airplanes. The report documents a series of adverse effects of glyphosate when applied to humans, various animals and plants. The report, however, consistently concludes in favor of glyphosate. It tends to diminish the chemical's effects and focuses on rapid recovery after adverse effects of application. The report analyses the effects case-by-case and organism-by-organism, but does not evaluate the possible combined effects on the environment if glyphosate were to be applied to an ecosystem with many organisms interacting.

Solomon (2009) reviews a series of more detailed studies that were carried out by several researchers following the 2005 report. This series of studies focuses on three aspects of the use of glyphosate sprays in coca eradication. The first aspect is droplet size and how that affects the distribution of the chemicals from the spray planes; a limited risk assessment with respect to plants and amphibians was also included. The second aspect is the effect of aerial spraying with glyphosate on the environment. And the third is the effect of glyphosate sprays on humans. The section on effects on the environment addresses only the effect on amphibians, based on the argument that amphibian species appear to be the most sensitive to environmental pollutants. Considering that aerial spraying with glyphosate is done to eradicate a cultivated *plant,* it would have been pertinent to conduct a much more in depth evaluation and discussion regarding the effects on plants that are not the subject of eradication.

Together the 2005 report and the series of studies published in 2009 underplay the possible effects on plants other than coca and poppy, and neglect possible effects on the ecosystem level, solely focusing on effects on single organisms.

V. Conclusion

The Colombia-Ecuador border region passes through some of the most diverse and vulnerable ecosystems in our World. The range of ecosystems include tropical lowland rain forests, mountain forests at various elevations, cloud forests near the tree limit, and mangroves along the Pacific coast. The western lowlands and slopes are part of one of the Worlds richest and most threatened biodiversity hotspots, the Tumbes-Chocó-Magdalena biodiversity hotspot. The eastern slopes and lowlands lie within the Amazon basin which is one of the last very large wilderness areas left in the World. The border region is inhabited by a diverse selection of the ethnic groups that live in north-western South America, including the Awá and the Cofán, who depend intensely on the diversity and the resources of these ecosystems. The level of endemism is extremely high, *i.e.,* the border region is the home of thousands of plant and animal species that occur nowhere else in the World. These species include hundreds of endemic plants, bird, reptile and amphibian species, and even several large mammals such as the Amazon Manatee, the Giant Otter, and Pink and Grey River Dolphins. The tropical rain forest ecosystem is made up of complex webs of organisms on different trophic levels that form interwoven food chains, and similarly complex pollination webs that maintain the reproductive processes of fertilization and seed dispersal. At the same time the ecosystems are extremely dynamic with a constant change and growth of individuals that replace each other in intricate stand levels dynamic processes. The organisms are bound together in highly complicated mutualistic relationships where the death or removal of one species affects the survival of other species. Due to the systems connectivity such impacts may have detrimental cascading effects, either as bottom-up processes where external effects on primary producers end up affecting the top predators, or in top-down effects where the removal of a top predator causes destruction in the lower trophic levels. The highly dynamic nature of the ecosystems make them vulnerable to external impacts and environmental perturbations. Aerial spraying with herbicides in this border region has the potential to cause significant damage to one of the Worlds richest and most diverse biological treasures.

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Valencia, R., Condit, R. G., Foster, R. B., Romoleroux, K., Villa Munoz, G., Svenning, J. C., Magaard, E., Bass, M., Losos, E. C., and Balslev, H. 2004a. Yasuní Forest Dynamics Plot, Ecuador. Pages 609–628 in E. C. Losos and J. Leigh, Egbert Giles, eds. *Tropical forest diversity and dynamism: Findings from a large-scale plot network.* University of Chicago Press, Chicago.

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APPENDIX 1

Curriculum Vitae of Henrik Balslev, PhD

Annex 4

HENRIK BALSLEV
Curriculum Vitae

PERSONAL DATA: Born 4 January 1951 in Bukoba, Tanganyika. Citizen of Denmark

WORK ADDRESS: Department of Biological Sciences, Aarhus University, Build.. 1540, Ny Munkegade, DK-8000 Aarhus C., Denmark, telephone +45-8942-4707 and 8942-2743 (direct), fax +45-8942-2722. **or:** Herbariet, Bygn. 1137, Ole Worms Allé, Universitetsparken, DK-8000 Aarhus C., Denmark. email: Henrik.Balslev@biology.au.dk

EDUCATION: Highschool, Hjørring Gymnasium (1970); Cand. Scient in Biology (= M.Sc.), Aarhus University (1978); Ph.D. in Botany, City University of New York (1982)

POSITIONS: Herbarium Fellow, The New York Botanical Garden (1978–1981); Profesor de Botánica and Director del Herbario, P. Universidad Católica del Ecuador, Quito (1981–1983); Associate Curator, The New York Botanical Garden (1983–1984); Associate Professor (lektor) Aarhus University (1984–1989); Senior Associate Professor (docent) Aarhus University (1989–1997); Professor (1997–present) Aarhus University.

RESEARCH INTERESTS: Neotropical botany with main emphasis on taxonomy of Juncaceae and Palmae, phytosociology of tropical rainforests and páramos, economic botany of Palmae, and ethnobotany of Amazonian indians.

EXPEDITIONS: East Africa (1974–1975, 5 months). Andes (1980, 3 months). Ecuador (1976, 5 months; 1985, 3 months; 1986, 3 months; 1987, 3 months; 1988, 2+2 months; 1989, 2 months; 1990, 2+1 months). Brunei, Borneo (1991, 1 month), Ecuador (2001, 1 month), Peru (2002, 1 month; 2003, 2 months; 2004, 2 months; 2005, 3 months; 2006, 2 months; 2007, 2 months; 2008, 2 months)).

MEMBERSHIPS: The Royal Danish Academy of Sciences and Letter; Fellow of the Linnean Society, London; Danmarks Naturvidenskabelige Akademi; Association for Tropical Biology; International Palm Society; American Society of Plant Taxonomists; Society for Economic Botany; Commision of the Organization for Flora Neotropica.

ADMINISTRATION: Director of the Herbarium, Pontificia Universidad Católica del Ecuador, Quito (1981–1984); Curator of the Herbarium, Botanisk Institut, Aarhus Universitet (1984–1994); Organizing Committee of Symposium on Tropical Forests, Aarhus Universitet (1988); Member of "Arbejdsgruppen for U-landsforskning ved Aarhus Universitet" (=The Committee for Research related to Developing Countries at Aarhus University) (1988–1995); Member of Committee for PhD studies (=Forskeruddannelses Udvalget) at Aarhus University Faculty of Natural Sciences (1990–1995); Member of Committee for PhD studies, Institute of Biology, Aarhus University (1991–1995); chair of Systematic Botany, Aarhus University 1999-; member of the Danish Natural Science Research Council 2000–2003.

EDITORIAL EXPERIENCE: **Member of Editorial Boards** of *Anales del Real Jardín Botánica de Madrid* (2003–2009). *Caldasia*, *Acta Botánica Mexicana, Ecotropica, Les Annales de Botanique de l'Afrique de l'Ouest,* and *Biodiversity and Conservation;* **Outside referee** for *American Journal of Botany, Brittonia, Opera Botanica, Symb. Bot. Upps., Biotropica, Bull. Inst. Franc. d'Etudes Andines, Ann. Missouri Bot. Gard., Willdenowia, Ann. Bot. Fennicii, Journal of Tropical Ecology, Journal of Vegetation Science, Flora Neotropica, Aquatic Botany, Journal of the Torrey Botanical Society, Kew Bulletin, Taxon* and *Ecology.* **Editor** of *AAU Reports*, 1989–1994 and *ENRECA-NEWSLETTER*, 1990–1994; **Editor** of *Tropical Forests: Botanical Dynamics, Speciation, and Diversity,* Academic Press, London, 1989; **Editor** of *Páramo: An Andean Ecosystem under Human Influence,* Academic Press, London, 1992. **Co-editor** of *Biodiversity and Conservation of Neotropical Montane Forests,* NYBG, New York, 1995. **Co-editor** of *Etsudios sobre diversidad y ecologia de plantas,* PUCE, Quito, 1997. **Co-editor** of *Botanica Austroecuatoriana – Estudios sobre los recursos vegetales en las provincias de El Oro, Loja y Zamora-Chinchipe*. Abya-Yala, Quito, 2002.

TEACHING EXPERIENCE: Teaching Assistant, Aarhus University (1975–1978); Taxonomy Course, Continuing Education, The New York Botanical Garden (1979); Several courses in General Botany, Plant Taxonomy, Plant Evolution, and Local Flora at Pontificia Universidad Católica del Ecuador, Quito (1981–1983); One yearly course in Tropical Biology at Aarhus University (1984–1987); Organizer (with P. Strømgaard, Copenhagen) of Ph.D. Course on Sattelite images and vegetation science in the developing countries (1989); Lectures in Advanced Taxonomy and Basic Taxonomy, Field course in local flora, Aarhus University (1989–1995); Organizor of The Danish Research Academy's European Summer School on *Botanical Diversity of Tropical Forests,* Aarhus, 13–27 Jul 1993; Course on *Herbarium Management,* Dakar University, 29 Mar – 3 Apr 1993. Organizer of PhD course on *Quantitative Plant Community and Population Ecology,* Aarhus University, Oct–Nov 1994, w. Pamela Hall. Taxonomy, P. Universidad Católica del Ecuador, 1995-1996. Plant Systematics and Tropical Ecology, Aarhus University, 1997–.

THESIS STUDENTS:

— PhD-students:

25. **Wolf Eiserhardt** (Phylogenetic impact on Amazonian palm communities; to be completed 2011; with co-supervision by Jens-Christian)
24. **Anne Overgaard** (Modelling African Palm distributions, to be completed 2011; main supervisor is Jens-Christian Svenning)
23. **Kamonnate Srithi** (PhD student at Chiang Mai University, Thailand, Ethnobotany of Thai hill tribes, to be completed 2012; I am external supervisor, main supeprvisor Prof. Chusie Trisonthi)
22. **Thea Kristiansen** (Amazonian Palm diversity, to be completed 2010; co-supervisor J.-Chr. Svenning).
21. **Lucia de la Torre** (Biodiversity and use-diversity in Ecuador, completed 2009; co supervisor with F. Borchsenius).
20. **Angkhana Inta** (PhD student at Chiang Mai University, Thai hill tribe ethnobotany, completed 2008; I was external supervisor, main supervisor is Prof. Chusie Trisonthi).
19. **Woranuch Laongsri** (PhD student at Chiang Mai University, Thai Nymphaeaceae, 8 completed 2008; I was external supervisor, main supervisor is Prof. Chusie Trisonthi).
18. **Stine Bjorholm** (Palm biogeography, completed 2007; co-supervisor w. J.-Chr. Svenning).
17. **Priscilla Muriel** (*Virola* systematics, completed 2004, currently researcher, QCA Quito);
16. **Anja Byg** (Ethnobotany in Amazonian Ecuador, completed 2004, currently postdoc KU-Life);
15. **Merete Kirstine Christensen** (Savannah ethnobotany in Burkina Faso, completed 2004, currently consultant Jyske Bank).
14. **Ralf Leimbeck** (Ecology and Diversity of Neotropical Araceae, completed 2002, currently highschool teacher).
13. **Jens Chr. Svenning** (Palm Communities in Amazonian Ecuador, completed 1999, currently professor Aarhus University).
12. **Gloria Galeano** (Quantitative inventories of useful species in rainforests, completed 1997, cuurently profesor Universidad Nacional, Bogotá).
11. **Rodrigo Bernal** (Natural history of *Phytelephas seemannii*, completed 1996, currently profesor Universidad Nacional, Bogotá).
10. **Carmen Josse** (Ecology of dry forests in Ecuador, completed 1996, currently Conservation International, Washington DC).
9. **Monica Moraes** (Taxonomy and natural history of Bolivian Palms, completed 1996, currently director of the herbarium at Instituto de Ecología in La Paz).
8. **Renato Valencia** (Composition and Structure of Andean Forests, completed 1994, currently professor of botany and director of the Institute of Biology at Univ. Catolica in Quito);
7. **Jørgen Korning** (Species composition and structure of the tree vegetation in rainforest, completed 1993, currently consultant);
6. **Peter Møller Jørgensen** (Andean montane forest vegetation, completed 1993, currently at Missouri Botanical Garden);
5. **Carmen Ulloa** (Taxonomy of Ecuadorean woody genera, completed 1993, currently at Missouri Botanical Garden);
4. **Jens Elgaard Madsen** (Ecology of the montane forest in Parque Podocarpus, Ecuador, completed 1991);

3. **Finn Borchsenius Kristensen** (A revision of the genus *Aiphanes*, Palmae, completed 1991, currently associate professor, Aarhus University);
2. **Flemming Skov** (A revision of *Geonoma* in Ecuador, completed 1990, currently senior reseacher, NERI);
1. **Anders Barfod** (Systematics of Phytelephantoideae, Arecaceae, completed 1988, currently associate professor at Aarhus University).

— Cand. scient. (= M.Sc.), Aarhus University:

44. **Mette Kronborg** (Economic botany in Sahel, to be completed 2009, A.M.Lykke is co-supervisor)
43. **Malene Jersild** (Economic botany in Sahel, to be completed 2009, A.M.Lykke is co-supervisor)
42. **Sandie Lykke Hansen** (Amazon palm ethnobotany, completed 2009, with co-supervision by Jens-Christian Svenning)
41. **Dennis Pedersen** (Amazon palm communities, completed 2008, with co-supervision by Jens-Christian Svenning)
40. **Anne Luise Møller** (Ethnobotany of palms in Peru, completed 2007).
39. **Marie Lindgren** (Local knowledge of palms in Payamino, completed 2007; co-supervisor with A. Barfod).
38. **Asser Øllgaard** (Ethnoecology in Payamino, Ecuador, completed 2007).
37. **Lone Hübschmann** (Diversity, variation and use of Desmoncus, to be completed 2007).
36. **Marianne Sørensen** (Forest herb distribution, completed 2006; co-supervisor with J.-Chr. Svenning).
35. **Rikke Rørby** (Factors affecting plant distribution in a Danish beech forest, completed 2006; co-supervisor with J.-Chr. Svenning).
34. **Anne Sandal** (GIS studies of Cyperaceae distributions in Denmark, completed 2006; co supervisor with J.-Chr. Svenning).
33. **Jens Clausen** (Regional vs. Global distributions patterns of plant families, completed 2006; co-supervisor with J.-Chr. Svenning).
32. **Adriana Sanjines** (Amazonian palm community ecology, completed 2005; co-supervisor with J.-Chr. Svenning).
31. **Narel Paniagua** (Amazonian palm ethnobotany, completed 2005; co-supervisor with J.-Chr. Svenning).
30. **Rikke Pape Thomsen** (Forest dynamics in Suserup forest, completed 2004; co-supervisor with J.-Chr. Svenning).
29. **Karen Ronge Hansen** (Understory Danish forest, completed 2004; co-supervisor with J.-Chr. Svenning);
28. **Kristian Skjerning Kyed** (The importance of Scale in Biodiversity, completed 2004).
27. **Birgitte Windeballe** (Deciduous forest ecology Denmark, completed 2003; co-supervisor with J.-Chr. Svenning);
26. **Tatiana Jaramillo** (Myristicaceae systematics, completed 2002);
25. **Luise Ugilt Jensen** (Distributional history of *Carpinus betulus* in Denmark, completed 2001);
24. **Rommel Montufar** (Amazonian Palm Biogeography, completed 2001);
23. **Lone Kristensen** (Herbs of northern Thailand, completed 2000);
22. **Selene Baez** (Palm communities in western Ecuador, completed 2001);
21. **Pablo Lozano** (Taxonomy and reproductive biology of *Machaerium* in Ecuador, completed in 2000);
20. **Anja Byg** (Ethnobotany of Madagascan palms, completed 2000);
19. **Morten Bjerrum** (Biogeograhy of Ecuadorian *Begonia*, completed 2000);
18. **Karen Jensen** (Quantitative ethnobotany, completed 1994);
17. **Karin Krogstrup** (Inventory of Economic Plants in Amazonian Ecuador, completed 1994);
16. **Christian Lange** (Brugen af Storsvampe til Naturovervågning, completed 1992, Mycological supervisor was Henning Knudsen, KU);
15. **Birgitte Mogensen** (Maya ethno-botany in Yucatán, completed 1991);
14. **Ole Stauning** (Maya ethno-botany in Yucatán, completed 1991);
13. **Henning Christensen** (Vegetation studies in tropical rainforest in Ecuador, completed 1991);
12. **Anders Bøgh Pedersen** (Vascular epiphytes in a montane forest in Ecuador, completed 1991, published 1992);
11. **Bjarke Eriksen** (Quantitative Inventory of the ground vegetation in a montane forest in Ecuador, completed 1990);
10. **Lis Elleman** (Ethnobotany of the Saraguro indians, Ecuador, completed 1990);
9. **Axel Dalberg Poulsen** (A quantitative inventory of the herbaceous ground vegetation in a 1-hectare plot in tropical rainforest in Ecuador, completed 1990);

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8. **Ingvar Nielsen** (Epiphyte vegetation in a one-hectare plot in tropical rainforest in Ecuador, completed 1989);
7. **Klaus Bloch** (A tree inventory in a one-hectare plot in tropical rainforest in Ecuador, completed 1989);
6. **Monica Moraes** (A revision of *Allagoptera* (Palmae), completed 1989);
5. **Birgitte Bergman** (A taxonomic revision of *Chamaedorea* in Ecuador, completed 1989);
4. **Ulla Blicher-Mathiesen** (Attaleinae (Palmae) in Ecuador, completed 1989);
3. **Henrik Borgtoft Pedersen** (Biology, utilization and management of some Ecuadorean palms, completed in 1988);
2. **Finn Borchsenius Kristensen** (The genus *Aiphanes* in Ecuador, completed in 1988);
1. Flemming Skov (A Revision of the genus *Hyospathe* — Palmae, completed 1986).

— Licenciatura en Biología, PUCE, Quito:
Elizabeth Velásquez Bravo (Dinámica y adaptaciones de las plantas vasculares de dos ciénegas tropicales en Ecuador, completed 1983, published 1985); **Patricio Mena** (Comparación entre la Vegetación de los Páramos y el Cinturón Afroalpino, completed 1984, published 1986); **Rosario Briones** (Estudios relacionados con la presencia de Organismos parecidos a Micoplasma en el cultivo de *Solanum marginatum,* completed 1984); **Catalina Quintana** (Diversity and community structure of herbs in a montane forest in Ecuador, completed 1998); **Priscilla Muriel** (*Virola*-Myristicaceae in Ecuador, completed 2000); **Tatiana Jaramillo** (*Iryanthera* etc. – Myristicaceae in Ecuador, completed 2000).

EXTERNAL EVALUATION OF DOCTORAL THESIS:

1991: External reviewer of PhD dissertation by **Risto Kalliola**, Turku University, Finland (Abiotic control of the vegetation in Peruvian Amazon floodplains: environment change and pioneer species);
1991: Fakultetsopponent for PhD dissertation by **Suk-Pyo Hong,** Uppsala University, Sweden (Taxonomny of *Aconogonon* s.lat., Polygonaceae)
1992: External examiner for PhD dissertation by **Padmi Kramidabrata**, University of Reading, UK (A Revision of the Genus *Calamus* (Palmae) Section *Macropodus* Sensu Furtado)
1993: Fakultetsopponent for PhD dissertation by **Roger Eriksson,** Göteborgs University, Sweden (Systematics of the Cyclanthaceae, especially *Sphaeradenia* and *Chorigyne*)
1994: External examiner for PhD dissertation by **Leng Guan Saw**, University of Reading, UK (The genus *Licuala* in Malaya)
1997: External examiner for PhD dissertation by **Renske Ek**, University of Utrecht, The Netherlands (Biodiversity in Guayana)
2000: External reviewer of PhD dissertation by **Jaana Vormisto**, Turku University, Finland (Palms in the rainforests of Peruvian Amazonia: uses and distribution)
2000: Reviewer of Habilitation thesis of **Michael Kessler,** University of Göttingen, Germany
2004: External examiner of PhD dissertation for **Alvaro Duque,** University of Amsterdam, The Netherlands
2004: External examiner of PhD dissertation for **Veerle van den Eynden,** University of Gent, Belgium
2004: Reviewer of Habilitation thesis of **Maximilian Weigend,** Freie Universität Berlin, Germany
2005: External examiner of PhD thesis for **Maurcio Sánchez**, University of Amsterdam, The Netherlands
2007: External examiner of PhD thesis for **Rommel Montufar**, l'Ecole Nationale Supéreure Agronomique de Montpellier, France
2008: External examiner of PhD thesis by **Eleanor Jones,** Trinity College, Dublin, Ireland
2010: External examinar of PhD thesis by **Stela Valenti Raupp,** INPA, Manaus, Brazil (Distribuçao, abundancia e fenologia reproductiva de palmeiras em uma floresta de terra firme da Amazonia Central)

OTHER EXTERNAL EVALUATIONS:

Institutions:
1993: Member of Advisory Board, Botanical Laboratory, University of Copenhagen;
2001: Member of Science Audit Team, Royal Botanic Gardens, Kew, UK;
2004: External reviewer of the PhD School for Biodiversity Studies, The Netherlands.

Evaluation of applicants for position as:
1998: Associate Professor, Botanical Garden, University of Copenhagen;

2000: Professor, Natural History Museum, Stockholm, Sweden.
2003: Lecturer in systematic botany, University of Stockholm, Sweden
2004: Professor in Molecular Systematics, University of Copenhagen
2004: Professor in Phylogenetic Botany, Botanical Museum, Copenhagen

Academic accomplishment:
1993: Professional Accomplishment and Evaluation Review, Smithsonian Tropical Research Institute

Foundations (panels):
1999–2003: Member of Danish Natural Science Research Council.
2001–2003: Expert panel for International Foundation for Science (IFS), Stockholm, biodiversity
2002: Expert panel Swedish Research Council (FORMAS), applications on biodiversity collections facilities,
2004: Expert panel for applications for Researchers Training and Network, Nordic Researcher Academy (NorFA)
2005-2008; Chairman, Expert panel for applications for Researchers Training and Network, Nordic Researcher Academy (NorFA)

Foundations (individual reviews):
2003: Reviewer of grant applications; National Science Foundation (NSF), USA
2003: Review of grant application, Swiss Research Council
2004: Review of book project, Princeton University Press
2004: Reviewer of applications for biodiversity collections facility grants, Swedish Research Council (FORMAS)
2005: Reviewer of applications for biodiversity, Swedish Research Council (Vetenskapsrådet)

EXTERNAL BOARDS & COMMITTEES.:
1999–present: Member of the Governing Board, Natural History Museum, Aarhus
2001–2010: Head of the Danish delegation to the Governing Board, Global Biodiversity Information Facility (GBIF)
2001-2010: Chairman of the Board of the Danish Biodiversity Information Facility (DanBIF)
2004–present: Member of the Research Committee, Aalborg Zoo, Denmark
2004–2008: Executive Committee of the International Union of Biological Sciences (IUBS)
2004–2008: IUBS representative to ICSU Scientific Committee on Data for Sciences and Technology (CODATA)

INVITED LECTURES GIVEN: *Distribution patterns of Ecuadorian Plant Species (*Symposium on Tropical Botany, Utrecht, September 1986). *The endangernment of Ecuadorean Palm species* (International Symposium on Palm Systematics and Evolution, Cornell University, Ithaca, June 1987). *Estudios en el bosque tropical de la Amazonía Ecuatoriana* (I Congreso Ecuatoriano de Ciencias Naturales, Quito, March 1987). *La flora del Ecuador* (Seminario de Incendios Forestales, Quito, April 1987). *La Evolución de la Flora del Ecuador en Relación a la Historia Geológica* (XI Jornadas Nacionales de Ciencias Biológicas, Riobamba, 19–21 Nov 1987) *Palmas Nativas del Ecuador y su Importancia* (XI Jornadas Nacionales de Ciencias Biológicas, Riobamba, 19–21 Nov 1987). *Ecuador – et plantegeografisk Laboratorium* (Folkeuniversitetet, Horsens, 19 Jan 1988). *Research in Tropical Forests at the Botanical Institute, Aarhus University.* (Meeting on "Miljø, Udvikling og Forskning" (Environment, Development and Research), Copenhagen, 25–26 Feb 1988). *Diversity of Ecuadorean Forests east of the Andes,* (Symposium on Tropical Forest, Aarhus, 8–10 Aug 1988). *Scientific collaboration between the Universidad Católica del Ecuador and Aarhus University,* (Meeting on "Directions and new working procedures in rural development research." Aarhus, 12 Sep 1988). *Tropisk Regnskog — Forskningsopgaver og Tverfaglige Perspektiver,* (Centre for Development Studies, University of Bergen, Norway, 12 June 1989). *Ecuadorean páramos — diversity and phytogeographic origin,* (Symposium on Tropical Ecosystems, Saarbrücken, 15–16 June 1989). *Palmae for the Flora of Ecuador,* (Symposium Nordic Botanic Research in the Andes and Western Amazon, Aarhus, 28–29 August 1989). *De tropiske skoves værdier,* (Kursus i u-landsskovbrug. Tune Lanboskole, 31 october 1989). *Kortlægning af naturlige genressourcer og potentiale i agroforestry-systemer,* (Miljøhensyn og Agroforestry i u-landsarbejdet. Temadag. Det danske FAO-udvalg, Skovskolen, 18 januar 1990). *La Palma Real de la costa Ecuatoriana — un recurso de grasa vegetal,* (I Simposio Ecuatoriano de Etnobotanica y

Botanica Económica. Quito, 27 Feb – 2 Mar, 1990). *Amazonas Palmer og deres betydning for mennesket,* (Göteborgs Botaniske Förening, 14 Nov 1990). *En hektar lavlandsregnskov ved Cuyabeno: En kvantitativ inventering,* (Afd. för Systematisk Botanik, Göteborgs Universitet, 14 Nov 1990). *Flowering plants of Amazonian Ecuador — a checklist, A quantitative 1-hectare flora inventory in Ecuador, Taxonomic problems in neotropical palms, and Economic botany of neotropical palms,* (Course in "Basic and applied taxonomic botany for the tropics" - University of Uppsala, Sweden, 27–28 Nov 1990). *How many vascular plants are supported in one hectare of tropical lowland rainforest ?* (The Symposium on Nordic Botanical Rsearch in the neotropics - University of Turku, Finland, 19–21 August 1991). *Warming og den neotropiske botanik [Warming and neotropical botany],* (150 Anniversary for Warming, Dansk Botanisk Forening and Botanisk Centralinstitut, Copenhagen, 8 November 1991). *The Future of Tropical Plant Resources for the Developing World,* (Conference on "Oils and Fats in the Nineties," Fredericia, Denmark, 23–26 March 1992).[not updated 1992–2002].

2003

Palm Diversity Patterns, Symposium on Plant Diversity and Complexity Patterns, Copenhagen 25-28 May 2003.

Sistematica de las Angiospermas, Guest lecture at Universidad Nacional Amazonense Peruana, Iiquitos, 17 July 2003.

Ecologia de Palmas, Guest lecture at Universidad Amazonense Peruana, Iiquitos, 21 August 2003.

La Nueva Clasificación de las Angiospermas, Keynote Lecture. Congreso Ecuatoriana de Botanica, Loja, 25 August 2003.

Global Biodiversity Information Facility (GBIF): a new oportunity for developing countries? Congreso Ecuatoriana de Botanica, Loja, 25 August 2003.

International Foundation for Science (IFS) — an opportunity for funding for young researchers. Congreso Ecuatoriana de Botanica, Loja, 25 August 2003.

Nordisk Biodiversitets Informatik Samarbejde indenfor netværket NordBIN. Meeting entitled Biologisk Mångfald på nätet, Natural History Museum, Stockholm, 18 Sept 2003.

Past, Present and Future Neotropical Palm Floras, Symposium on Biodiversity and Evolution, Frankfurt 21-27 Sept 2003.

2004

Traditional use and extraction of Aphandra natalia *fibre.* Contributed talk. Thematics Day on Biodiversity and Ethnoecology. Aarhus University, 30 March 2004.

The Danish GBIF node's Symposium on Molecular Biodiv ersity. Global Biodiversity Information Facility, Governing Board Meeting 8, Oaxaca, Mexico, 25-29 April, 2004.

Filogénia y Clasificación de las Angiospermas. Keynote Lecture. X Congreso Nacional de Botanica (X CONABOT), Trujillo, Peru. 2–5 May, 2004.

Evolución y Diversidad de las Angiospermas. Guest lecture, Universidad Nacional Amazonense Peruano, Iquitos, Peru, 29 May, 2003.

2006

Palms and palm communities in the western Amazon. Annual Meeting of the Department of Biology, Aarhus University, 5 May 2006.

Ethnoecology of west Amazonian Palms, invited speaker, 6th International Workshop on Biodiversity Conservation and Utilization, Beijing China, 22–24 May 2006.

Palms and palm communities around Iquitos, Peru. Contributed talk. 6th meeting of the European Network of palm Scientists, 27-28 May 2006, Geneva, Switzerland.

Uses and management of Amazonian palms. Invited lecture. University of München, Germany. 31 May 2006.

[not updated]

2009

Neotropical Ethnobotany. Invited Speaker, R.G.J. Congress X, The Thailand Research Fund, 3-5 April 2009.

GRANTS RECIEVED: 1978–1980, Monographic studies of tropical American Juncaceae, Danish Natural Science Research Council (# 511-10226, 511-15358, 11-0431, 11-1606), DKr 138,293; 1980, Doctoral Dissertation Improvement Grant, National Science Foundation, USD 6000; 1985-1987, Taxonomy and Economic Potential of Ecuadorean Palms, Danish Natural Science Research Council (# 11-5117, 11-5582, 11-6273); 1987, Conservation and Sustainable use of *Attalea colenda* in coastal Ecuador, Lindbergh Fund, USD 10,580; 1990-1992 Species Diversity and Dynamics in Tropical Rainforests, Danish Natural Science Research Council (#11-6848) DKr. 690,000; 1992-1995, Palm Extractivism in Amazonian Ecuador, European Commission STD3 subcontract, ECU 35,000; 1990-1995, Natural Resources for Development, Research Collaboration between Denmark and Ecuador, Danish Agency for International Development, Danida, DKr. 11,562,000; 1993, European Summer School on Botanical Diversity of tropical Forests, The Danish Research Academy (V920264), DKr. 400,000; 1993–1998, Center for Tropical Biodiversity (w. Jon Fjeldså, Ib Friis & P. Arctander), Danish Natural Science Research Council (11-0390), DKr. 22,000,000; 1994, PhD course in Tropical Plant Community Ecology (w. P. Hall), Danish Research Academy (V930164), DKr. 55,000. 1999-2001, Enhancement of Research Capacity in Ecuador, DKr 4,121,000 from Danida; 2002–2004, Factors controlling biodiversity in Western Amazonia, 400,000 DKr, Danish Natural Science Research Council; 2003-2005, Palm base, 360,000 DKr, Danish Natural Science Research Council; 2003, Plant Diversity and Complexity Patterns - an International Symposium, 60,000 DKr, Danish Natural Science Research Council; 2003–2004, Western Amazonian Piassaba Fibers, 369,600 DKr, Danida Research Council (RUF); 2003-2005, Invitation of guest professor, 180,000 DKr, Velux Foundation; 2003–2006, Biodiversity and Economically Important Plants in the Andes, 5,000,000 Dkr, Danida Research Council. 2004-2006, Superpáramo plant distributions – visiting professor Petr Sklenar, 150.000 DKr, Aarhus Universitets Forsknings Fond. 2007, DanBIF conference on Barcoding, 100,000 DKr, Danish Natural Science Research Council. 2007-2009, Modelling Neotropical Palm Distributions, 3,000,000 DKr, Danish Natural Science Research Council. 2007-2008, Forskningslegat for students participation in biodiversity research,100,000 DKr, WWF/Novozymes. 2009-2013, Impacts of palm harvesting on tropical forests, 3.2 mio€, FP7-EU-grant.

PLANT NAMES:

Centropogon balslevii Jeppesen, Fl. Ecuador 14: 60. 1981
Phoradendron balslevii Kuijt, Fl. Ecuador 24: 31. 1986
Parkia balslevii Hopkins, Fl. Neotropica 43: 103, 1986
Disterigma balslevii Luteyn, Opera Botanica 92: 113. 1987
Cynanchum balslevii G. Morillo, Ernnstia 2(3-4): 60. 192 (=*Jobinia balslevii*(Morillo) W.D.Stevens, Novon 10(3): 244. 2000
Anthurium balslevii Croat & J. Rodriguez, Aroideana 18: 54. 1995
Boehmeria balslevii Friis & Wilmot-Dear, Monogr. Syst. Bot. Missouri Bot. Gard. 75: 956. 1999

HONOURS:

Golden Medal, Faculty of Science, Charles University, Prague, 1998.
Profesor visitante, Universidad National de la Amazonía Peruana, Iquitos, Peru, 2004—
Doctor Honoris Causa, Pontificia Universidad Católica del Ecuador, Quito, Ecuador, 2009

PUBLICATIONS & ABSTRACTS:

1979

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2. Balslev, H. 1979. Juncaceae *In:* G. Harling & B. Sparre (eds.) Flora of Ecuador 11: 1–44.
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Annex 5

Norman E. Whitten, Jr., Ph.D., Dr. William T. Vickers, Ph.D. & Michael Cepek, Ph.D.,
Tropical Forest Cultural Ecology and Social Adaptation in the Ecuadorian Border Region with Colombia (Jan. 2011)

Annex 5

Tropical Forest Cultural Ecology and Social Adaptation in the Ecuadorian Border Region with Colombia

Norman E. Whitten, Jr.
William T. Vickers
Michael Cepek

Annex 5

Table of Contents

I. Executive Summary

This report discusses the communities of the tropical-forest regions of Ecuador near the Colombian border. The people who live in the border region include indigenous peoples, the Cofán, Kichwa, Siona, Secoya and Awá, as well as other groups such as the Afro-Ecuadorians of the western Pacific region and the more recent colonist farming communities in the Amazonian region. These groups are diverse in terms of their heritage, traditions, cultures, belief systems, languages, and social and ecological adaptations. However, one unifying characteristic of the border communities is their heavy dependence upon the natural environment for food, shelter, medicine, spiritual practices and other critical aspects of their livelihoods.

Many border communities practice "swidden agriculture" or "shifting cultivation," a system that depends upon a delicate balance between the natural forest ecosystem and crops grown for human consumption. These forest gardens produce crops such as plantains and manioc (yuca) that are staples in the local diet. While carefully managed swidden agriculture systems can be very productive, food must be produced on an on-going basis to maintain a healthy human population because food storage is extremely limited in the warm, humid environments of the border region. As a complement to the crops produced by these forest gardens, fishing from the border region's rivers and creeks, and hunting wild game provide important sources of protein. Some families also raise domesticated animals such as chickens or pigs, and the larger animals often serve as a repository of wealth that can be sold in the case of an emergency, such as a crop failure or a family member in need of medical care. Thus, border communities are reliant not only on the health of their crops, but the health of their animals for survival. Some communities, particularly the Afro-Ecuadorians in Esmeraldas and the colonists in Sucumbíos, also participate in the market economy by selling small quantities of products such as rice, coffee, maize or cacao. Thus, even though they participate in local markets, these communities are heavily dependent upon the health of their crops for both nutritional and economic security.

Beyond the importance of the natural environment as a food source and the economic backbone of the region, many indigenous cultures rely on forest resources for traditional medicines and as a source of spiritual beliefs. For example, cultural and cosmological systems of the Amazonian Kichwa are tied to the hydrosphere, to rain-forest dynamics, and to the ancient and traditional system of shifting cultivation. Cofán medicinal practices also depend upon residence in a relatively intact environment, including reliance on a great variety of medicinal plants. In short, the people of the border region are inextricably linked to their natural environment and are thus extremely vulnerable to environmental perturbations that upset this balance.

II. About the Authors

Norman E. Whitten, Jr.

Dr. Norman E. Whitten Jr. is Professor Emeritus of Anthropology and Latin American Studies at the University of Illinois at Urbana-Champaign and Curator of the Spurlock Museum. Dr. Whitten began his research in San Lorenzo, in Northwest Ecuador, in 1961, and continued through 1963, publishing his first book on the dynamics of Afro-Ecuadorian cultural adaptations and transformations in northern Esmeraldas in 1965. After a year of doing research on Afro-Colombian culture and indigenous cultures in Colombia in 1964-65, and after more comparative research on African American social organization in Canada, the United States, Colombia, and Ecuador, he and is spouse, Dorothea Scott Whitten, initiated research in Upper Amazonian Ecuador in 1968, where they continue working in 2010, primarily with Amazonian Quichua and Achuar Jivaroan native peoples. They have covered topics on cultural ecology, political economy, social organization and structure, cultural adaptation, symbolism, ritual, shamanic performance, cosmology and ideology.

Dr. Whitten received his Ph.D. degree in Anthropology at the University of North Carolina, Chapel Hill in 1964, and held positions at Tulane University, the Universidad del Valle, Cali, Colombia, Washington University, St. Louis, and the University of California Los Angeles prior to moving to the University of Illinois at Urbana-Champaign in 1970. Dr. Whitten served as the Head of the Department of Anthropology from 1983 to 1986 and Director of the Center for Latin American and Caribbean Studies from 2000 to 2003. He has also been and still is an Adjunct Professor of International Studies at the Universidad San Francisco de Quito in Ecuador since 1990.

Dr. Whitten's research has been supported by the National Science Foundation, the National Institute of Mental Health, the Social Science Research Council, the National Endowment for the Humanities, the Illinois Council of Humanities, the Wenner-Gren Foundation, and the University of Illinois. He has been a recipient of a John Simon Guggenheim Fellowship and has served as a Fulbright Research Scholar.

Dr. Whitten has written two ethnographies on Afro-Latin American people of Ecuador and Colombia (published in English and Spanish), four ethnographies (two joint with Dorothea Scott Whitten) on Amazonian Quichua-speaking people (one published in Spanish); edited two volumes on Ecuador; and edited three volumes on African American peoples and cultures (one with John Szwed, two with Arlene Torres). He is the author and co-editor of several other books and over one hundred forty articles, book chapters, and monographs plus seventy reviews or review articles. His new book on Ecuador (joint with Dorothea Scott Whitten), *Histories of the Present: People and Power in Ecuador,* is scheduled for publication in spring, 2011. Of his forty Ph.D. students now professionally engaged, fifteen of them did their doctoral dissertation research in Ecuador (9 in the Sierra, 4 on the Coast, and 2 in Amazonia), many of them publishing the results both in the United States and in Ecuador. Dr. Whitten's complete curriculum vita is attached in Appendix 1.

William T. Vickers

Dr. William T. Vickers is Professor Emeritus of Anthropology at Florida International University in Miami. He received his Ph.D. in Anthropology from the University of Florida in 1976. He first became interested in anthropology while serving as a Peace Corps volunteer in Ecuador in 1964-65, where he worked on rural community development projects in Cotopaxi and Tungurahua Provinces. In 1972 he initiated a program of field research among the Siona and Secoya peoples of northeastern Ecuador and his relationship with these communities continues to the present. Dr. Vickers' research focuses on the human ecology of native communities, land and civil rights, and frontier development. He is particularly interested in studying the relationships between people, nature, and culture and how these evolve through time. The research issues he has addressed include the use of forest and aquatic resources in Amazonia, ethnobotany, shifting cultivation, and the sustainability of hunting. He has also written extensively on frontier expansion and how it affects indigenous societies, including their social and political responses to national and regional development. In the 1980s, Dr. Vickers served as a consultant to Ecuador's Ministry of Agriculture on the demarcation of lands for Siona, Secoya, and Cofán communities in Sucumbíos Province. In 1995, the Catholic University of Quito invited him to serve as an international observer in Shuar border communities in Morona-Santiago Province that were impacted by the Cenepa War between Ecuador and Peru.

Professor Vickers' books include *Los Sionas y Secoyas: Su Adaptación al Ambiente Amazónico*, *Useful Plants of the Siona and Secoya Indians* (co-authored with Timothy Plowman) and Adaptive Responses of Native Amazonians (coedited with Raymond B. Hames). His articles have appeared in such journals as *Science*, *American Ethnologist*, *Human Nature*, *Human Ecology*, *Interciencia, Law and Anthropology*, *Cultural Survival Quarterly*, *Studies in Third World Societies*, *Latin American Research Review*, *Latin American Anthropology Review*, and *Reviews in Anthropology*. Professor Vickers has been a Fulbright Fellow in Ecuador, a National Endowment for the Humanities Fellow at the School for Advanced Research in Santa Fe, New Mexico, and a Doherty Foundation Fellow. He has also been Visiting Professor at the Pontificia Universidad Católica, Quito, Ecuador. The State University System of Florida has presented Dr. Vickers with awards for excellence in teaching and excellence in research. Dr. Vickers' complete curriculum vita is attached in Appendix 2.

Michael Cepek

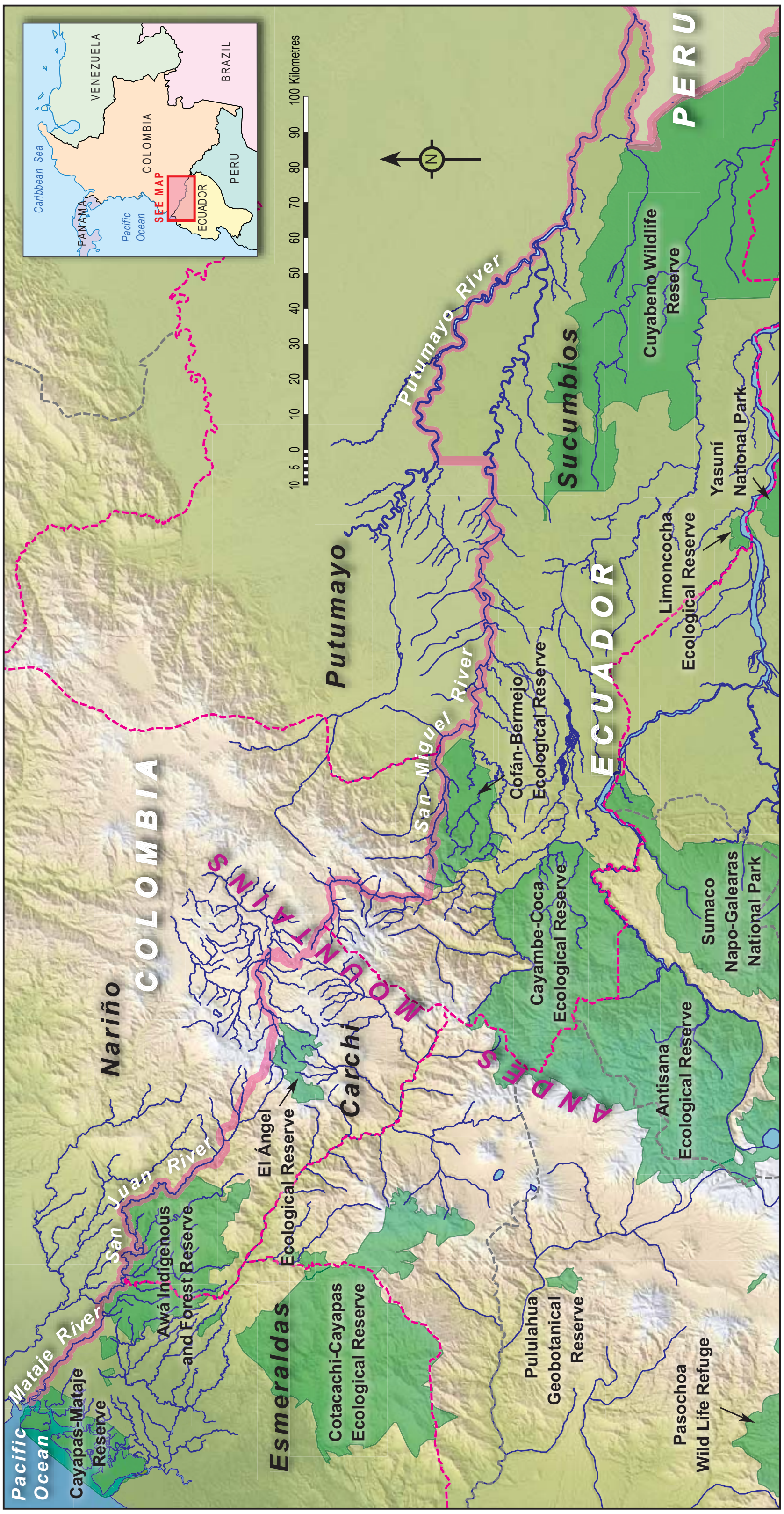
Dr. Michael Cepek is Assistant Professor of Anthropology at the University of Texas at San Antonio, and has broad background in social and cultural theory and the peoples and politics of lowland South America. He began working with Cofán people in 1994, and he returns to their Ecuadorian territory every year. To date, he has completed approximately three years of immersed research in Cofán territory, resulting in a number of publications on Cofán culture, society, and environmental politics.

Dr. Cepek received his Ph.D. from the University of Chicago in 2006. After completing a Mellon Postdoctoral Fellowship at Macalester College, he began an Assistant Professorship at the University of Texas at San Antonio, where he was hired as part of an effort to build a doctoral program focusing on anthropology's engagement with the environment. He has been awarded grants from the National Science Foundation, the Woodrow Wilson Foundation, the Tinker Foundation, and the Fulbright Commission.

In addition to his position at the University of Texas at San Antonio, Dr. Cepek serves as a Fellow in the Division of Environment, Culture, and Conservation at the Field Museum of Natural History in Chicago, Illinois. He is a book review editor for *Environment and Society: Advances in Research*, and is Secretary/Treasurer for the Society for the Anthropology of Lowland South America. He is a member of the American Anthropological Association, the American Ethnological Society, the Society for Latin American and Caribbean Anthropology, the Anthropology and Environment Section of the American Anthropological Association, and the International Work Group for Indigenous Affairs. Dr. Cepek's complete curriculum vita is attached in Appendix 3.

III. Overall Dimensions of Tropical-Forest Ecology in the Ecuador-Colombia Border Region

The tropical-forest regions of Ecuador along its northern border with Colombia exist on both the eastern and western sides of the Andes. Both of these are tropical-forest regions inhabited mostly by indigenous peoples and colonists from other areas of the country in the east (in the Upper Amazonian region) and mostly Afro-Ecuadorian and indigenous peoples in the west (between the Andean foothills and the Pacific Ocean). Each tropical rain-forest region grades down from the foothills of the Andes at about 3,000 feet elevation to about 650 feet above sea level in the east, and about 3,000 feet altitude to sea level in the west. Following an overall description of tropical-forest cultural ecology that characterizes the regions on both sides of the Andes, we turn to the exploitative strategies and cultural orientations of the indigenous residents of the east, including the Cofán and the Siona and Secoya, who are long-term residents of the region, the newer Amazonian Quichua indigenous in-migrants, and the nonindigenous colonists. We then turn to the western side of the Andes, with attention paid to the Awá indigenous group and the Afro-Ecuadorians. Our focus in this report is on the tropical-forest regions of Ecuador that border Colombia depicted in Map 1. We do not discuss the Andean region of this border.



Pacific Ocean
Cayapas-Mataje Reserve
Mataje River
San Juan River
Awá Indigenous and Forest Reserve
Esmeraldas
Cotacachi-Cayapas Ecological Reserve
El Ángel Ecological Reserve
Carchi
Nariño
COLOMBIA
ANDES MOUNTAINS
Putumayo
San Miguel River
Cofán-Bermejo Ecological Reserve
Cayambe-Coca Ecological Reserve
Antisana Ecological Reserve
Pululahua Geobotanical Reserve
Pasochoa Wild Life Refuge
Sumaco Napo-Galearas National Park
ECUADOR
Limoncocha Ecological Reserve
Yasuní National Park
Sucumbios
Cuyabeno Wildlife Reserve
Putumayo River
PERU
N
10 5 0 10 20 30 40 50 60 70 80 90 100 Kilometres
Caribbean Sea
PANAMA
Pacific Ocean
VENEZUELA
COLOMBIA
SEE MAP
ECUADOR
PERU
BRAZIL

Map 1

The concept of *agroforestry* is critical to understanding the cultural adaptations of the peoples described in this report. Agroforestry is defined as “a farming system that integrates crops and/or livestock with trees and shrubs. The resulting biological interactions provide multiple benefits, including diversified income sources, increased biological production, better water quality, and improved habitat for both humans and wildlife.” (Beetz, 2002). Agroforestry involves human action that utilizes forest resources together with domestic plant resources to create and maintain a dynamic, adaptive system to sustain human life. Although sometimes thought of as a modern, development-oriented, sophisticated “new” strategy to exploit the moist tropics, agroforestry systems of human-managed biodiversity go back millennia to the very beginnings of indigenous exploitation of tropical-forest habitats in the Americas.

Native and Afro-Ecuadorian cultures of the tropical-forest borderlands with Colombia are characterized by what ecologist David Harris calls “Permanent settlement swidden cultivation” (Harris, 1971; 1972:249; Whitten, 1981: 143-44). Swidden simply means shifting cultivation. This form of gardening (horticulture, agriculture) utilizes the natural decay of leaves, stems, vines and wood to release the nitrogen, phosphoric acid and potash (potassium carbonate with other elements from decay) to multiple crops planted in some areas, while allowing other areas to restore themselves (fallow or second growth) in a cyclical manner. In short, the growing matter itself is utilized to provide the soil nutrients. A typical swidden agriculture system is shown in Figure 1.

Figure 1. Typical swidden agriculture system in the tropical-forest regions of northern Ecuador near the border with Colombia.

The combination of forest and hydrosphere (rainfall and river-stream activity) constitutes the basic features of what those in temperate zones call "the soil." The vegetation provided by the rain forest itself captures and stores the nutrients and protects the soil from excessive solar radiation and erosion. Leaf litter falls constantly from the trees, building up a mat. Tiny hair roots grow quickly in the leaves of the mat as a result of the action of mycorrhizal fungi that fasten to the roots of anything growing there and exchange minerals for sugars produced by their plant hosts. As the garden diversifies, the chemical inhibitors of the various plants increasingly protect the garden by producing various threats to predating insects and fungi. These symbiotic relationships underpin the growth of the luxuriant tropical-forest ecosystem of which the indigenous and Afro-Ecuadorian garden becomes an important part. Such agroforestry systems and the human communities that depend on them are nonetheless quite vulnerable to environmental perturbations.

One common misperception about the populations of the border region is that they use a destructive practice called "slash and burn" agriculture. In fact, most horticultural practices in this region depend upon a healthy, fully functioning successional ecosystem, one where minor disruptions can materially affect the health and productivity of the system. More specifically, "slash and burn" agriculture does not often characterize the eastern region (the Siona and Secoya constitute an exception, as noted below), and never pertains to the western region. The system described by the cultural geographer Robert C. West as slash-mulch characterizes both areas (West, 1957; Whitten, 1974). In slash-mulch (or slash-and-mulch) horticulture people manage a complex, culturally significant, human-made ecosystem. The mature tropical-forest garden (often called a *chacra* or a *finca*) contains three vertical layers, each containing many different crops. While the types of crops grown vary somewhat from the west to the east, among the most important crops (depending on the region) are plantains (large cooking bananas) and manioc (yuca). Other "root crops," also called "earth vegetables," include a large variety of taro (*Colocasia* and *Xanthosoma* species) and sweet potatoes. Maize is a prominent crop in sectors of the western region. Several varieties of palm trees, particularly the domesticated peach palm, are also important food sources. The rain-forest canopy above the crop layer protects the crops by breaking up rainfall and filtering sunlight. The soil beneath, made up of the natural rain-forest mulch and the undersoil root lattice, retards the leaching of vital nutrients.

Typically, about three years after initial planting, the area used to grow crops is allowed to return to fallow. Particularly in cases where manioc (yuca) is the predominant crop, the fallow itself may remain without further cutting for up to thirty years, by which time its diversity has been enhanced and its nutrients made even more valuable for continued swidden horticulture. (Where plantains are the primary crop, the fallow cycle may be shorter). The fallow forest also attracts small game and birds, providing favorable hunting. Some planted tree species such as peach palm (*chontaduro, pejibaye*) and guayusa (*huayusa*) are harvested on a regular or seasonal basis for many years and provide "markers" to identify the areas. Thus, the overall strategy for exploitation of the tropical forest involves a cyclical movement of relatively small groups of people who are able to maximize approximately three years of intensive horticulture while at the same time exploiting fallow areas for hunting and harvesting of selected tree crops.

When properly managed, swidden agricultural systems are efficient and productive, and such systems provide an important source of carbohydrates for many communities in the border region. Writing about tropical forest ecosystems and the swidden garden, distinguished ecologist

David Harris argues that “contrary to the common assumption that swidden is an inefficient method of cultivation, it can be shown that such systems are highly productive. In terms of yields per unit of labor expended its productivity can equal or even exceed that of some kinds of permanent, fixed-field agriculture” (1972:257). Nevertheless, these systems are vulnerable to exogenous forces such as damage caused by herbicides, which can destroy the delicate balance upon which the swidden horticultural strategy depends and significantly compromise their productivity.

When thinking about the cultural ecologies of rain-forest systems, many assume that “hunting and gathering” is the primary means by which humans obtain their necessary protein. However, contrary to such popular notions about “hunting and gathering” for indigenous people and “plantation labor” for black people, both indigenous and Afro-Ecuadorian people rely heavily on fish and shellfish for their protein supply. This subsistence practice is particularly true in the Ecuador-Colombia border region, which is dominated by a network of rivers and creeks. Of course, when aquatic life is so crucial a source of sustained protein capture, impacts to the rivers, creeks and ponds that serve as a habitat for aquatic life can be severely compromising.

Hunting for game, gathering small forest animals, and raising domesticated animals provide other important sources of protein for residents of the border region. Depending on the area and the season, hunting for monkeys that live in the canopy and come half way down to feed, ground animals such as the tapir, white-lipped and collared peccary, paca, agouti, and smaller animals provide high-grade protein. Figure 2 depicts two Cofán youth returning from a hunt.

Figure 2. Cofán youth returning from a hunt with tapir from the forest.

In some regions, protein is also obtained from forest snails, tortoises, larvae, or insects. Other sources include chickens and eggs, which are very important in both eastern and western sectors. Pig-raising on a small scale is common in sectors of the western region. As is described in greater detail below, some families maintain a limited number of domesticated animals as a sort of “bank account” that can be sold in the case of an emergency, such as a crop failure or a family member in need of medical care. Thus, these animals serve not only as a food source, they also provide economic security.

Most of the inhabitants of both sides of the Andes within the rain-forest-riverine areas bordering Colombia are best described as remote from modern infrastructure. Although rural schools may exist, they typically feature one teacher for the entire school, and that teacher must walk long distances when he or she does not reside in the region. Access to road and rail requires long over-land treks, or by river travel, often in handmade dugout canoes (see Figure 3).

Figure 3. Transportation by dugout canoe.

In part due to their sophisticated understanding of their natural environment, many of the people in this region consider time in terms of seasonal cycles or natural changes; the ages of people are marked relative to one another and/or by generations rather than by precise birth dates.

With regard to shelter, most people in the tropical rain-forest regions of the border area either dwell in large open-sided houses, or in houses that are sided with split palm or bamboo. Clothing appropriate to life in very hot and wet tropical environments offers limited protection from the elements. Examples of the housing utilized in the region are shown in Figure 4. Examples of typical clothing are shown in Figure 5.

Figure 4. Cofán house near Colombian border; House in colonist farming community in northern Sucumbíos.

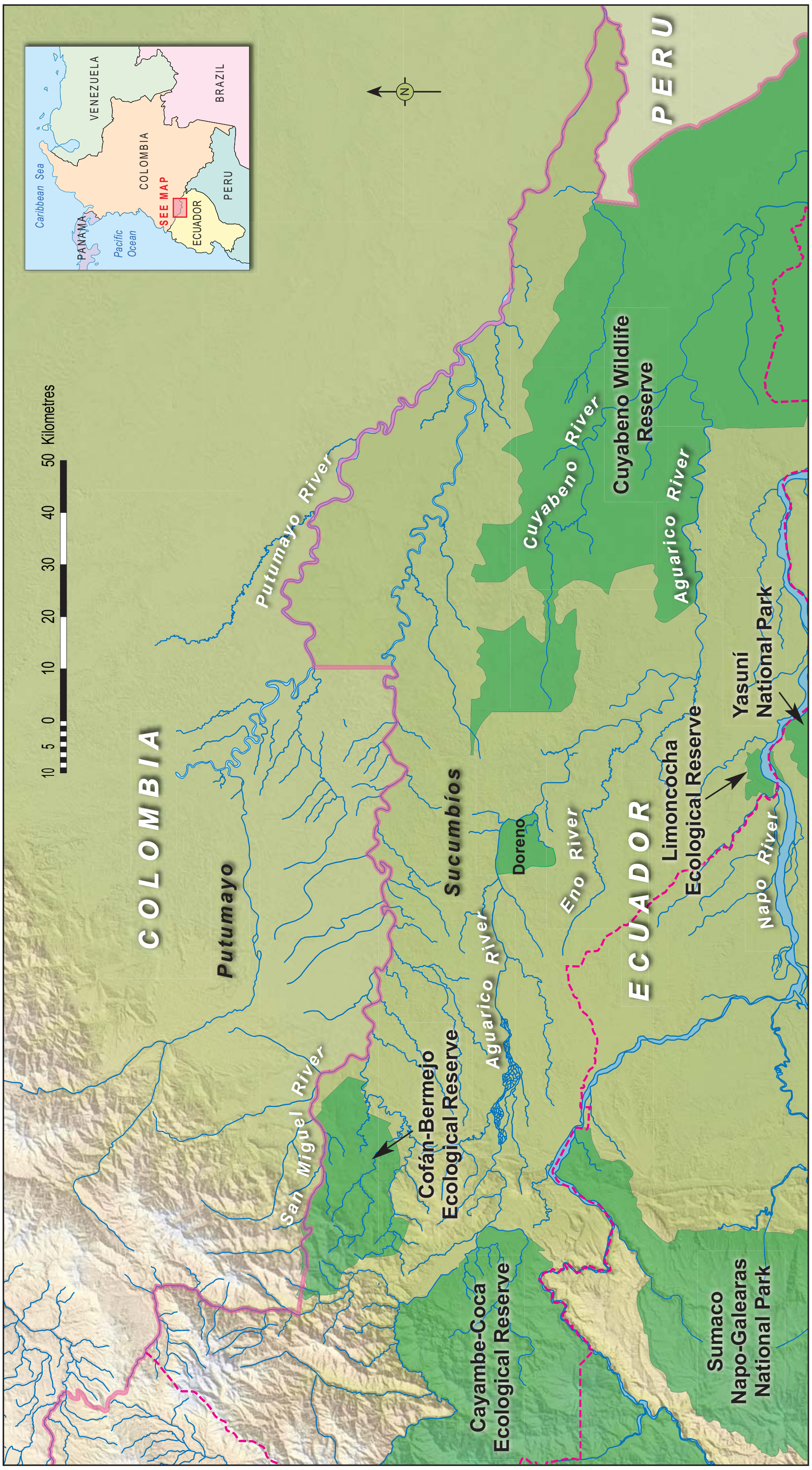
Figure 5. Children in the Afro-Ecuadorian community of Mataje in western Ecuador, near the Colombian border (Source EFEAmerica)

IV. Eastern Ecuador: Sucumbíos

Sucumbíos is the northernmost province of Ecuador's Amazon region and covers an area of 18,327 square kilometers. Its northern boundary constitutes about two-thirds of the 717 km border between Ecuador and Colombia. Lago Agrio (also known as "Nueva Loja"), the provincial capital, located approximately 16 km south of the Colombian border, has 35,000 inhabitants. Map 2 depicts the eastern portion of northern Ecuador including the Sucumbíos province.

The provincial government estimates the current population of Sucumbíos to be 150,000. The Ecuadorian census of 2001 registered a population of 128,995 (INEC, 2001). This census classified two-thirds of the population as rural dwellers and one-third as urban. In the 2001 census the indigenous population numbered 13,476, or 10.45 percent of the total population in Sucumbíos.

Until the late 1960s the tropical rain-forests, rivers, and indigenous peoples of Sucumbíos were largely isolated from the rest of Ecuador. There were no roads into the region and mail was delivered by a monthly postal canoe that traveled up the Aguarico River from the port of Rocafuerte on the Napo River. A few small and scattered Ecuadorian military outposts were located on the San Miguel, Putumayo, Aguarico, and Cuyabeno Rivers. Two evangelical missionary-linguist families worked in indigenous communities, and Carmelite and Capuchin priests periodically visited native villages from their bases at Rocafuerte and Pompeya on the Napo River.


10 5 0 10 20 30 40 50 Kilometres
N
Caribbean Sea
VENEZUELA
PANAMA
Pacific Ocean
COLOMBIA
SEE MAP
ECUADOR
PERU
BRAZIL
C O L O M B I A
Putumayo
Putumayo River
San Miguel River
Sucumbíos
Aguarico River
Cofán-Bermejo Ecological Reserve
Cayambe-Coca Ecological Reserve
Doreno
Eno River
Cuyabeno River
Cuyabeno Wildlife Reserve
Aguarico River
E C U A D O R
Limoncocha Ecological Reserve
Napo River
Yasuní National Park
Sumaco Napo-Galearas National Park
P E R U

Map 2

Almost all of the population at this time was indigenous. The Cofán people occupied the region's western portion with settlements along the middle and upper Aguarico River and the San Miguel and its tributaries to the north. he Siona resided along the Putumayo, the San Miguel, the middle and lower Aguarico and its tributaries, the Eno, Shushufindi, and Cuyabeno. The Secoya, close relatives of the Siona, lived along the middle and lower Aguarico, the Cuyabeno, and the Santa María Rivers. These three groups are ancestral inhabitants of the Sucumbíos region dating to Pre-Colombian times. In the 19th and 20th centuries, Amazonian Kichwa (Quichua) families also began migrating from the Napo River to the Putumayo and Aguarico Rivers and their tributaries. Amazonian Kichwa communities have had a substantial presence in this region for over a century. More recently, a significant number of Kichwa families have moved into Sucumbíos from Orellana, Napo, and Pastaza Provinces to the south.

The indigenous groups that currently reside in Sucumbíos have traditional subsistence economies based on shifting cultivation (swidden agriculture), hunting, fishing and gathering. Their adaptations are characterized by the use of a large variety of cultivars and wild plant resources, which serve as foods, medicines, and construction and craft materials. A variety of terrestrial, arboreal, and aquatic animal species contribute to native diets and supply essential nutrients, including proteins and fats. Many native families also seek to supplement their traditional subsistence with income-generating activities, such as cash cropping, livestock raising, and wage labor.

Subsequent sections of this report describe the indigenous Cofán, Amazonian Kichwa, Siona and Secoya of the border region in greater depth. The discussion then turns to the more recent in-migrants to the area: the colonist farmers of northern Sucumbíos. These colonists began arriving in the late 1960s when the first roads penetrated the region, and colonization has continued ever since. Most of these migrants come from the Andean and coastal provinces of Ecuador. Since their arrival, they have quickly staked out land claims and begun to establish farms. In contrast to the indigenous peoples, these colonist farmers are more oriented to the market economy, the growing of cash crops such as coffee and cacao, and the raising of livestock. As relatively recent arrivals in Ecuador's Amazonian lowlands, colonists often lack the deep ancestral knowledge of the rain forest ecosystem, flora, and fauna that is characteristic of indigenous peoples. Their dependence on relatively few cash crops and national and international markets makes them especially vulnerable to fluctuations in the prices of farm products and commodities, and environmental stresses that impact their production.

A. The Cofán

The Cofán are an indigenous people who have lived in the Ecuador-Colombia border area since pre-colonial times. Currently, approximately 1,200 Cofán people live in the Ecuadorian province of Sucumbíos, and approximately the same number reside in the Colombian department of Putumayo. As described below, the Cofán rely heavily on forest resources for their culture, spiritual traditions, and livelihoods. Therefore, the survival of this important indigenous group depends upon continuous access to the healthy and intact environments that compose large portions of their territory.

Cofán people are amongst the original inhabitants of the Ecuador-Colombia border region. Spanish chroniclers mention contacts with them in the mid-1500s, when their population ranged from 35,000 to 70,000 individuals. Centuries of colonial wars and epidemic disease reduced the Cofán to their current numbers. In Ecuador, Cofán people reside in 13 legalized communities along the Aguarico, San Miguel, and Bermejo rivers and their tributaries. In Colombia, they live in at least 11 legalized communities along the main bodies and tributaries of the Guamués, Putumayo, and San Miguel rivers. Kinship ties, visiting practices, and intermarriage join the Ecuadorian and Colombian Cofán. An elder Cofán man and a Cofán woman are shown in Figure 6.

Figure 6. Elder Cofán man; Cofán woman.

Currently, Ecuadorian Cofán have legal control of 433,400 hectares of montane and lowland Amazonian forests. The great majority of their territory overlaps with three protected areas: the Cayambe-Coca Ecological Reserve, the Cuyabeno Wildlife Reserve, and the Cofán-Bermejo Ecological Reserve (see Map 2). The Ecuadorian state created the first two reserves to safeguard their biological diversity and later formed use and residence agreements with Cofán people. The Ministry of Environment created the third protected area, the Cofán-Bermejo Ecological Reserve, with the direct participation of Cofán leaders and residents. The Cofán people have both co-management and co-administration rights over the area. As such, the government gives equal weight to the reserve's importance for protecting Ecuador's cultural and biological heritage.

All of the Cofán people's currently titled lands are in their ancestral territory. The Cofán are the earliest recorded inhabitants of the region. Their myths contain innumerable references to the cultural and natural features of the lands on which they live. The landscape continues to hold deep significance for the Cofán. They maintain strong ties to old burial sites, former village locations, and existing ecological zones, which provide resources for subsistence and traditional medical practice. Culturally and economically, residing in their territory is essential to the Cofán people's maintenance of their identity and way of life.

Cofán territory ranges in altitude from 3,000 meter mountain peaks in the Andean foothills to the lowland forests of the community of Zábalo, which sits at 200 m above sea level along the Peruvian border. Figure 7 shows traditional Cofán territory along the upper Aguarico River bordering the Cofán-Bermejo Ecological Reserve.

Figure 7. Traditional Cofán territory along the upper Aguarico River bordering the Cofán-Bermejo Ecological Reserve.

The natural environments of the Cofán's legalized territory remain relatively intact. A series of biological inventories conducted by the Field Museum of Natural History note extremely high levels of animal and plant diversity in all Cofán lands (Borman et al., 2007; Pitman et al., 2002; Vriesendorp et al., 2009). The Cofán-Bermejo Ecological Reserve is an especially important protected area. The authors of the Field Museum inventory write that the area contains "a spectacularly diverse mix of lowland and montane biota, including a large number of undescribed and endemic species protected nowhere else" (Pitman et al., 2002:93). Together with the Cofán-managed portions of the neighboring Cayambe-Coca Ecological reserve, the Field Museum estimates an immense amount of biological diversity for the upriver portion of Cofán territory: 2,000 to 3,000 plant species; at least 42 species of large mammals; 12 species of primates (as well as reports of a primate species that is potentially new to science); and up to 700 bird species.

The ecological integrity of Cofán lands is no accident. Over the last two decades, the Cofán have worked with the Ecuadorian government and international environmental organizations to devise management and protection initiatives for the majority of their homeland. Community conservation rules exist in almost all Cofán villages. Moreover, the Cofán Park Guard program employs 50 legally accredited Cofán rangers to monitor ecological processes and potential threats, to work on community management, and to create a conservation infrastructure throughout Cofán territory. In Ecuador, the Cofán people are known as one of the indigenous groups most committed to conservation objectives. Many earn a living as rangers, research assistants, and ecotourism guides. The Cofán remain absolutely opposed to the entrance of oil companies onto their land, and no oil extraction has occurred within the territory that makes up the Cofán-Bermejo Ecological Reserve. In 1998, Cofán people voted to make each community's territory the patrimony of the entire Cofán nation, thereby adding a level of collective political control over the resource-use decisions of dispersed households and villages.

Although Cofán collaborations with scientists and conservationists are relatively recent, these interactions have a deep grounding in Cofán attitudes toward the forest environment. In the most general terms, Cofán people do not believe that they would be able to maintain their culture and identity without residing in their traditional territory's montane and lowland ecosystems. In their native language of A'ingae, Cofán call themselves *tsampini can'jensundeccu* (dwellers of the forest). In their political discourse, Cofán leaders proclaim, "Without our Forest, which has been the one constant throughout our history, we are no longer Cofán." Cofán language, cosmology, social life, healing practices, and subsistence patterns interweave profoundly with the Amazonian environment. The fact that very few Cofán have left their communities to reside permanently in urban centers demonstrates that ties to their forest remain strong.

Some Cofán engage in periodic wage labor as well as small-scale sale of cash crops and non-timber forest products. The sale of produce is limited due to the lack of roads and good transport in much of Cofán territory. Nevertheless, Cofán people pay attention to shifting prices for certain crops, and if the potential for additional income presents itself, they will plant some items for sale. In the past, coffee was an important cash crop. In recent years, cacao, a principal ingredient in chocolate, has replaced it. Currently, the most important non-timber forest product is *sangre de drago* (*Croton lechleri*), which is desired regionally for its healing properties. If they have sufficient time and money for transport, many residents of the Cofán-Bermejo Ecological Reserve sell this product to middlemen in Lago Agrio or Cascales. In addition, some Cofán people manufacture handicrafts from local seeds and plant fibers and sell them to tourists and merchants.

Although many Cofán people rely upon the Amazonian environment for limited market engagement, the subsistence sphere continues to be the most important element of the Cofán economy. In all Cofán communities, the majority of residents construct their homes with locally obtained trees, vines, and leaves. They depend on forest resources for making important tools as well as hammocks and body adornments. An example of a basket made from forest resources is shown in Figure 8. Hunting, fishing, gathering, and small-scale agriculture provide the majority of their foodstuffs. In nearly all communities, water for drinking and cooking comes from rain or streams, and rivers provide the only sites for bathing and washing clothes.

Figure 8. Cofán man with basket.

The diversity of species that Cofán people use is impressive. In Doreno, the ethnobiolgoist Carlos Eduardo Cerón confirmed the earlier research of ethnobotanist Homer Pinkley (1973) by cataloguing the use of nearly 300 plant species (Cerón, 1995). The Cofán leader and natural historian Randy Borman estimates that Cofán eat approximately 50 species of terrestrial mammals, 50 species of fish, and hundreds of species of birds (Borman, 2002). Cofán people rely on shotguns, rifles, spears, blowguns, and traps for hunting, and they use a variety of nets, as well as hooks, lines, and spears, for fishing. Although most Cofán hunting and fishing occurs within the boundaries of titled territories, many people harvest outside of their communities and protected areas, especially along the Aguarico and San Miguel rivers. It is uncommon for a family to go two days without eating meat or fish. Cofán people also eat dozens of species of wild fruits, depending on seasonal availability. Although less impressive in its diversity of cultigens, agricultural knowledge is also extremely important. Plantains and bananas supply the overwhelming majority of carbohydrates. In addition, manioc, fruit, corn, and squash are staples. A functioning household is never without certain products, such as the daily standby of *cui'ccu*, a drink made from boiled bananas or plantains. Examples of foods that make up the Cofán diet are shown in Figure 9. When living in a large, intact, and contamination-free environment, Cofán people have sufficient resources for maintaining a robust state of health.

Figure 9. Manioc; preparation of cui'ccu.

In the Cofán communities close to the most colonized regions along the middle Aguarico River, purchased foodstuffs such as rice, noodles, and tuna have become important elements of the Cofán diet. In the great majority of Cofán villages, however, people produce the bulk of their food directly from the forest environment. Given the warm and humid climate of the Amazonian forest, storing food is nearly impossible, apart from smoking fish and game, which can secure a household's protein supply for a week or two. If a family's banana, plantain, and manioc fields are damaged, hunger and malnutrition are real and serious threats. There is no way to store bananas and plantains, and very few Cofán families transform manioc into cassava flour or bread, unlike other indigenous peoples of the region, such as neighboring Siona and Secoya people.

Cofán medicinal practices also depend upon residence in a relatively intact environment. According to the estimates of Randy Borman, Cofán people use approximately 250 plant species for medicinal purposes (Borman, 2002). Medicinal knowledge is widely distributed in Cofán society. Many men and women are proficient in identifying and using plants to treat a wide array of ailments. Shamanic healing, in contrast, depends upon the extensive knowledge of a small number of ritual experts who are masters at utilizing plant species for their visionary properties. The most important are *yajé* (*Banisteriopsis caapi*), *opirito* (*Psychotria pschotriaefolia*), *yajé oco* (*Diplopterys cabrerana*), *va'u* (*Brugmansia suaveolensis*), *ccumba* (tobacco, in various solid and liquid forms), *yoco* (*Paullina yoco*), *tsontimba'cco* (*Brunfelsia* sp.), as well as plants that have not been described by science. Some of these plants are cultivated in Cofán gardens. Others are found in the forest, sometimes at a great distance from Cofán homes. The availability of all of these plant species, whether hallucinogenic or not, is essential for Cofán healing practices. The preparation of the *yajé* drink, and a *yajé* house, where this drink is consumed, are shown in Figure 10.

Figure 10. *Yajé*; *yajé* house.

Cofán shamans, such as the man depicted in Figure 11, are deeply attuned to the ecological state of waterways and plant resources. “Contamination” is a key notion in shamanic ideology. If hallucinogenic plants or the water in which they are prepared are deemed to be *ámundetssi* (dirty or filthy), they lose their curative powers and become dangerous to the people who consume them. Although shamans are especially concerned with potential contamination from menstruating women and pregnant people, they are also wary of new contaminants. For example, the most powerful shamans refuse to bathe with Western soap, and they tell people in their communities not to wash clothes in nearby streams. Others believe that some waterways are too contaminated by garbage or waste to be useful for preparing hallucinogenic brews. Contamination is especially severe along the middle and lower Aguarico River. In contrast, the upper reaches of the San Miguel River are considered to be relatively free of contamination.

Figure 11. Cofán shaman.

In addition to their vulnerability to river-borne contamination, Cofán people maintain few boundaries between their bodies and harmful air-borne contaminants. Cofán territory is hot and humid, and people dress accordingly. Many older men continue to wear their traditional *ondiccu'je* (tunics), and they go barefoot in both the forest and the village. Older women wear hand-sewn blouses that partially cover their stomachs as well as *foño* (skirts) that descend to their knees. They, too, frequently wear no shoes. The younger generations typically wear shorts and T-shirts, and they follow their elders' preference for going without footwear. Children often spend the entirety of their days in a pair of underwear or swimming trunks. Figure 12 shows typical Cofán dress.

Figure 12. Cofán people in typical clothing.

Even in their homes, people are open to the elements. No Cofán houses are sealed off from their surroundings. Walls are constructed from roughly cut boards or split palm trees, as are floors. Many residences combine a partially closed sleeping area with a cooking and living area that has no walls. Palm leaf or tin roofs do a good job keeping rain out, but air circulates freely through all Cofán living structures. Figure 13 shows typical examples of Cofán houses.

Figure 13. Cofán houses.

Although Cofán people believe that their healing practices are sufficient for curing "traditional" illnesses, they recognize that colonists brought new ailments to their homeland.

They now depend upon Western medicine to treat many of the more serious diseases that plague them, as well as typical wounds associated with forest life, such as broken limbs and snake bites. However, many Cofán people live far from health centers, which can be more than a day's travel from their homes. In some communities, people can only access roads and buses by trekking for hours through difficult terrain. In others, canoes are the only means of access to urban centers. Transport via canoe can require days of paddling or the expenditure of money on gasoline and oil far beyond the means of most Cofán, as well as access to a functioning outboard motor. Many Cofán people thus do not have enough money to make the trip or pay for treatment. The main medical facility in the region is the hospital in Lago Agrio, which is often overcrowded and out of essential medicines, and is in ill repair. Seriously sick people sometimes attempt to travel to Quito, where superior services are available. Nevertheless, the capital is far from Cofán territory, and few can afford to make the trip or to pay for lodging in the city. For these reasons, Cofán often rely only on traditional medicine. Furthermore, the inaccessibility and expense of Western medical facilities mean that many health problems go undocumented.

The existence of the Cofán as a people depends on their continued access to what remains of their traditional territory, the majority of which overlaps with ecologically protected areas, especially the Cuyabeno Wildlife Reserve, the Cayambe-Coca Ecological Reserve, and the Cofán-Bermejo Ecological Reserve. As an indigenous nation with deep cultural and economic ties to their homeland, the Cofán are especially vulnerable to activities that compromise the ecological integrity of their territory. Their leaders continuously proclaim that if they were no longer able to live in the intact forests that support their way of life, the Cofán people would cease to be who they are.

B. The Amazonian Kichwa (Quichua)

The Kichwa (Quichua) people are part of a larger indigenous group that inhabits various regions of Ecuador. While the 50 Amazonian Kichwa communities that live along the San Miguel and Aguarico Rivers in the Sucumbíos Province are more recent in-migrants to the area than other indigenous groups such as the Cofán, they have maintained many of their traditional practices including swidden agriculture and hunting of tropical-forest species, making them heavily reliant on environmental resources for their well-being. The limited extent of the Kichwa's engagement in the market economy also depends on agriculture and forest resources that are vulnerable to environmental perturbations. The Kichwa are further linked to the natural environment through their spiritual beliefs.

There are about 150,000 Amazonian Kichwa (Quichua) speakers in Ecuador who speak dialects closely related to Amazonian Inga (Colombia) and the Amazonian Quechua of Peru (Uzendoski and Whitten, n.d.). They self identify as Runa (fully human beings), and call their language *Runa shimi* (human speech). It is likely that Amazonian Kichwa existed in pre-Hispanic times as one of many languages of the Amazonian world After the Spanish conquest, missionaries also promoted it as a *lingua franca*, which contributed to its use by a number of indigenous groups.

During the colonial era the use of the Amazonian Kichwa language spread in the greater Pastaza and Napo regions. It became the language of mediation and trade for previously warring peoples such as the Shuar-Andoa/Zápara in the Pastaza region and Zápara-Waorani in both the

Napo and Pastaza regions. Many indigenous peoples, especially Achuar, Shiwiar, Zápara, Andoa and Caninche in the Pastaza region and Quijos, Zápara, Omagua and Cofán in the Napo region became incorporated into the Kichwa speaking aggregate of Amazonian Ecuador (Uzendoski and Whitten, n.d.).

There are currently four major Amazonian Kichwa groupings recognized in Ecuador: Napo (Napo Runa or Kichwas de Napo), Orellana (also Napo Runa or Kichwas de Napo), Pastaza (Canelos Kichwa, Pastaza Runa), and Sucumbíos. It is common for people of the four Amazonian Kichwa groups to intermarry, and they also exchange shamanic knowledge, medicinal plants, game, and other forest products. The Kichwa intermarry with other indigenous groups as well, such as the Achuar, Waorani, Cofán, Siona, and Secoya. Thus, the Amazonian Kichwa are intercultural in both their historical heritage and in their contemporary lives (Uzendoski and Whitten, n.d.).

There are 50 Amazonian Kichwa communities along the San Miguel and Aguarico Rivers in Sucumbíos Province (Pierre, 2008). Their estimated 2008 population was 18,000, which makes them the most numerous indigenous group in the province. Along the middle and lower Aguarico River in Sucumbíos there are long-established Amazonian Kichwa (Quichua) families who originally came upriver from the Napo in the late 19th and early 20th centuries. For example, there is a sizeable old Kichwa community at the confluence of the Cuyabeno and Aguarico Rivers and another in the environs of Chiritza farther up the Aguarico (between the Cofán settlement at Doreno and the beginning of Siona territory at the Eno River). Since the early 1970s, other Kichwa from Napo, Orellana, and Pastaza Provinces have traveled north via the new roads and settled along the San Miguel and Aguarico Rivers. Kichwa people live in several communities including Yana Amarum, San Francisco I, and San Francisco II along the San Miguel River, which forms the border with Colombia.

The Amazonian Kichwa belief system is closely articulated with the environment. Although most Amazonian Kichwa are nominally Christian, all subscribe to a complex indigenous cosmology that is based on a myriad of forest spirits and supernatural beings. Their mythology is rich and includes accounts of floods, culture heroes, jaguars, anacondas, the former "human" lives of many plants, birds, animals, and the spirit protectors of forests, rivers, and mountains (Uzendoski and Whitten, n.d.). The Amazonian Kichwa word for shaman is *yachaj* (one who knows). While all people may know and interact with the spirit world, shamans have broader knowledge of the spirits and interact with them more frequently (Macdonald, Irvine, and Aranda, 1993:14). Powerful shamans, called *sinchi yachaj* (strong ones who know) or *bancu* (repository of deep knowledge), are the "behind the scenes" motivators of prominent younger leaders in Kichwa communities and organizations. They draw on deep knowledge of ancestors through the use of *Brugmansia suaveolensis* and *Banisteriopsis caapi* with plant additives. Because the shaman is prescient, community leaders will consult with him to help ensure success in any endeavor.

The Kichwa people conceptualize the ecosystem as consisting of three spheres of power: the hydrosphere, the forest itself, and their gardens. They believe the master spirit who empowers the hydrosphere (all water systems as they relate to one another) is the first shaman, an androgynous spirit who becomes manifest as the giant anaconda. This spirit force oversees rainfall and all fluvial systems that can, if not controlled, overwhelm the world through flood. Kichwa-speaking people say that the spirit of the forest controls the water forces and provides all of the mechanisms of fertility and fecundity that exist in wild forms. The second sphere is overseen by the forest spirit, which is also androgynous and is manifest by the great black jaguar who is the forest shaman. The third sphere of gardens is said to be overseen by a feminine spirit known as *Nungüi* or *Chagra Mama*. She is the giver of domestic crops and her manifestation is a small coral snake that lives under the leaf mat of the forest and gardens. Manioc stems are said to be her children. Just as the forest spirit controls the awesome power of water, the garden spirit controls the wild forces of the forest.

In short, the cultural and cosmological systems of the Amazonian Kichwa encompass tropical-forest ecology from the hydrosphere and rain-forest dynamics to the ancient system of shifting cultivation (see, e.g. Whitten, 1976; D. Whitten and N. Whitten, 1988; N. Whitten and D. Whitten, 2008; N. Whitten and D. Whitten, 2011). The Kichwa concept of landscape (*tintillu*) is also a holistic sense of environment that constitutes not only a set of sites for a livelihood, but also a sacred, cosmic phenomenon embodying everything by which people identify as "us" and "other" (e.g. Trouillot, 1995, 2003; Whitehead, 2003; Bunker, 2006; Kohn, 2008; Corr, 2010: 59-66, 141-164). As such, the tropical-forest fluvial systems and gardens along the Ecuadorian border with Colombia have profoundly cultural dimensions.

The traditional subsistence economy of Amazonian Kichwa people is based on the slash-mulch system of shifting cultivation as well as hunting, fishing and gathering. As burning is not usually practiced, a garden (*chacra*) may be cleared and planted in any season of the year. One exception is maize (*Zea mays*) gardens, which are burned before they are planted with maize kernels and a nitrogen-fixing bean that enhances yields (N. Whitten and D. Whitten, 2008). Both the ears of corn and the beans are harvested at the same time, and the beans are kept to be used the next time; they are not eaten. The Kichwa make gardens from one-third of a hectare to three hectares in size depending on household size and needs. Men do the heavy work of slashing undergrowth and felling trees. As they clear they save and protect some of the forest's useful trees and plants. Both men and women plant the tropical cultivars that are the foundation of the Amazonian Kichwa diet. They also transplant seedlings of forest plants and trees that were not in the original area. After planting, gardens are periodically weeded to promote good growth of the food-producing and other useful plants.

The principal starchy staples of the Amazonian Kichwa are manioc (*Manihot esculenta*) and plantains (*Musa* x *paradisiaca*). Manioc is essential for the preparation of *chicha*, a fermented, mildly alcoholic beverage that is consumed daily and is a major component of the Kichwa diet. Additional root crops include sweet potatoes (*Ipomoea batatas*) and several varieties of taro (*Colocasia* and *Xanthosoma* species). Papaya (*Carica papaya*), pineapple (*Ananas comosus*), peanuts (*Arachis hypogaea*), and various chile peppers (*Capsicum* spp.) are also grown in Kichwa gardens. A sample of the Kichwa diet is depicted in Figure 14.

Figure 14. Manioc; pineapple; peach palm fruit.

A drink called chicha (*asua* in Kichwa) is made by women, who peel and boil manioc roots, then pound the boiled roots in a huge wooden bowl (made by a husband or father-in-law). Women then gently masticate the pulpy manioc mash and place it back in the wooden bowl. An enzyme in the saliva, *ptyalin*, prompts fermentation. When they finish, individual women fill a large pottery jar, called *tinaja* or *asua churana manga*, with the mash, which begins to ferment immediately, and is ready to be served and drunk the next day. This process is repeated a week to ten days later.

The fruit of the peach palm (*Bactris gasipaes*) is the third most important Amazonian Kichwa crop after manioc and plantains. Peach palm is the only fully domesticated palm in the tropical forests of South America. It reproduces only when its seeds and seedlings are propagated by humans. Peach palms fruit once or twice a year for approximately one month during each ripening season. Fallen palms also attract large wood-boring palm weevils that lay eggs inside their trunks. These develop into large and very fat larvae which the Amazonian Kichwa collect and eat, thus serving as an important source of dietary fats and proteins. Peach palms also provide wood and materials for house construction and hunting and fishing implements.

After a garden starts producing food it is enlarged by additional clearing of adjacent forest (Macdonald, Irvine, and Aranda, 1993:13). The new area is called the "head" (*uma*) of the garden and the older area becomes the "rear end" (*siqui*). Eventually, the older portion of the garden is fallowed and becomes secondary growth (*mauca* or *purma*) that is managed by weeding and the clearing of vines from fruit trees. After 30 years the secondary forest increasingly resembles mature tropical rain forest. Dominique Irvine (1987, 1989) interprets Amazonian Kichwa shifting cultivation as part of a sophisticated forest management system that creates a complex mosaic of habitats in different stages of succession and with variations in their plant and animal communities.

The Amazonian Kichwa are renowned for their extensive knowledge of hundreds of useful plant species, many of which are medicinal (Cerón Martínez, 1993; Marles et al., 1986). The pharmacopoeia of the Amazonian Kichwa includes both wild forest species and plants that are cultivated in gardens. This information is shared widely and most Kichwa adults are able to prepare common medicines and remedies for their children and other household members. For example, one of the most widely-used cultivars is *guayusa* (*Ilex guayusa*) of the Aquifoliaceae family. Guayusa bark is used to brew a caffeine-rich tea that both stimulates and serves as a treatment for aches and pains. Many Kichwas drink guayusa tea each morning to start the day. Despite this communal knowledge of common medicinals, Kichwa shamans are especially respected for their vast plant knowledge and experience in healing.

A few examples of the hundreds of Amazonian Kichwa medicinal plants are given here for illustrative purposes. An infusion of *dunduma huasca* (*Sparattanthelium glabrum*, Hernandiaceae) bark is used to treat malaria, and an infusion of *amaron caspi* (*Cespedesia spathulata*, Ochnaceae) is a remedy for stomach ache and diarrhea. An infusion of the leaves and bark of *chiricaspi* (*Brunfelsia grandiflora*, Solanaceae) is employed to treat fevers and pain. Sindicara (*Sloanea fragrans*, Elaeocarpaceae) is given for vomiting and dysentery, and intestinal parasites are cured with an infusion of *huambula* (*Minquartia guianensis*, Olacaceae). The reputations of Kichwa shamans are such that they often attract non-indigenous patients and are sought out by botanists and ecotourism companies to serve as research collaborators and guides.

Holt et al. (2004:1-34) studied two Amazonian Kichwa communities in Sucumbíos Province and one in Orellana Province. In a survey of food preferences their Kichwa respondents said game animals and fish are their favorite foods. Ideally, people would like to eat some game meat or fish each day, along with their carbohydrate-rich *chicha* and *yuca* (manioc). In actuality, the Kichwa participants in the study "reported consuming game on 39% of the recorded days and fish on 57% of the days" (Holt et al., 2004:17-18). Domestic animals and purchased meat were part of the diet on only 17% of the days. Holt et al. conclude that the wild resources of fish and game provide most of the proteins in the Amazonian Kichwa diet. Fish are caught in the San Miguel and Aguarico Rivers, as well as in smaller creeks that feed these river systems. Among the preferred game animals include the paca (*Agouti paca*), armadillo (*Dasypus novemcinctus*), and Cracid birds such as the *perdiz* (*Tinamus major*), white-lipped peccary (*Tayassu pecari*), collared peccary (*Tayssu tajacu*), agouti (*Dasyprocta fuliginosa*), and acouchy (*Myoprocta acouchy*), Holt et al. (2004:26), as well as monkeys and other bird species. Figure 15 shows a Kichwa youth with a giant armadillo and a fish caught from a river in the border area.


Figure 15. Kichwa youth with a giant armadillo; fish caught from a river in the border area.

The Amazonian Kichwa also participate in Ecuador's market economy, generating modest incomes through cash cropping, livestock raising, the selling of timber and non-timber forest products, and wage labor. About 80 percent of the households studied by Holt et al. (2004) engaged in the sale of agricultural products. In the Kichwa community of Pachacutik in Sucumbíos Province most of the households sold maize, half sold coffee and naranjilla (*Solanum quitoense*), and one sold cacao (used for making chocolate). The annual household earnings from these sales ranged from $90 to $600, with median earnings of $144. In Pastaza Central, another Sucumbíos Province Kichwa community, all households sold coffee and maize, and some sold manioc and plantains, with earnings ranging from $120 to $500 per year and a median of $308 (Holt et al., 2004:19).

Forty percent of the Kichwa households studied by Holt et al. (2004) sold livestock to supplement their incomes. Almost all families raised chickens. Some had pigs and cows, but most did not. Raising and selling chickens was primarily women's work. The annual household earnings from chicken sales ranged from $12 to $60. Some Kichwa households are also learning fish-farming techniques by participating in aquaculture projects sponsored by the provincial government of Sucumbíos and several NGOs. The principal fish farmed are the exotic tilapia and the cachama (*Piaractus brachypomus*), a native of Amazonian waters.

Kichwa-speaking people rely on a predictable rain-forest-riverine dynamic ecosystem, to which their economic, social, and cultural lives are well adapted. However, due to their heavy reliance on the natural environment, they are acutely vulnerable to perturbations that depart from these natural cycles, which can cause significant disruptions to their subsistence and sacred realms.

C. The Siona and Secoya

The Siona and Secoya are two closely related indigenous groups that make up the third important population of indigenous peoples in northeastern Ecuador. Numbering only 780 individuals in Ecuador as of the 2001 census, this vulnerable indigenous group also relies heavily upon the natural environment. A Secoya youth and a Siona grandmother are shown in Figure 16.

Figure 16. Secoya youth with pierced nose and "jaguar whiskers" nose ornament; Siona elder.

The Ecuadorian government granted the Siona of Cuyabeno a holding of 127,028 hectares (1,270 square kilometers) in 1994, which lies entirely within the 6,034 square kilometer Cuyabeno Wildlife Reserve. The northern border of this reserve ranges from 10 to 15 kilometers from the Ecuador-Colombia border. In addition, there are Siona households located along the San Miguel River, to the north of the Cuyabeno Reserve.

The Siona and Secoya languages are closely related and mutually intelligible dialects that belong to the western branch of the Tucanoan language family. The Siona and Secoya share similar cultural patterns and cosmologies, intermarry frequently, and sometimes reside in the same villages (Vickers, 1994a). From the late 1500s through the 1700s the Europeans who contacted the Siona and Secoya referred to them as the "Encabellado" because of their custom of wearing unusually long hair, which they sometimes arranged into elaborate coiffures (Chantre y Herrera, 1901).

The Encabellado population is estimated to have been 16,000 at the time of first European contact (Steward, 1949). This contact exacted a terrible toll on the Encabellado population, primarily due to the introduction of infectious diseases such as smallpox, measles, and the common cold. The demographic decline probably reached its nadir in the early 20th century when many communities suffered epidemics of measles and were reduced to a few small communities located in the border areas of Ecuador, Colombia, and Peru.

Traditional Siona and Secoya dwellings were oval longhouses with earthen floors. These were called hai wï'e (big houses). Longhouses were constructed from forest resources including posts, beams, and rafters fashioned from the wood of various trees, palm-thatched (*Hyospathe* sp.) roofs, and lashings made from vines. Some longhouses had open sides, while others had exterior walls of split bamboo (*Bambusa* sp.). The longhouses were inhabited by extended families based on patrilineal descent and patrilocal residence (i.e., sons remained at the homes of their fathers and took wives from outside their patrilineages). The father or eldest male typically served as the head of the extended household. Often, a settlement consisted of a single longhouse located kilometers from any other household. Larger settlements were comprised of multiple longhouses with their extended families. A typical longhouse is shown in Figure 17.

Figure 17. Longhouse.

In recent decades traditional Siona and Secoya longhouses have largely been replaced by rectangular houses (wï'e) that are elevated above the ground on posts or pilings. Initially, these elevated houses had floors made from split palm trunks (*Iriartea* sp.) and thatched-palm roofs (*Attalea* sp.). Most of these houses were open-sided, but some had walls or half-walls of split bamboo. In recent years, many younger Siona and Secoya adults have begun to build elevated houses with flooring made of sawn wooden boards and "zinc" metal roofing. Such houses are considered to be more "modern" and finished in appearance than the older style of houses with thatched roofs and split-palm flooring. One disadvantage of metal roofs, however, is that they radiate heat into the interior of the houses on sunny days, making them less comfortable in hot weather.

Elevated houses are smaller than traditional longhouses and are typically occupied by a single conjugal-nuclear family (i.e., a married couple and their children). The modern variant of the traditional extended family household is a cluster of elevated houses in which the married offspring and their children reside in separate dwellings located adjacent to the parents' dwelling.

Beyond the leadership vested in the male heads of households, there was another form of Siona and Secoya leadership based on shamanism. The term for "shaman" is *yajé unkukï* (drinker of *yajé*). *Yajé* is a hallucinogenic potion made from the woody vine *Banisteriopsis caapi* of the Malpighiaceae family. It contains psychoactive alkaloid compounds and its drinkers experience hallucinations similar to those induced by LSD. To become a shaman a male must undergo a lengthy apprenticeship which involves fasting, sexual abstinence, and frequent drinking of *yajé* and other psychotropic potions made from plants such as *Brugmansia* x *insignis* and *Brunfelsia grandiflora* (both of the Solanaceae family). This taking of hallucinogens is essentially a vision quest in which the apprentice comes to know the supernatural realms of existence and the many spirits and demons that inhabit them. The shaman is the medium through which the Siona and Secoya maintain their relationships with the spirit world, which they believe are vitally important to their health and welfare. Shamans are seen as the supernatural protectors of Siona and Secoya communities. They diagnose and cure illnesses, punish evil sorcerers, provide abundant game, and influence the weather through their *yajé* ceremonies and rituals. Examples of medicinal plants used by the Siona and Secoya are shown in Figure 18.

Figure 18. Siona elder with *uhahai* medicinal plant (*Brunfelsia grandiflora*) used to treat fevers; Secoya man with *wa'ro* medicinal plant (*Eleutherine bulbosa*) used to treat intestinal parasites.

The Siona and Secoya view the universe as being divided into multiple layers of existence. The Earth's surface constitutes *yihá* (earth) where humans live. Beneath the earth is another plane known as *yihá wï'e wï* (the earthly home), the ancestral abode of the pre-human ancestors of the Siona and Secoya. These were beings who, like monkeys, had tails. This underworld is also the home of animal spirits. The spirits of game animals are tended by a keeper or master named *Weapau*. The Siona and Secoya believe their shamans can contact *Weapau* through the medium of *yajé*. When hunting is poor shamans drink *yajé* and converse with the master of game animals. *Weapau* then releases animals through caverns in the forest and they may be hunted.

The Siona and Secoya believe that a hard, but transparent, sky barrier exists just above the earth. It is called *kïnawï* (the rock layer) and is described as "being hard like glass." This barrier is believed to be solid except for a hole that exists in the eastern sky. The sky realm *matïmo* exists above the hard *kïnawï* layer. A great river called *Umesiaya* (Burning Rope River) flows through the sky realm. The spirits of the dead live in large villages on the banks of this celestial river. Their lives parallel those of the earth plane, except the spirits are tiny people who lead easy lives. Their work is effortless because they plant gardens on broad beaches that are devoid of trees. Manioc roots hang from their stems and can be easily picked (i.e., they do not have to be dug from the ground). And the animals the spirits hunt walk tamely into their villages and do not have to be chased.

These happy spirits or *matïmo pai* (heavenly people) spend much of their time singing and visiting each other's villages (favorite Siona and Secoya pastimes). They are always well dressed in the finest *hu'ika* (tunic-like garments that are called *cushmas* in Spanish), and their faces are always beautifully painted. In short, the Siona and Secoya have an idyllic vision of an afterlife that is free of heavy labor.

In actual life the subsistence economy of the Siona and Secoya is based on the harder reality of shifting cultivation, hunting, fishing, and the gathering of wild plant resources. Their horticulture is based on the slash-and-burn system rather than the slash-mulch method employed by the Amazonian Kichwa and the Afro-Ecuadorian communities of the western border region. Gardens may be cleared in both primary and secondary growth forest. They are normally cleared, burned, and planted during the December-February dry season. When a new home is built the initial garden is located adjacent to the house. Most families add a new garden each dry season. These usually cover a half hectare to a hectare, depending on the size of the household. Since gardens are harvested for three or more years each family typically has several gardens in production at any given time.

Most Siona and Secoya gardens are polycropped and some have more than 60 varieties of cultivars in them. The gardens closest to the home tend to be the most diverse. In addition to the starchy food staples they contain many plants that are used as medicines, condiments, perfumes, ornamentals, dyes, craft materials, and snack foods. A Secoya garden is shown in Figure 19.

Figure 19. Three-year old Secoya garden with plantains.

The major staples of the Siona and Secoya include fifteen varieties of manioc (*Manihot esculenta*), fifteen of plantains (*Musa* x *paradisiaca*), and nine of maize (*Zea mays*). Peach palms (*Bactris gasipaes*) produce abundant harvests of fruit twice a year and are also a staple in the Siona and Secoya diet. Other starchy root crops are cultivated in addition to manioc, including sweet potatoes (*Ipomoea batatas*), yams (*Dioscorea* spp.), taro (*Colocasia esculenta*), and malanga (*Xanthosoma* sp.). Many tropical fruits are also found in Siona and Secoya gardens, including caimito (*Pouteria caimito*), papaya (*Carica papaya*), pineapple (*Ananas comosus*), sapote (*Quararibea cordata*), tree grapes (*Pourouma cecropiifolia*), and several species of *Inga*. The Siona and Secoya grow many varieties of both hot and mild peppers (*Capsicum* spp.) which serve as their primary condiments (Vickers and Plowman, 1984). Preparation of some of these typical crops is shown in Figure 20.


Figure 20. Siona elder peeling manioc (yuca) roots; Siona elder preparing to cook peach palm fruits.

Gardens are initially planted with multiple cultivars, but these mature and produce at different rates. Maize grows quickly and is ready for harvest in 90 days. Manioc may be harvested at nine months, but the roots will be small. The preferred age for its harvesting is between one and two years (after three years the roots become woody and unpalatable). Plantains take 18 months to mature and produce, and if well tended will generate basal clones that can grow and be harvested over a number of years. Peach palms and tropical fruit trees take longer to grow, with harvests typically coming after five years. Because of these dynamics, a family with several gardens planted in different years harvests a different mix of crops from each garden. The newest garden produces maize, a year-old garden is starting to produce manioc, a two-year old garden is producing manioc and plantains, and the oldest gardens are producing peach palm and other tree fruits.

When the normal environmental conditions are maintained, Siona and Secoya gardens are very productive. The estimated gross yield per hectare is 12,300 kg of foodstuffs per year, with an edible portion of nearly 8,400 kg, or 8.8 million calories (Vickers, 1989). This level of production is sufficient to meet the annual caloric needs of eleven people. However, environmental stresses can reduce production. The most common stresses experienced in Siona and Secoya gardens are high winds, occasional flooding, and pests. Winds can knock over plantains and tree crops, while river flooding can spoil manioc roots and wipe out entire gardens. Birds, rodents, and insects may also damage maize and some other crops. The fact that most households have three or four gardens in production normally reduces the impacts of such stresses. However, were all gardens to be damaged simultaneously, for example, by exposure to herbicide, it would place significant stress on the household’s ability to maintain an adequate level of nutrition.

Most Siona and Secoya hunting is done by men. Women occasionally assist in the collection of turtle eggs, or catch a tortoise along a jungle trail, but they rarely hunt in the systematic and intensive way that men do. Female respondents state, "Hunting is for men," and "The forest is the place of the men and our place is in the village." Fishing, in contrast, is practiced by men, women, and children (Vickers, 1994b).

The traditional hunting weapons of the Siona-Secoya are the blowgun, spear and club, although most hunters now use shotguns. Animals are also taken with various traps and deadfalls, and smaller animals may be captured by hand. Over 60 species of animals are hunted. The principal terrestrial game include tapir (*Tapirus terrestris*), white-lipped and collared peccaries (*Tayassu pecari* and *T. tajacu*), capybara (*Hydrochaeris hydrochaeris*), paca (*Agouti paca*), agouti (*Dasyprocta fuliginosa*), and armadillos (*Dasypus kappleri* and *D. novemcinctus*). Arboreal game include woolly and howler monkeys (*Lagothrix lagotricha* and *Alouatta seniculus*), and large birds such as Salvin's curassow (*Mitu salvini*), Spix's guan (*Penelope jacquacu*), the blue-throated piping guan (*Pipile pipile*), and the gray-winged trumpeter (*Psophia crepitans*). Turtle eggs are also collected from river beaches during the December nesting season.

Fishing is highly seasonal, with the best catches coming during the dry season of December through February. During this period people use hooks and lines to catch large migratory catfish in the major rivers and use piscicides in streams to catch smaller fish. Large air-breathing paiche (*Arapaima gigas*) are also harpooned in oxbow lakes. During wetter months some fishing is done by hook and line, but the catches tend to be smaller in the rain-swollen streams. Taken together, hunting and fishing provide all of the meat in the traditional Siona and Secoya diet, and an estimated 81.5 percent of the dietary proteins.

Wild plant foods make a relatively small contribution to the annual diet (about five percent of the total calories). However, they assume seasonal importance, as with the fruiting of morete palms (*Mauritia flexuosa*) in January and February and the fruiting of hungurahui palms (*Oenocarpus bataua*) in December. Wild plant foods become critically important when people travel away from their gardens and settlements. Wild plants also make indispensable contributions to the material culture of the Siona and Secoya as medicines, craft and construction materials, and decorative and toilet items (Vickers and Plowman, 1984).

Although the Siona and Secoya still practice their traditional subsistence activities, they have lost large areas of their ancestral homelands and hunting territories to colonists and oil palm plantations, among other causes. Hence, they are trying to adapt to their new circumstances by growing some cash crops, raising livestock, and sometimes seeking jobs that pay wages.

The principal cash crops at present are coffee and maize, but neither is produced in great quantities. The markets are distant and the transportation costs, via canoe with outboard motor, are high. Prices and production levels are low. Therefore, the overall income from cash cropping is quite low. The average Siona and Secoya household probably earns less than $300 per year from the sale of cash crops. Instead, they depend on their traditional gardening and subsistence crops to feed themselves on a daily basis. Thus, even this limited participation in the market economy is marginal, and the very modest cash incomes derived from this practice would be eliminated were these crops to be destroyed.

Since ancestral times the Siona and Secoya have based their livelihoods on the use of natural resources from their tropical forest and aquatic habitats. Even today gardening, hunting, fishing, and gathering remain their primary means for supporting themselves and their children, and ensuring their cultural survival. Because they use a wide variety of plant and animal species, and cultivate multiple gardens in different locations, their subsistence has proven to be flexible, sustainable, and resilient in the past. The Siona and Secoya traditionally enjoyed large territories and could move about with ease if a particular location presented problems or became depleted of resources. With the development and colonization of Sucumbíos Province since the late 1960s native territories have been invaded, settled by outsiders, and reduced in size. Movement is now more restricted and the Siona and Secoya are becoming more sedentary with time. While the traditional subsistence activities and economy survive, they are perhaps less resilient and more vulnerable to environmental perturbations than in the past.

The routines of Siona and Secoya life revolve around daily or almost daily efforts to acquire, process, and cook foodstuffs because they have few ways of preserving and storing foods for extended periods of time. The tropical climate is very humid and warm, and villages lack electricity and refrigeration. As a consequence, prepared foods spoil quickly. Cooked plant foods, such as manioc roots and peach palm fruits, must be consumed within a day or two before they become moldy and unpalatable. Manioc bread may be kept for up to a week if it is hung on a line during daylight hours to reduce its moisture content. Meat and fish are smoked over cooking fires, but become infested with maggots within a week. Manioc roots growing in gardens do provide one form of relatively long-term in-ground storage. Unlike many temperate zone crops, it is not necessary to harvest manioc roots all at once. They are left in the ground and several pounds of roots are dug up every few days to meet a household's cooking and consumption needs. But even this usually reliable method of in-ground storage would fail if the manioc plants were injured or killed by exposure to herbicide.

D. Colonist Farming Communities in Sucumbíos

In addition to the three indigenous groups described above, the northern border of Sucumbíos Province is inhabited by non-indigenous colonists who migrated to the region in the late 1960s and early 1970s. Most of these colonists were poor farmers and landless people from the Andean and coastal provinces of Ecuador. Quite a few were small farmers who had experienced severe droughts in Ecuador's southern Andean provinces, and were seeking a new start. A smaller number were entrepreneurs who established shops, restaurants, bars, and other small businesses in the growing towns. Regardless of their origins and motivations, most of these new settlers arrived in Sucumbíos with few personal assets and little operating capital.

The first wave of colonists settled along the Quito-Lago Agrio road and cleared forest for farms and pastures. While this colonization was spontaneous in nature, the Ecuadorian government stipulated a size of 50 hectares for individual land claims, so the typical colonist marked a plot with a road frontage of 250 meters and a depth of 2 kilometers (Pan et al., 2004). Much of this colonization occurred between 1974 and 1982, when the population growth of the northern Ecuadorian Amazon grew at a very high rate of eight percent per year during the period (more than double the national population growth rate during that time) (Mena et al., 2006:803). Since 1982, the population of the northern Ecuadorian Amazon has continued to grow at a rate of between five and six percent per year.

As the road frontage filled in later-arriving colonists established a second and deeper line of settlement paralleling the main road. This process has been repeated many times so that in some areas there are nine or more lines of settlement extending 18 or more kilometers into the forest. In subsequent years additional roads were extended from Lago Agrio, thus reaching the San Miguel River and Colombian border to the north, the headwaters of the Cuyabeno River to the east, and the town of San Francisco de Orellana (also known as Coca) and the Napo River to the south. All of these roads attracted additional spontaneous colonization and lines of settlement. Colonists also followed the rivers and streams of Sucumbíos and settled along their banks, including the San Miguel River, which forms the border between Ecuador and Colombia.

Most colonist households practice small-scale farming using simple hand tools such as machetes and axes. The few who can afford them now use gasoline-powered chainsaws for the initial clearing of trees. Family members provide most of the labor, although day workers are occasionally hired. Colonist farmers grow a mix of both subsistence and cash crops. Some crops, such as manioc (yuca), plantains, and maize provide subsistence and may also be sold when additional household income is needed. Colonist farmers are heavily dependent on their crops for their incomes and their diets, and are therefore vulnerable to any environmental stresses that might threaten their production.

A minority of colonist households grow cash crops such as cacao, rice, and African oil palm. The principal cash crop in Sucumbíos, however, is coffee, with 80 percent of the colonist farming households growing it. Nevertheless, there are disadvantages associated with growing and selling coffee. First, it is a major commodity and its pricing is subject to the fluctuations of the world coffee market, which has suffered several depressions in the past 20 years. Second, the robusta variety of coffee grown in Sucumbíos is considered to be of mediocre quality and brings low prices at best. The government of Sucumbíos is concerned that provincial farmers depend too heavily on coffee, and has developed several educational programs to promote crop diversification (Gobierno de Sucumbíos, 2010).

The principal livestock raised by colonist farmers include chickens, pigs, cattle, and horses. Colonists with Andean roots sometimes keep guinea pigs (a delicacy in the Ecuadorian Sierra). Several NGOs are also promoting fish farming projects throughout the region. One study indicated that small animals provided five percent of total household income in 1999 (Navarette, 2005:51). Cattle raising is most common among households that have larger farms, which are relatively infrequent in the border region. A limited number of livestock, however, do serve as "living bank accounts" for many colonist families. Animals can be quickly sold to meet urgent financial needs, such as unanticipated medical expenses and the purchasing of uniforms for children who are starting school. A colonist house with pasture and livestock in the background is shown in Figure 21.

Figure 21. Colonist house with pasture and livestock in the background.

While most colonists claimed holdings of 50 hectares in the late 1960s and early 1970s, there has been increasing fragmentation of these farms over time. One study found that the mean farm size in 1990 was 46.5 hectares, but had dropped to 25.5 hectares by 1990 (Navarette, 2005:33). This is due to offspring inheriting sections of farms from their parents and also to the selling of portions of farms to newly-arriving colonists (Pan et al., 2004). Financial pressures due to medical emergencies and crop failures have led some colonists to sell parts of their land (Barbieri, 2005; Bilsborrow et al., 2004).

Figure 22. Secoya leader (left) conversing with a colonist farmer (right) in front of the latter's house.

The overall situation for most colonist farming households in Sucumbíos Province is one of extreme poverty and vulnerability to environmental and economic perturbations. In 1999, the average annual income for such households in the northern Ecuadorian Amazon was only $1,481.50 (Navarette, 2005:37). Perhaps due to the fragmentation and declining size of most farms, household members often find themselves forced to seek employment off the farm to make ends meet.

In addition to their poverty, the vulnerability of Sucumbíos colonist farmers is exacerbated by the province's inadequately-developed infrastructure and limited access to healthcare and educational opportunities. The transportation of produce to middlemen buyers at markets, whether by trucks and buses on roads, or by motor canoes on rivers, is a significant expense for cash-strapped farmers. When crop prices are low, farmers' sales may not even recoup their transportation costs.

While many colonist communities have state-supported schools, these are mostly limited to the primary level. Larger towns, such as Lago Agrio and San Francisco de Orellana, have secondary schools (colegios), but most rural farming families cannot afford the expense of sending their children away from home to attend them. The educational levels of most colonist farmers are quite low. Pan et al. (2004:127) found the mean educational level of colonist heads of household was but 2.7 years of primary school in 1999.

Access to healthcare is also limited in Sucumbíos Province. Lago Agrio has a small state-supported hospital, but it is primarily staffed by doctors who are relatively inexperienced because they are recent medical school graduates (Ecuador's Ministry of Health requires such graduates to serve one year of clinical practice in rural areas). The Lago Agrio hospital lacks sufficient diagnostic and clinical equipment, and the trained medical technicians to operate such equipment. It also lacks the essential medicines that patients need. Patients and their families are routinely instructed to take their prescriptions to the private pharmacies in downtown Lago Agrio. Once they have purchased their medications they bring them to the hospital where they are administered by doctors. Regrettably, many patients cannot afford to fill their prescriptions as 68 percent of the Sucumbíos population lives below the poverty line (Picone, 2010:3). Lago Agrio does have several private medical clinics that provide alternatives to the state-run hospital, but these are more expensive and beyond the means of the poorest colonist households.

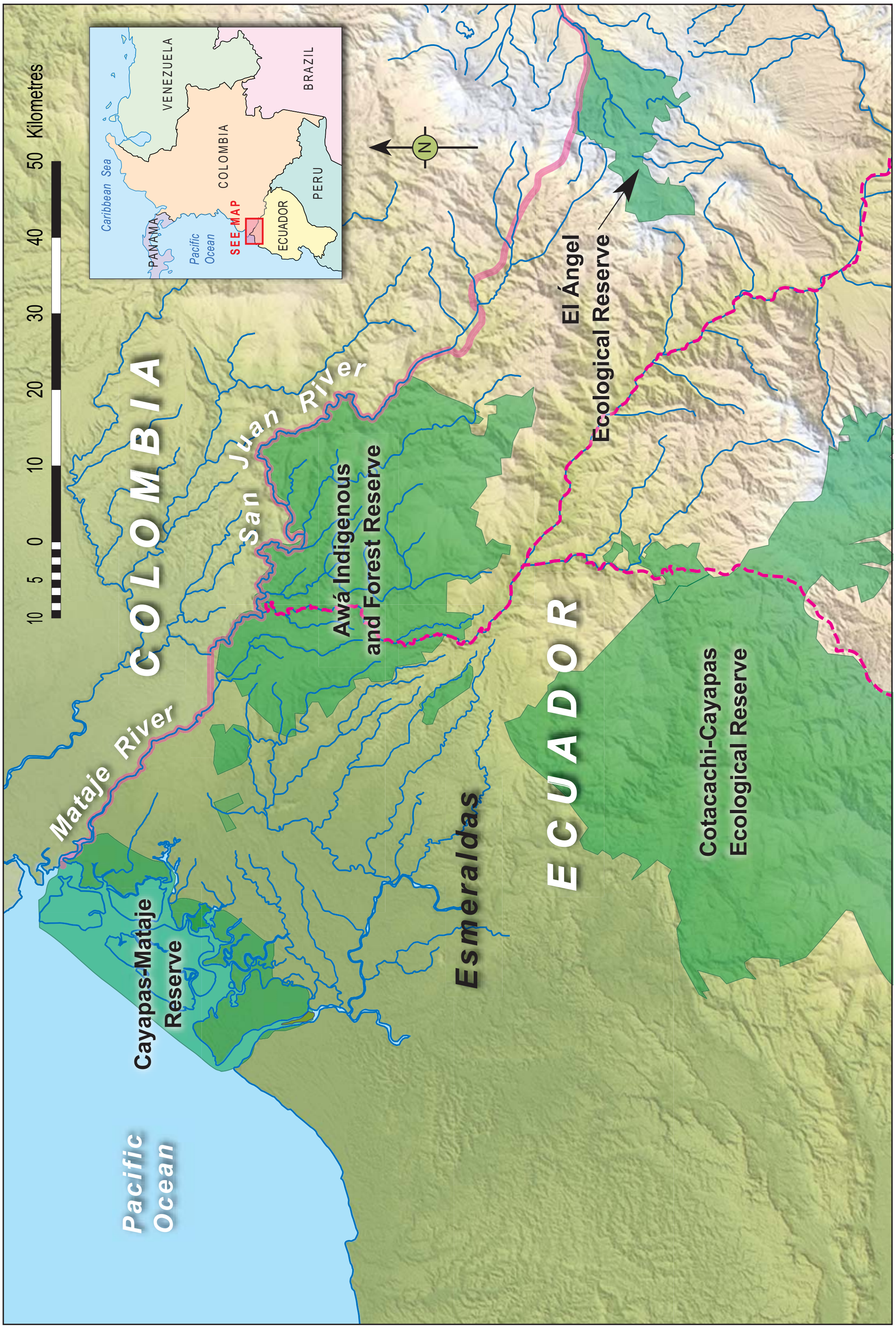
V. Western Ecuador: Esmeraldas and Carchi

The western region of Ecuador's border with Colombia, mostly in the province of Esmeraldas, begins on the mangrove-choked Pacific coast with its multiple islands and inlets, and proceeds inland through one of the larger three-tiered rain forests in the world. Map 3 depicts the western portion of northern Ecuador including the Esmeraldas province.

Robert C. West's exhaustive monograph on the Pacific Lowlands of Colombia (continuing into northern Ecuador) provides the following description of this luxurious rain forest:

> Tall evergreen broadleaf trees or numerous species, sixty to one hundred feet high, comprise the upper stratum; occasionally their spreading crowns form a solid canopy, shutting out sunlight from the forest floor. Sometimes scattered giant trees rise thirty or more feet above the canopy, giving the forest roof and irregular appearance as seen from the air. . . . A second stratum in the forest is formed by a large variety of scattered slender trees and many palms, both growing to a height of twenty to thirty feet. . . . A third stratum of trees sometimes occurs as an intermediate story between the first and second" (West, 1957:41-43; see also, Acosta-Solis, 1944, 1959).

The human inhabitants of the border region include the Awá, an indigenous group also known in Colombia as the Coaiquer or Kwaiker (who speak a dialect of Barbacoan). Also living in this region is a black population that Norman Whitten has called "Black frontiersmen" and Afro-Esmeraldans, with an "Afro-Hispanic" culture (e.g. Whitten, 1965, 1974, 1992, 1997).



Kilometres
10 5 0 10 20 30 40 50
Caribbean Sea
VENEZUELA
BRAZIL
COLOMBIA
PANAMA
Pacific Ocean
SEE MAP
ECUADOR
PERU
N
COLOMBIA
San Juan River
Mataje River
Awá Indigenous and Forest Reserve
El Ángel Ecological Reserve
Cayapas-Mataje Reserve
Pacific Ocean
Esmeraldas
ECUADOR
Cotacachi-Cayapas Ecological Reserve

Map 3

A. The Awá

The indigenous Awá (also known as Kwaiker or Coaiquer) number about 3,000 individuals in Ecuador living in 22 legally established Awá centers (communities). Their relatives live in Colombia, just north of the Ecuador-Colombia border. As such, they are best regarded as "binational" in their distribution. We must add, however, that the Ecuadorian Awá have worked hard to establish their legal Ecuadorian citizenship, and to demonstrate this by their national identity cards. They have had help in this by Ecuadorian officials and by the national Ecuadorian indigenous organization (Confederation of Indigenous Nationalities of Ecuador, CONAIE). The Awá live mostly in very remote areas in moist pristine forests on the western slopes of the Andes in the provinces of Carchi, Imbabura and Esmeraldas. As there are few roads in this part of northern Ecuador, walking, and river transport in some areas, are the only ways of getting from one place to another. Figure 23 shows an example of local transportation by canoe.

Figure 23. Awá children in canoe. (Source: Victor Englebert)

Three key factors must be taken into account in understanding the twenty-first century Awá. First, their inhabited region in Ecuador on the border with Colombia is one of the richest, wettest, high biodiversity rain-forest regions of the world. Second, the Awá territory has been designated as an ecological reserve by the Ecuadorian government and is known as the *Reserva Étnico Forestal Awá* (Awá Indigenous and Forest Reserve). Third, the Awá people have been charged as the agents to protect that biodiversity by the government of Ecuador. Given the fragility of the Awá ecosystem in its diversity and the charge to them to maintain their aboriginal role as guardians of the environment, perturbations take on added dimensions.

The Awá seem to descend from the indigenous people known at the time of the European conquest as the Quillacinga (Ortiz, 1946). This is the Quichua (Kichwa) word for “moon nose” (*quilla singa*) that references the gold moon-like nose piece once worn by men in this region. The internally diverse people called “Quillacinga” once inhabited the area from the mangrove coasts of the Ecuador-Colombia border to the area from Pasto east into the rain-forest region. First attacked in their Andean habitat by warriors of the northern Incaic expansion, and then on the coast and in the Andes by the conquering Spanish, a segment of the Quillacinga moved into the high, very rugged rain-forest region now inhabited by the Awá. The Awá are, in all probability, their only living descendants. Awá territory began as, became, and remains, an indigenous refuge region that endures as a viable landscape for the Awá people. As such, the territory, including its rain-forest and riverine resources, constitute the basis for secular subsistence and small-scale commercial life, and a sacred zone of cultural creativity and tradition.

The region inhabited by the Awá in Ecuador on the border of Colombia is one of the most biodiverse rain-forest regions in the world. The Awá’s current habitation area is approximately 115,000 hectares, not counting the areas where cohabitation with Afro-Ecuadorians occurs. This area includes the Awá Indigenous and Forest Reserve, an area designated as an ecological reserve established by the Ecuadorian government to be maintained by the Awá and located immediately adjacent to the Colombian border. As noted above, these lands are undoubtedly ancestral. They may have been relatively sparsely inhabited in precolonial times, but became the primary refuge region in the face of colonial incursions; and the Awá have continued to inhabit these areas to the present day.

In the words of Olindo Nastacuaz, President of the Federation of Awá Centers of Ecuador (FCAE):

> We Awá are an ancestral indigenous nation from the Northwest of Ecuador and the Southwest of Colombia. We have a unique culture and our own language “Awá pìt.” We have 22 legally established Awá centers (communities) in Ecuador. They are all organized in the Federation of Awá Centers of Ecuador (FCAE), which is legally recognized by the Ecuadorian State. FCAE and its 22 centers have been granted a total of some 115,336 hectares of community land (under different kinds of deeds), located in the Provinces of Esmeraldas, Carchi and Imbabura. We are protected by our legitimate rights, guaranteed by the Ecuadorian Constitution and by international treaties such as the International Labor Organization’s Convention 169, signed by the Ecuadorian State (Nastacuaz, 2007).

Like other indigenous and Afro-Ecuadorian peoples, the Awá strongly hold the dual and enduring identity as a legitimate indigenous “nationality” (*nacionalidad*, the preferred referent for indigenous peoples within the legal structure of Ecuador); and as “Ecuadorian.” In the former case they affiliate through their own organization with CONAIE) and in the latter case, through their legalized affiliation as an Ecuadorian people (see, e.g. Whitten, ed. 2003). The Awá are also to be regarded, as they at times regard themselves, as bi-national in that they are part of an aggregate of Awá people who live on both sides of the Ecuador-Colombia border.

Contemporary Awá use a system of horticulture (agriculture) practices that includes maize cultivation that dates to at least four thousand years ago. This is not a population of "several generations," but of millennia. The main crops grown in these slash-and-mulch agricultural systems are plantains (*Musa x paradisiaca*), which are a staple food, and sugar cane (*Saccharum officinarum*) in monoculture; and cassava (*Manihot esculenta*) and maize (*Zea mays*) in mixed culture. Because of the extraordinarily heavy rainfall in the Awá region, the fallowing in the slash-mulch system is accelerated and families may circulate among older fallow fields prior to attainment of the optimum fifteen-year span for plantain and maize horticulture. Critical to such circulation is a social system that stresses reciprocity in marriage, the ideal being brothers of one family marrying sisters of another. A strong division of labor by gender exists. Men clear primary and second-growth forest, fish, hunt, and manipulate networks of kinship so as to achieve alliances; women plant, harvest, sometimes carry firewood and products, rear children, and plot and plan strategic marriages for children, which are communicated to their husbands. Depending on the time of the year and the specific situation, women may help men in both clearing forest and in fishing.

Awá extended families and kindreds coalesce in large, open houses, and disperse into smaller nuclear-family dispersed households, some a daylong trek from the nodal household. House construction is initiated by a nuclear family, either one of the nodal families or dispersed families. All materials are from the forest, including the strong posts that raise the house many feet off the ground, the floor of split bamboo or palm, and the thatch on the roof. The houses are relatively large, and sometimes open, like those of the nearby Cofán on the other side of the Andes. An Awá hamlet, depicting a house raised off the ground on posts, is shown in Figure 24.

Figure 24. Awá hamlet in northern Ecuador. (Source: Victor Englebert)

Rights of usufruct are held by the nodal (large) household and parceled out to sons and daughters when they marry (usually between fifteen and twenty years of age). Small families prefer not only to maintain a household in or near the nodal one, but also a second or even third house near a distant garden. New gardens may be established adjacent to the old, or may be a great distance away, usually in a fifteen-year fallow (secondary growth) site. This kind of garden- and household-maintenance system has been described by Whitten (e.g. 1977; N. Whitten and D. Whitten, 2008) as residential and trekking garden-households.

In addition to garden crops, the Awá hunt, fish, and raise some domesticated animals to supplement their diet. As late as the mid-1980s blowguns were still used for hunting birds. Most fishing takes place in small streams rather than in major rivers, with nets, hooks, or other methods. Currently, Awá gardens and small domestic animals, such as pigs and poultry, provide the most important sources of protein as well as source of potential income when they are sold on the external markets in towns adjacent to Awá territory. The Awá also raise Andean guinea pigs (*cui*) as a protein source in their own households, an unusual practice for rain-forest dwelling people.

When illness strikes, the Awá rely on individual and group curing systems. The individual system involves the shaman and patient, and the group involves large ceremonies attended only by Awá in which the Afro-Ecuadorian marimba plays a prominent role, for it helps chase away the evil that causes the illness. Accidental cuts, snakebite, influenza, diarrhea, and other such maladies/misfortunes are treated locally within the family, or patients simply heal on their own. Sometimes a shaman is called on to a remove spirit-intrusive substance. Some Awá communities also have local health promoters who administer basic treatments using medicinal plants, as well as provide health education to the communities. Otherwise, the Awá depend on distant coastal (San Lorenzo) or Andean (Tulcán, Ibarra, Otavalo) hospitals where Western medicine is administered. Only San Lorenzo has expertise in tropical-forest medicine. However, reaching San Lorenzo from some Awá communities can take up to several days (by foot and then by boat or by bus). Due to the time and cost of the journey, many illnesses go untreated.

B. Afro-Ecuadorians of Northern Esmeraldas

Besides the Awá, the other major population group living on the western side of Ecuador's border region with Colombia is the Afro-Ecuadorians of northern Esmeraldas. Strictly speaking, this group is not indigenous to Ecuador; however, having lived in the region for nearly half a millennium, they have developed sophisticated horticultural and other technologies adapted to the region's humid environment. Nevertheless, as with the groups discussed previously, Afro-Ecuadorians rely heavily on forest, agricultural, and aquatic resources for their basic well-being, and are thus extremely vulnerable to environmental damage.

Northern Esmeraldas became home to self-liberated African and Afro-Hispanic people in the mid-1500s. In fact, the black people of this part of the Ecuador-Colombia borderland are among the first self-liberated African-descended people in the Americas (the earliest were those who escaped slavery in 1502 on the island of Hispaniola and fled to the rain-forest interior, called the haití in the Arawakan Taíno language). Different groups seized their freedom in the north and south of the "Emerald Province" after fortuitous mutinies and shipwrecks, intermarried with indigenous people, and became the dominant force in the region, resisting all attempts by the Spanish military and the European establishment to subdue and subvert them (Lane, 2002; Whitten and Whitten, 2011 [in press]). Thus, contrary to common stereotypes of black slaves brought to work plantations by white owners and overseers and eventually liberated by their white slave owners in the nineteenth century, black people arrived in northern Esmeraldas as self-liberated free people. They were called *cimmarones* (maroons) as early as 1553, and were followed by other self-liberated black people coming from Africa, Spain, and Panama. In addition to subsistence horticulture, black people in this region sporadically engaged with the Spanish-dominated mercantile economy by working rivulets and streams for placer gold, and by providing food to miners. No plantations existed in this area, and placer mining overseers were not white. Ubiquitous intermarriage with indigenous people created a "race" called *zambo* or *zambaigo*. The resulting cultural system, which rapidly spread throughout the province, and beyond, is more than 460 years old. Thus, the Afro-Ecuadorian population of northern Esmeraldas has inhabited the region for nearly half millennium, during which time they have developed in response to the diverse microenvironments of this region unique cultural adaptations (see, e.g. Savoia et al., 1988).[1]

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[1] In 1599, 56-year old don Francisco de Arobe and his two sons, don Pedro and don Domingo (ages 22 and 18 respectively), direct descendants of one group of the original maroons, journeyed to Quito to pay homage to the Spanish Court. Their portraits were painted by an indigenous artist, Andrés Sánchez Gallque, in a magnificent work entitled "Esmeraldas Ambassadors." Today, a restored version of this 1599 painting hangs in the Museo de Américas in Madrid, Spain (Lane, 2002).

According to the cultural geographer Robert C. West, drawing upon the sixteenth century observations of Cabello Balboa (1945: 16), the slash-mulch system of horticulture can be dated to the expansion of the free black maroons of the 1500s (Whitten 1974:67). Learning from indigenous practices, Afro-Esmeraldans rapidly developed a system of swidden gardening based, by the sixteenth century, primarily on plantains and taro and secondarily, in some areas, on maize and rice. Prior to the arrival of plantains and rice from the Old World, maize was a primary cultivar in this extraordinarily wet region of the neotropics. Manioc is seldom grown here and only in the poorest of soils. Instead of a strict division of labor by gender in gardening, men and women can exchange roles depending on their needs in other sectors of subsistence activity or in gainful employment. Like cultural congeners in the east, the polycultural (many crops) plantain garden replicates the forest ecosystem with canopy, mid-layer plants, and root crops. e mulch enhances the subsoil mycorrhizal fungal action and maintains the garden floor at an even, relatively cool temperature ideal for productive bacterial activity in a very hot area. Coconut groves are planted and tended by men in high ground areas of the mangrove swamp (or forest). Men often work their "*fincas de coco*" while women paddle to their gathering areas for conchas. The coconut groves are monocultural in that they exist in brackish water, and they are riddled with canals to channel water properly to roots. Harvesting of coconuts for sale in San Lorenzo (thence to be transported to Esmeraldas, Manta and Guayaquil), is done by men, who then bring them to port in large dugout canoes. Women with their concha harvest often come in the same canoes. This is one of the few areas in the Americas where two species of coconut are grown, the regular coconut and the smaller *coco manila*, which apparently have different origins.

In addition to swidden agriculture systems, Afro-Ecuadorian communities rely heavily on fish and shellfish as part of their diet (Whitten 1974). Fishing takes place in the sea, mangrove swamp and mangrove-flanked tidal estuaries, and lower and upper riverine regions. In tidal areas, various fish species, including *pargo*, *corvina*, red grouper, croaker, various sea bass, albacore and yellowtail tuna are caught by hook and line. The schooling mullet, used both as food and as bait for larger fish, are caught by men throwing the *atarraya* (a round hand-oven casting net with small sinkers around the periphery). Groups of men drag the large *chinchorro* net in sea and estuaries, and harpoons may be used for very large fish, such as shark, ray, and sawfish, which are also caught initially on hook and line. Near the mangrove swamp, large fish screens are used. They are constructed of mangrove wood, palm wood and bamboo and have many forms. Frequently, right below a town one finds large baited traps called *corrales* for larger river fish, especially catfish. In addition to fishing, groups of women, assisted by young boys and girls, cooperate to exploit the small mussel, called *concha*, in the mangrove swamp. The *concha* is not only used for subsistence but is an important part of the limited cash economy of Afro-Hispanic peoples in this region. Smaller streams and rivulets are also exploited by capturing shrimp, crayfish, and fish in pots made of *chonta* palm.

Rivers and estuaries, including the Mataje River that divides Ecuador and Colombia, not only provide an important food source but serve as the primary mode of transportation inside the rain forest. Travel to many communities in this region, particularly those located along the Mataje River, is often by dugout canoe.

Some of the Afro-Ecuadorians of the Esmeraldas Province also participate in the market economy, and therefore must adjust their horticultural and fishing strategies to fluctuating economic conditions according to the waxing and waning of international demand for forest and sea products. Such products include cacao, rubber, tagua (ivory nut), fine woods, softer woods for veneers, coconuts (on the coast), and more recently shrimp. The region's residents move toward towns during boom periods to find cash work, and move back to forest-riverine habitation sites to engage in subsistence pursuits when the inevitable "bust" occurs. Whether or not a boom or a bust is characteristic of the region in a given period of time, the people of the region are heavily dependent at all times on agriculture and forest products for their primary sources of income. During boom periods people exploit forest and garden resources for cash gain with which to purchase basic foods, and during bust periods of the cycle people depend entirely on agriculture and fishing to supply their food requirements (Whitten 1965, 1974, 1992, 1997). As a result, for Afro-Ecuadorian people, time and place are inextricably tied to booms and busts in the international economy, as well as to the movement of tides and the dual "wet-dry" system of the coast and low-lying interior.

Afro-Ecuadorians in Esmeraldas Province live in four social niches: rural, scattered dwellings; small rural settlements (hamlets); small towns; and larger towns. (Whitten 1965, 1974, 1992, 1997). Along the Ecuadorian border with Colombia, there are no towns of any size and thus people live in rural scattered dwellings and very small rural settlements. Access to these communities is usually by river or by walking. Housing in the areas outside of the principal towns is often open or sided by split bamboo. A typical house, located along a river in the Esmeraldas is shown in Figure 25. Clothing is light given the very hot environment; especially in the areas outside of town, people often are without shoes or boots.

Figure 25. House Bordering River in Esmeraldas Province
(Source: Conservation International Ecuador).

When illness occurs, Afro-Hispanic people may turn to an indigenous curer from the region, or to an itinerant curer from the Andes. They also have their own curers who take *Banisteriopsis caapi* with plant additives, called *pildé* (this is the same as *ayahuasca –yajé* in Amazonia). Access to Western medical care is limited to the hospital in San Lorenzo, which, from outlying towns such as Mataje on the Mataje River, or Maldonado on the Santiago River, can be several days journey by dugout canoe propelled by paddles, or by trekking through forest and swamplands. Travel by canoe in this region is shown in Figure 26.

Figure 26. Local Residents in Dugout Canoe in Northwestern Ecuador (Source: Conservation International Ecuador)

The entire system of human adaptation in this region is crucially predicated upon a healthy forest ecosystem and the knowledge about how to wrest a living from its plant, animal, and fluvial resources. Thus, the Afro-Ecuadorians of Esmeraldas are highly vulnerable to environmental perturbations, particularly those which might cause the destruction of the crops and aquatic resources upon which they rely so heavily.

VI. Conclusion

The people of Ecuador's tropical forest regions near the border with Colombia are inextricably linked to the natural environment as a source of food, shelter and medicine, and as a basis for spiritual practices and other critical aspects of their livelihoods. Traditional swidden agriculture systems require a delicate ecological balance. The crops produced from these systems are critical to the daily survival of the border communities, particularly because food storage is difficult in the hot and humid environments of the region. Additional nutrition comes from hunting, gathering and fishing from the area's forests and rivers, and from raising domesticated animals. Dwellings are constructed from forest resources, and many indigenous cultures rely on native plant species for traditional medicines. Due to their heavy reliance on environmental resources, border communities are extremely vulnerable to perturbations that upset this balance. 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.

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1965 Class, Kinship, and Power in an Ecuadorian Town: The Negroes of San Lorenzo. Stanford: Stanford University Press.
1974 Black Frontiersman: Afro-Hispanic Culture of Ecuador and Colombia. Prospect Heights: Waveland Press.
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1981 Amazonia Today at the Base of the Andes: An Ethnic Interface in Ecological, Social, and Ideological Perspectives. In Norman E. Whitten, Jr., ed . Cultural

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1997 Clase, parentesco y poder en un pueblo ecuatorianos: Los negros de San Lorenzo. Quito: Centro Cultural Afro-Ecuatoriano.

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Annex 5

APPENDIX 1

Curriculum Vitae of Norman E. Whitten, Jr., Ph.D.

Annex 5

VITA

NORMAN E. WHITTEN, Jr.

Fall 2010

BIRTH: May 23, 1937

PLACE OF BIRTH: Orange, New Jersey

MARITAL STATUS: Married: Dorothea (Sibby) Scott Whitten, no children

ADDRESSES: 507 E. Harding Drive
Urbana, Illinois 61801-6205
Cell phone (217) 649-2454
Home phone: (217) 344-1828
Office phone: (217) 244-3514
Office Fax: (217) 244-3490
Internet E-mail: nwhitten@uiuc.edu
World Wide Web: http://www.anthro.uiuc.edu/faculty/Whitten

EDUCATION: Oswego High School 1951-55; Colgate University 1955-59, B.A. 1959; University of North Carolina at Chapel Hill 1959-64, M.A. 1961, Ph.D. 1964.

HONORS, LISTINGS: Colgate University Dean's List, Cum Laude, high departmental honors in Anthropology and Sociology. 1966 New Jersey Teachers' Association Author's Award in Anthropology. Society of Sigma Xi. Who's Who in the Midwest. International Authors and Writers Who's Who. Contemporary Authors. The Writers Directory. Who's Who In America. Who's Who in the Social Sciences. Senior University Scholar, UIUC, 1992. Graduate College Outstanding Mentor Award, UIUC, 2003. Three Special Panels in two sessions to honor Sibby and me at the 2008 AAA meetings in San Francisco, with 18 scholars participating, entitled "Symbolic Affinities, Pragmatic Engagements: Shaping Latin American Ethnology through the Collaborative Work of Norman and Dorothea Scott Whitten," organized and Chaired by Kathleen Fine-Dare, and Michelle Wibbelsman, sponsored by the American Ethnological Society and the Society for Latin American and Caribbean Anthropology.

ELECTED POSITIONS: Central States Anthropological Society, Executive Board Member 1967-70; 2nd Vice President to President, 1971-74; Latin American Anthropology Group, corresponding editor, 1975-76; American Anthropological Association, Executive Board Member, 1975-78; American Ethnological Society, Executive Board Member, 1980-84; Latin American Studies Association, Executive Board Member, 1983-1987; member of section council (Executive Board) of Ecuadorianists of the Latin American Studies Association, 2000-2003, 2003-05. Executive Committee, Human Relations Area Files, 2003-2005. Selected in November 2002 by the Executive Board of the American Anthropological Association to run for President-Elect—President in 2003; declined to run due to need for 4-year commitment if elected (2003-2007).

PREDOCTORAL SCHOLARSHIPS, FELLOWSHIPS, AND TRAINEESHIPS: Colgate University—University Scholarship; University of North Carolina—NIMH Traineeship in Health and the Health Professions, 1959-60; Institute for Research in Social Science Research Assistantship, 1960-61; NIMH Research Fellowship, 1961-64; research supplements to NIMH Research Fellowship, 1961, 1963.

POSTDOCTORAL GRANTS, FELLOWSHIPS, AND AWARDS: NIMH Research Associate—Tulane University and the Universidad del Valle, Cali, Colombia, at the International Center for Medical Research and Training, 1964-65; NIMH Small Grants 1966, 1967 (Summer); Washington University Faculty Grant, 1966, 1968; NIMH Project Director on NIMH Program, 1968-69; NSF Research Grant, 1970-72; Director of University of Illinois Latin American Studies Project (Ford Foundation Grant), 1972-74; NSF Research Grant, 1972-75; John Simon Guggenheim Memorial Foundation Fellowship 1976-77; University of Illinois Center for Advanced Study half-time Associateship, 1976-77; University of Illinois Research-Travel Grant, Center for Latin American and Caribbean Studies, 1976, 1977, 1978, 1980, 1981, 1984, 1991; CICS Research Grant, 1978, 1979; Wenner-Gren Foundation for Anthropological Research Grant, 1978; University of Illinois "Study in a Second Discipline" award, 1979 (tropical ecology); Survival International grant for applied project, 1979; Cultural Survival grant for applied research, 1980; American Council of Learned Societies/Social Science Research Council Fellowship in Latin American Studies, 1981-82; Fulbright-Hays Research Fellowship,1983; Wenner-Gren Foundation for Anthropological Research Grant, 1983; U.S. Office of Education Grant through the Center for Latin American and Caribbean Studies, 1984, 1988; University of Illinois, Urbana-Champaign Grant from the Film Center, 1985; Hewlett Award in International Studies, UIUC,1987; Illinois Humanities Council, 1988 (see also Imagery and Creativity Symposium funds, p. 8); Wenner-Gren Foundation for Anthropological Research Grant 1990; National Endowment for the Humanities Summer Fellowship, 1992; Illinois Humanities Council Grant, 1992; UIUC Senior University Scholar, 1992; MillerCom Grant (to Department of Anthropology to bring Richard and Sally Price to campus for month of October), 1994; Beckman Institute Research Award, 1994-95; Beckman Institute Research Award, 1996-97. United States Information Agency Grant to enhance Agreement between the UIUC and the Universidad San Francisco de Quito, pending. FLACSO (Ecuador) travel grant, November 1998. Graduate College Special Grant for Ecuadorian Research, 1998-99. LAS Special Travel Award, 2000; Center for Latin American and Caribbean Studies Research Award, 2000-2003; Spurlock Museum Research Award 2002. Major Institutional: principal author and PI of US/ED Title VI-FLAS awards to Center for Latin American and Caribbean Studies, UIUC, 2000, 2003. Total award for the two grants $4,905,034. Author and PI of Tinker Foundation Awards to Center for Latin American and Caribbean Studies, UIUC, 2001, 2003. Total of Tinker awards approximately $210,000.

EMPLOYMENT HISTORY: University of North Carolina, Chapel Hill, Acting Assistant Professor, summer 1964; Washington University, St. Louis, Assistant Professor, 1965-68, Associate Professor, 1968-70; Acting Chair, summer, 1969. Visiting Associate Professor at University of California, Los Angeles, 1969-70; University of Illinois (Urbana), Associate Professor, 1970-73; Professor, 1973; Department Head, 1983-1986; Affiliate of Afro-American Studies, 1986-continuing; Professor of Latin American Studies 1987-continuing; Professor of Campus Honors, 1988-1992. Adjunct Professor of Anthropology and International Studies, Universidad San Francisco de Quito (Ecuador), 1989-continuing. Curator of the Spurlock Museum of World Cultures, 1998-continuing. Director-designate of the Center for Latin American and Caribbean Studies, 1999-2000; Director, Center for Latin American and Caribbean Studies, 2000-2003. Emeritus status, UIUC, 2003 (August).

FIELDWORK: Afro-Americans in central North Carolina, 1959-60; Afro-Americans in west Ecuador, 1961, 1963, 1968; Afro-Americans in Wet Littoral, Chocó and Cauca Valley of Colombia, 1964-65; Afro-Canadians of Nova Scotians, 1966,1967. V various groups of Upper Amazonian and Andean Native peoples in Ecuador,1968, 1982, 1984; additional travel in Ecuador, Colombia, and Peru to visit various indigenous and Afro-American groups (Indigenous: Cayapa (Chachi), Colorado (Tcháchila), Coaiquer (Awá), Chocó (Emberá), Tukuna, Witoto, Cofán, Siona-Secoya, Shipibo-Conibo; Amazonian: Mestizo, Shuar, Achuar; Highland Quichua in various locations in Ecuador; Afro-American: Chocó, Atlantic littoral, Highland Ecuadorian and Colombian). Sporadic work with Salasaca Quichua, 1983, 1984, 1985, 1986, 1987, 1988, 1989, 1990,1991,1992, and with various Quichua-speaking peoples in Quito,1982,1983,1984, 1985,1986,1986-87, 1988, 1989, 1992, 1998; Tigua Quichua painters in Guamaní, 1998,1999, 2000; Afro-Ecuadorians, 1994, 2000. Travel to Nicaragua as invited observer of national elections, and to briefly assess Miskito situation of Atlantic Coast, 28 October-5 November, 1984. Amazonian Quichua (Quechua) and Achuar Jivaroans of Ecuador, 1968, 1970,1971, 1972-73,1974, 1975, 1976,1977, 1978, 1979, 1980,1981,1982, 1983, 1984, 1985, 1986,1986-87, 1988, 1989,1990, 1991,1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003,2004, 2005, 2006, 2007. Multicultural indigenous systems radiating out of and moving into Urban Puyo (Canelos Quichua, Napo Runa, Achuar, Shiwiar, Shuar, Záparo, Andoas, Waorani), 1990-2009-continuing.

MAJOR RESEARCH AND TEACHING INTERESTS: Social organization, power structure and dynamics, ritual, symbolism, ethnoaesthetics, cultural imagery, modernity and magicality, nationalism, national development, ethnic-bloc formation, cultural transformations, millennial movements, political democracy and social movements, South America (particularly indigenous peoples of the moist tropics and the Andes and Afro-Latin Americans); African Diaspora.

PROFESSIONAL AFFILIATIONS: American Anthropological Association (Fellow), Current Anthropology (Associate), American Ethnological Society (Editor of Society's journal, 1979-1984), Society of Cultural Anthropologists (Fellow), Instituto Indigenista Interamericano, Royal Anthropological Institute of Great Britain and Ireland (Fellow); American Association for the Advancement of Science (Fellow; AAA representative to AAAS, 1989-1992, 1992-1995, 1995-1998); AES representative to AAAS, 1992-1995), Society for Applied Anthropology (Fellow), Central States Anthropological Society (President, 1973-1974), Latin American Studies Association (advising editor, 1994-continuing, Instituto Nacional de Antropología e Historia (Ecuador), to 1987. Instituto Colombiano de Antropología, to

1975. Adjunct Professor of Anthropology and International Studies, Universidad San Francisco de Quito,1989-continuing. Board of Trustees, Universidad San Francisco de Quito—US (Miami) extension, 2000-continuing. Board of Trustees, Universidad San Francisco de Quito, 2006-continuing.

MUSEUM AND ARCHIVAL CONTRIBUTIONS: Contributor to Indiana University Archives of Traditional Music (Ecuadorian, Colombian, Brazilian and Nova Scotian Tapes and cassettes, with documentation and commentary—approximately four hundred hours of recording time). Small archaeological collection from Pacific Lowlands of Ecuador given to the Research Laboratories of Anthropology, University of North Carolina, Chapel Hill. Copies of all field notes, diary, and other materials given to the Social Psychiatry files of Harvard School of Public Health, in collaboration with the Leightons' project of social psychiatry in Nova Scotia. A comprehensive collection of material culture of the Canelos Quichua of eastern Ecuador, with full documentation, given to the Museum of the Central Bank of Ecuador (over two hundred distinct pieces of pottery, and all other aspects of material culture; value in Ecuador set at US $3,000 in 1973). Additional ethnographic and archaeological collection donated to the National Museum (Central Bank) of Ecuador, 1977, 1986-87, 1988; Research Collaborator with the Museo del Banco Central 1986-90; Collection of Amazonian ceramics and other artifacts from South America donated to the Spurlock Museum of World Cultures (through the Illinois Foundation), 1997. Curator for Ethnology, Laboratory of Anthropology, University of Illinois (1973-75). Director of Laboratory of Anthropology, University of Illinois, Spring, 1984; co-director 1984-1986. Guest Curator, Krannert Art Museum, 1987-88. Advisory Committee, Spurlock Museum of World Cultures), 1997; Curator, Spurlock Museum of World Cultures),1998-continuing; Chair of Curatorial Advisory Committee, Spurlock Museum, 2000-.

EXHIBITIONS: (all with Dorothea S. Whitten) "El Patrimonio Oriental," Puyo, Ecuador, May 1973 (with collaboration of indigenous people for founding day ceremonies). Sacha Museo, Nucleo Río Chico, Sacha Museo, Nucleo Río Chico, an indigenous museum founded in the Comuna San Jacinto, August, 1973, under the auspices of the Museum of the Central Bank of Ecuador with total native autonomy; dissolved in 1982.

"Upper Amazonian Art," Illini Union Art Gallery, University of Illinois, November 15-December 14, 1976.

"Art and Technology from Ecuador's Rainforest," Museum of Science and Natural History, St. Louis, Mo., February 12-April 10, 1978.

"Art and Technology from Ecuador's Rainforest," State Historical Building, Madison, Wisconsin, in conjunction with the second symposium Amazonia: Extinction or Survival?, University of Wisconsin, April 17-24, 1978.

"Traditional Amazonian Ceramics," William Stix Friedman Gallery, Craft Alliance, St. Louis, October 7-November 8,1978.

"Art and Technology from Ecuador's Rainforest," Department of Anthropology, University of Illinois, Urbana, December 1978- February 1980.

"Andean Ecuadorian Textiles," William Stix Friedman Gallery, Craft Alliance, St. Louis, April 14-May 11, 1979.

"Amazonian Ceramics from Ecuador," University Gallery, University of Florida, Gainesville, April 13-May 25, 1980.

"Aesthetic Resurgence in Amazonian Ecuador," Grinter Galleries, University of Florida, in conjunction with a symposium on Amazonia, January 11-February 25, 1982.

"Amazonian Ceramics from Ecuador," University Museum Gallery, Southern Illinois University-Carbondale, March 1-31, 1982.

"Amazonian Ceramics from Ecuador," accepted for distribution by the Smithsonian Institution Traveling Exhibition Services (SITES). Originally accepted 1979 to begin summer or fall of 1982 to run through 1984-86 (depending on subscribers), then "canceled" due to substantial federal cutbacks.

"*Yachaj Awashka:* Master Arts of Amazonian Ecuador," Logan Museum of Anthropology, Beloit College, Beloit, Wisconsin, March 15, 1984-January 15, 1985.

"*¡Causaunchimi!:* Arte, Cultura y Poder de los Canelos Quichua de la Amazonía Ecuatoriana" Galería de Arte del Banco Central del Ecuador, 10 March-20 May 1987. Facsimile Exhibit opened in Lima, Peru, 16 August 1987 and returned to Ecuador in November 1987.

"Arte, Cultura y Poder de los Canelos Quichua de Pastaza." Exhibition in the Municipal Library of Puyo, 8 May-20 May,1987.

"From Myth to Creation: Art from Amazonian Ecuador." The Krannert Art Museum, UIUC, 16 April 1988-22 May 1988. Funded by 23 UIUC units and Illinois Humanities Council.

"From Myth to Creation: Art from Amazonian Ecuador." The Wheelwright Museum of the American Indian. Santa Fe, New Mexico, tentatively scheduled for February-March, 1991. Canceled after Director resigned.

"'*¡Causaunchimi!*' 'We are Living!' 500 Years of Canelos Quichua Aesthetics." Art Museum of Southern Illinois University, February-December,1992.

"Culture and Ceramic Art From Amazonian Ecuador". A demonstration of pottery making from Amazonian Ecuador by Esthela Dagua and Mirian Vargas, 1 September-30 September, 1992. Carbondale, Carterville, Renn Lake, Mt. Vernon, Centralia, and Urbana, Illinois. Funded by the Illinois Humanities Council, the UIUC, and the Sacha Runa Research Foundation.

"'*. . . To a Remarkable Degree of Perfection':* Amazonian Ceramics from Ecuador." University of Illinois "I-Space" Gallery, Chicago, Illinois. 26 March-26 April 1993.

"We Are Living! *Causáuchimi!* " Permanent exhibition. Gallery of the Americas. Spurlock Museum of World Cultures. Opened September 2002. Redesigned 2008-2010.

"South America: Unity in Diversity." Permanent exhibition. One half of Americas Gallery (above). Spurlock Museum of World Cultures. Opened September, 2002. Revised and upagraded fall 2007-fall 2010.

"Rain Forest Visions" Temporary Exhibition in the Campbell Gallery of the Spurlock Museum. February 28-August 20, 2006. Five gallery tours and three lectures accompanied exhibit. Now being designed for travel.

APPLIED PROGRAMS: Applied program of health care delivery and legal service for land programs established in eastern Ecuador, 1972-73, using NSF funds initially, but then developing a self-sufficient program with the Native peoples by using the resources of the "Jungle Museum" noted above. Close collaboration in this program with Evangelical medical missionaries, German volunteers, and the Dominican medical missionaries. In 1975-76 program consolidated as Sacha Runa Research Foundation, incorporated as Not-For-Profit organization in State of Illinois, 1975; federal tax exempt status granted, 1976, for an initial period of five years. Permanent federal tax exempt status granted by IRS June, 1981. Through 1990 engaged in program of training of indigenous "Medical Auxiliary" personnel funded initially by Survival International. Self-evaluation of program carried out summer of 1980, funded by Cultural Survival. Active financial collaboration in this program of medical auxiliary training with the Organización de Pueblos Indígenas de Pastaza, "OPIP" (formerly, the Federación de Centros Indígenas de Pastaza, "FECIP"), and with the Provincial Office of Public Health, Pastaza Province, 1979,1980-81,1981-82, 1983, 1984. Monograph on medical program published in English, 1985 (p. 10), translation into Spanish for publication in Ecuador in 1986; publication withheld for reasons of political sensitivity. From 1989 through 1993 worked with the Instituto Indigenista Interamericano, the University of Florida, Kalamazoo College, the Universidad San Francisco de Quito, and the Municipio of Puyo on project of bilingual indigenous writing. Founder and Director of the "Programa para la Producción de Literatura Indígena por Computación," Quito and Puyo,1990-1994 (program suspended, 1995).

EDITORIAL EXPERIENCE: Abstracter for <u>Folklore Abstracts</u>, 1964-65. Manuscripts read for Harvard University Press, Stanford University Press, University of Minnesota Press, University of Illinois Press, Southern Illinois Press, University of California Press, Rutgers University Press, Cambridge University Press, The Johns Hopkins University Press, Duke University Press, American Anthropological Association special publications, American Ethnological Society, Human Relations

Area Files, Worth Publishing Co., Prentice-Hall, Harper & Row, University of British Columbia Press, Indiana University Press, University of Florida Press American Association for the Advancement of Science Press, Holt, Rinehart, and Winston, Waveland Press, Westview Press, Greenwood Press, Lexington Press, and McGraw-Hill Press. Chairman of University of Illinois Publications in Anthropology Series, 1971-72, 1974-76, 1977-84. Editor or co-Editor of fourteen books or monographs listed below (pp. 11-13). A number of manuscripts read for Current Anthropology, Trans-Action, International Wildlife, Studies in Comparative International Development, Journal of Developing Areas, Transforming Anthropology, Ethnohistory, American Ethnologist, and American Anthropologist. Editor of Boletín de Antropología Ecuatoriana (with José Pereira and Marcelo Naranjo), 1973-76. LAAG editor for Anthropology Newsletter, 1975-77. University of Illinois Press Board, 1978-1982. Advisory Board Anthropology (Annual Editions), 1975-78. Editorial Board of Latin American Research Review, 1979-83. Latin American Music Review,1979-present. Journal of Anthropological Linguistics, 1982-1987. Editor, American Ethnologist (two terms), 1979-84 (Vol. 7 through Vol. 11), Special Issues of AE (see page 10 published 1981(8:3),1982 (9:2 and 9:4), 1984 (11:4). Advisory Editorial Board of the Smithsonian Series in Ethnographic Inquiry,1984-present. Editorial Board, Association of Black Anthropologists, 1987-present. Editorial Board, Latin American Anthropological Society Publications, 1994-1999. Editorial Board, Transforming Anthropology 2000-present. Editor, Illinois Series in Ethnography: "Interpretations of Culture in the New Millennium," 2001-continuing (two books published, four scheduled for 2008-09, three others forthcoming. Editorial Board, Journal of Latin American Anthropology (Became Journal of Latin American and Caribbean Anthropology in 2007), 2003-07; 2007-continuing through 2010.

GRADUATE ADVISING: Directed in past fieldwork andpreparation for fieldwork of students with NIMH, NSF, AAUW, SSRC-FAFP, FLAS, University Fellowship, Fulbright-Hays, Woodrow Wilson, OAS, LASPAU, Doherty, Canada Council, Illinois Historical Society, Tinker, and Ford Foundation grants. Ph.D. theses completed (filed) under my direction at Washington University, St. Louis: James C. Pierson, DeWight Middleton, Ronald Stutzman; at University of Illinois: Michel Laguerre, Virginia Kerns, Douglas Midgett, Theodore MacDonald, Marcelo F. Naranjo, J. Peter Eckstrom, Patricia Drolet, Catherine Cameron, Iria d'Aquino, Peter Stahl, James Belote, John Ndulue, Mary-Elizabeth Reeve, Kathleen Fine, Mary Weismantel, Jane Adams, Cheryl Pomeroy, Luis Uriarte, Robert Carlson, Diego Quiroga, Arlene Torres, Kyejung Rhee-Yang, Patricia Hammer, Marta Zambrano, Jill Leonard, Nan Volinsky, Ricardo Herrera, Isabel Pérez, Rachel Corr, Gina Hunter de Bessa, María Tapias, Kathryn Litherland, Giovanna Micarelli, Derek Pardue, Michelle Wibbelsman, Angelina Cotler (40).

Student advisee fieldwork (M.A. and/or Ph.D.) funded and carried to completion under my direction in these countries: United States (4; one in Puerto Rico, one in Hawaii), Canada (1), Dominican Republic (1), Haiti (1), St. Lucia (1), Martinique (1), Cuba (1), Panama (1), Belize (1), Honduras (1), Guyana (1), Trinidad (1), Brazil (4), Colombia 2), Peru (3), Bolivia (2), Ecuador (17), Australia (1), United Kingdom (Wales) (1), Tanzania (1). Student advisee fieldwork undertaken during 2004-06: Ecuador (2), Brazil (1).

ADMINISTRATIVE AND OTHER PROFESSIONAL EXPERIENCE:

International, National, and Regional—chairman of the American Anthropological Association subcommittee on ethics and international research for Ecuador and Colombia, 1966. Executive Board, Central States Anthropological Society, 1967-70, 1971-75. President, Central States Anthropological Society, 1973-74. Program Chairman of Central States Anthropological Meetings (Cleveland), 1972. Peace Corp lecturer on Ecuador, 1966. Organizer and co-chairman of symposium on "Negroes in the New World," AAA meetings, Washington, D.C., 1967. Chairman of volunteered session of "Role and Role Behavior," AAA meetings, Seattle, 1968. Chairman of Plenary Session of "Regional and National Professional Integration," CSAS meetings, 1972. Chairman of Symposium on "Afro-American Cultures in Latin America," AAA meetings, San Francisco,1975. Chairman of "Table talk" luncheon on the AAA and Activist Concerns, AAA meetings, Los Angeles, 1979. Chairman of LAAG "Table talk" luncheon on research in Ecuador, AAA meetings, Los Angeles,1981. With John Moore (University of Florida) organized a two day (session) Symposium entitled "Ethnogenesis in the Americas, 1492-1992: New Cultures, New Languages, Continuities, Transformations, and Radical Change" for the American Association for the Advancement of Science Meetings in Chicago in February, 1992. All day series of presentations (slides, videos, lectures) on the subject of "Arte, La Cultura Indígena, y los Mundos de Arte en Museos Modernos," at the Museo Nacional de Antropología, Arqueología y Historia, Lima, Peru, January 1994. Board of Trustees, Universidad San Francisco de Quito United States Extension, 2000-continuing. Field training of Ecuadorian students and non Ecuadorian students in ethnological and ethnographic method and technique, 1971 (3 students), 1972-73 (1 student), 1975 (2 students), 1978 (1 student), 1979 (2 students), 1980 (3 students), 1981 (4 students), 1984 (1 student), 1986 (2 students),1987 (2 students), 1989-90 (2 students), 1993-94 (2 students).

Application reviews for National Science Foundation, Canada Council, National Museum of Canada, Social Science Research Council, Canadian Social Science Research Council, Smithsonian Institution, Fulbright-Hays, International Work Group for Indigenous Affairs, Wenner-Gren Foundation for Anthropological Research, National Institute of Education, National Endowment for the Humanities, National Endowment for the Arts, National Geographic Society, MacArthur Foundation (3 reviews in three disciplines), Institute for Advanced Studies, Princeton; Center for Advanced Study, Palo Alto; John Simon Guggenheim Memorial Foundation; Rockefeller Foundation; Ford Foundation; American Philosophical Society; American Association for the Advancement of Science, American Council of Learned Societies. Review of anthropology department: University of Minnesota. Review of Latin American and Caribbean Studies Programs: Northwestern University, University of Kentucky. Site Review for promotions: Brandeis University, Tufts University.

Participated as delegate by invitation in the ler Congreso de la Cultura Negra de las Américas, 24-28 August, 1977, Cali, Colombia; participated as invited observer in the Primera Reunión Técnica sobre Problemas de las Poblaciones Indígenas en la Región Amazónica, July 27-30, 1981, Puyo, Ecuador; participated as invited observer in Nicaraguan elections (October 28-November 5, 1984), Managua, Masaya, Monambó, Matagalpa, Puerto Cabezas, Granada; Appointed to position of Director of Anthropology and Archaeology, Casa de la Cultura Ecuatoriana de Pastaza, August-November, 1987. Appointed "Asesor Técnico" to the Museo del Banco Central and to the Department of Culture of the Ministry of Education to develop Museum in Puyo, June, 1988-1994. Appointed Adjunct Professor of Anthropology and International Studies, Universidad San Francisco de Quito, 1989-present. Delivered Conferencia Magistral (keynote address) at the FLACSO conference "Entender el Racismo: El Caso de Ecuador, 20 November 1999 (sponsored by UNICEF). Lecturer, Arizona State University, Title VI Field School, Venencia, Napo, Ecuador, 2005.

Executive Board, American Anthropological Association, 1975-78. Committees of the AAA Executive Board: Publications Policy (Chairman 1977-78), Administrative Advisory, Anthropology as a Profession, Task Force on Human Rights. Board of Advisors, Survival International (United States Office). Executive Board, Latin American Studies Association, 1983-87. Human Relations Area Files Board of Directors, 1983-1986. Advisory Board, Association of Black Anthropologists, 1987-1991. International Advisory Board, African Diaspora Research Project (Ford Foundation-Michigan State University), 1988-present. AAA representative to the American Association for the Advancement of Science, February 1989 - February 1992; appointed to second term through February 1995; appointed to a third term through February 1998; American Ethnological Society representative to the American Association for the Advancement of Science, 1992-1995. Elected to the Council of Ecuadorianists, Latin American Studies Association, 2000; elected for second term, 2002. Human Relations Area Files Board of Directors 1995-2007; elected to HRAF Executive Committee of Board of Directors, 2003-05. Board of Trustees (one of five members) Universidad San Francisco de Quito, 2006-continuing.

<u>Significant campus and local</u>—Executive Board, Center for Latin American and Caribbean Studies, 1971-76, 1977-1986, 1988 - present. Executive Board, Afro-American Studies Program, 1977-79, 1980-82, 1984-1986. Research Committee, School of Social Sciences, 1977-78. Committee on Future of Social Sciences, School of Social Sciences, 1977-80. University Press Board, 1977-81. Director of Research, Center for Latin American and Caribbean Studies, 1974-76. Fulbright-Hays Committee, 1974-present. On COPE Committee to evaluate Sociology, 1973-74. Executive Committee, School of Social Sciences, spring semester 1976, 1979-80, 1982-85. Chancellor's Allerton Conference on Research, 1980. Chancellor's Allerton Conference on International Affairs, 1984. University of Illinois Senate, 1980-81. Task force in the humanities to explore super computing facilities, 1986. Official responsible for agreement between UIUC and the Instituto Nacional de Patrimonio Cultural del Ecuador, 1982-1988. Official responsible for agreement between UIUC and the Universidad San Francisco de Quito 1989-1997, 1997-2002. Department Head, Department of Anthropology, 1983-86. Appointed Affiliate of Afro-American Studies and Research Program,

1987; Adjunct Curator of Krannert Art Museum, 1987-88; Professor of Latin American Studies, 1987-, Professor of Campus Honors, 1988-1991. Chancellor's Committee to select Minority Postdoctoral Fellows, 1987-1989 (committee chair,1989). College of Liberal Arts and Sciences Grievance Committee 1989-91. Co-Organizer and Co-Chair (with Dorothea S. Whitten) of four-day "LAS State of the Art" symposium entitled, "Imagery and Creativity," Krannert Art Museum, 29 April- 2 May, 1988; 12 participants; financial support from 23 UIUC units and Illinois Humanities Council. Organizer of LAS Social Sciences Commencement, 1988. Served on the Committee of the Vice Chancellor for Research to select University Scholars and Senior University Scholars,1993, 1994. Elected to the Executive Committee of the Graduate College for 1993-1995. Chair of the Committee for Programs and Curricula, Social Science and Education, UIUC Graduate College, 1993-1994, 1994-1995. Appointed to the Executive Committee of the Fellowship Board of the Graduate College, 1994-1997. Appointed to the General Committee of the Fellowship Board of the Graduate College, 1994-1997.
Chair, Committee of the Behavioral and Social Sciences, Fellowship Board of the Graduate College, 1994-1997. Elected to the Executive Committee of the College of Liberal Arts and Sciences, 1996-1998. Chair of the Fellowship Board and Chair of the Executive Committee of the Fellowship Board, 1997-1999. Chair of the interdisciplinary committee on History and Anthropology, 1997-1998, 1998-99, 1999-2000, 2000-2001. Curator of the Spurlock Museum of World Cultures , 1997-continuing; Board of Directors and Advisory Committee of the Spurlock Museum of World Cultures-continuing. Director of the Center for Latin American and Caribbean Studies, 2000-continuing. Elected to LAS Executive Committee for 2000-2002. Chair of Advisory Committee (committee of curators), Spurlock Museum of World Cultures, 2000-. Elected Vice Chair of the LAS College Executive Committee (2001-02). Elected Chair of "Cuban Interest Group," 2001, a campus wide steering committee to determine UIUC-Cuban relationships over the next few years. Appointed to the executive committee of the Center for International Business Education and Research (CIBER), 2002. Co-founder (with Dorothea Scott Whitten) and President of Sacha Runa Research Foundation, 1975-present.

PUBLICATIONS AND MANUSCRIPTS

Authored Books and Monographs

1965 Class, Kinship, and Power in an Ecuadorian Town: The Negroes of San Lorenzo. Stanford: Stanford University Press. 228 pp.

1974 Black Frontiersmen: A South American Case. New York: Halsted (John Wiley). 221 pp. + 16 pp. photographs set out in 8 two-page "photographic essay" spreads.

1976a (with the assistance of Marcelo F. Naranjo, Marcelo Santi Simbaña and Dorothea S. Whitten) Sacha Runa: Ethnicity and Adaptation of Ecuadorian Jungle Quichua. Urbana: University of Illinois Press. 350 pp. + 57 photos, + maps, diagrams, illustrations. Selected in 2005 for the History E-Book Project of the American Council of Learned Societies.

1976b Ecuadorian Ethnocide and Indigenous Ethnogenesis: Amazonian Resurgence amidst Andean Colonization Copenhagen: IWGIA Document No. 23. 40 pp., 3 maps. Reprinted as article in the Journal of Ethnic Studies, 4(2):1-22, September, 1976. Reprinted in Spanish in book edited by Stefano Varese, entitled La Selva Invadida, Mexico: Nueva Imagen, in special issue of América Indígena, 39(3):529-562, and by the Universidad Católica, Quito.

1978 Amazonian Ecuador: An Ethnic Interface in Ecological, Social and Ideological Perspectives. Copenhagen: IWGIA Document No. 34. 80 pp., 2 maps, photographs. Reprinted in Spanish in Ecuador by the Federación Shuar, Sucúa, 1981, and by the Instituto Otavaleño de Antropología, Otavalo,1981.

1984 (With 14 other authors) The Electoral Process in Nicaragua: Domestic and International Influences. Austin: Latin American Studies Association Monograph.

1985a (with D.S. Whitten) Art, Knowledge, and Health. Cambridge: Cultural Survival Monograph #17, 126 pp.

1985b Sicuanga Runa: The Other Side of Development in Amazonian Ecuador. Urbana: University of Illinois Press. 315 pp.+150 line drawings, art illustrations, photographs, bibliographic essay, Epilogue.

1985c Black Frontiersmen: Afro-Hispanic Culture of Ecuador and Colombia. Prospect Heights: Waveland Press. Third, expanded edition, 1994. Now in its fourth edition.

1987a Sacha Runa: Etnicidad y Adaptación de las Quichua Hablantes de la Región Amazónica Ecuatoriana. Quito: Abya Yala. 400 pp.

1987b (with Dorothea S. Whitten) *Causáunchimi!:* Arte, Cultura, y Poder de los Canelos Quichua de la Amazonia Ecuatoriana. Quito: Banco Central del Ecuador, 45 pp. black and white photographs, maps, drawings, plus four pages of color.

1988 (with Dorothea S. Whitten) From Myth to Creation: Art from Amazonian Ecuador. Book to accompany exhibition (listed above) by the same name. 108 Black and white photographs and 8 pages of color. Urbana: University of Illinois Press, 80 pp.

1992 Pioneros Negros: La Cultura Afro-Latinoamericana del Ecuador y de

Colombia. Quito: Centro Cultural Afro-Ecuatoriano, 235 pp.
1997 Clase, Parentesco y Poder en un Pueblo Ecuatoriano: Los Negros de San Lorenzo. Quito: Centro Cultural Afro-Ecuatoriano. 255 pp. with nine page Prólogo,1996.
2008 (with Dorothea Scott Whitten) Puyo Runa: Imagery and Power in Modern Amazonia. Urbana: University of Illinois Press. Released in November, 2007, 335 pp.
2011 (with Dorothea Scott Whitten) Histories of the Present: Culture, Power, and Race in Ecuador. Urbana: University of Illinois Press, accepted 28 April 2010. Will include four color plates, 344 pp ms. Scheduled for spring.

Edited Books and Monographs

1970 (edited with John F. Szwed) Afro-American Anthropology: Contemporary Perspectives. New York: The Free Press, London: Collier-Macmillan. 486 pp. + 32 pp. photographic essay.
1976 (edited) Afro-American Ethnohistory in Latin America and the Caribbean. Washington, D.C.: American Anthropological Association, Contributions of the Latin American Anthropology Group, Vol. 1, 66 pp.
1977 (edited with Marcelo F. Naranjo and José Pereira) Temas sobre la Continuidad y Adaptación Cultural Ecuatoriana. Quito: Centro de Publicaciones, Universidad Católica, 212 pp. 2nd edition published 1984, 195 pp.
1981a (edited) Cultural Transformations and Ethnicity in Modern Ecuador. 27 articles and Foreword, Preface, Introduction, Afterword, Maps, Diagrams, Illustrations. Urbana: University of Illinois Press, 811 pp.
1981b (edited) Amazonía Ecuatoriana: La Otra Cara del Progreso. Sucúa and Quito: Editorial Mundo Shuar, 229 pp. expanded 2nd edition, with new Foreword and two new articles published 1985 by Abya Yala, 285 pp. 3rd edition, 1990, 285 pp.
1982a (edited) Transformaciones Culturales y Etnicidad en el Ecuador Contemporaneo. Otavalo, Ecuador: Prensa del Instituto Otavaleño de Antropología, 250 pp.
1993a (edited, with Dorothea S. Whitten) Imagery and Creativity: Ethnoaesthetics and Art Worlds in the Americas. 377 pp., 16 color plates, 67 illustrations. Tucson: University of Arizona Press.
1993b (edited) Transformaciones Culturales y Etnicidad en la Sierra Ecuatoriana. Quito: Prensa de la Universidad San Francisco de Quito, 450 pp.
1998a (edited, with Arlene Torres) Blackness in Latin America and the Caribbean: Social Dynamics and Cultural Transformations. Volume I: Central America and Northern and Western South America. Bloomington: Indiana University Press (Blacks in the Diaspora Series) 520 pp.
1998b (edited, with Arlene Torres) Blackness in Latin America and the Caribbean: Social Dynamics and Cultural Transformations. Volume II: Eastern South America and the Caribbean. Bloomington: Indiana University Press

(Blacks in the Diaspora Series), 557 pp.

2003 (edited) Millennial Ecuador: Critical Essays on Cultural Transformations and Social Dynamics. Iowa City: University of Iowa Press (Preface plus 13 chapters and Epilogue 2003; 14 authors, including indigenous and nonindigenous Ecuadorian authors), 417 pp.

Special Issues of Periodicals (edited)

1981 (Edited with C. Cunningham, J.W.D. Dougherty, J. Fernandez) Symbolism and Cognition. Special Issue of the American Ethnologist 8:3, 256 pp.

1982a (Edited with Stephen Gudeman, Virginia Kerns, and Harold K. Schneider) Ecological and Economic Processes in Society and Culture. Special Issue of the American Ethnologist 9:2, 208 pp.

1982b (Edited with J.W.D. Dougherty, James W. Fernandez, and Emiko Ohnuki-Tierney) Symbolism and Cognition II. Special Issue of the American Ethnologist 9:4, 208 pp.

1984 (Edited) Social Structure and Social Relations. Special Issue of the American Ethnologist 11:4, 224 pp.

Book Series (Series editor)

2003 Interpretations of Culture in the New Millennium. A new series on contemporary ethnography. Book length to be approximately 175-220 pp (70,000-80,000 words). Seven books published, Three under contract and listed as “forthcoming.”

Published:

Seligmann, Linda
2004 Peruvian Street Lives: Culture, Power, and Economy among Market Women of Cuzco. Urbana: University of Illinois Press.

Uzendoski, Michael
2005 The Napo Runa of Amazonian Ecuador. Urbana: University of Illinois Press.

Hill, Jonathan H.
2008 Made-from-Bone: Trickster Myths, Music, and History in an Amazonian Community. Urbana: University of Illinois Press.

Wibbelsman, Michelle
2009 Ritual Encounters: The Making of the Otavalan Modern and Mythic Community. Urbana: University of Illinois Press.

Isbell, Billie Jean
2009 Finding Cholita. Urbana: University of Illinois Press.

Ntarangwi, Mwenda
2009 East African Hip Hop. Urbana: University of Illinois Press.

Markowitz, Fran
2010 Kalaidoscopic Bosnia: Heterogeneity and Hybridity in Sarajevo. Urbana: University of Illinois Press.

Under Contact:

Rahier, Jean Muteba
2011 The Festival of Kings among the Black Lowlanders of Ecuador. (ms anticipated 2010)

de Jorio, Rosa,
2011 Democracy and Change in Mali (ms anticipated 2010)

Course, Magnus
2012 Becoming Mapuche: Person and Ritual in Indigenous Chile (ms under review April 2010; being revised for late August 2010)

Tapias, María
2012 Bolivian Women Under Stress

Works that do not fall into Book or Monograph categories, and Works in Progress

1984 (compiled and edited with Dorothea S. Whitten and Carmen Chuquín) Yachaj Sami Yachachina, by Alfonso Chango. 35 pp. text in Quichua and Spanish and 35 pp. colored drawings. Cayambe: Mundo Shuar.

Accepted for publication. (with Dorothea S. Whitten) Arte, Conocimiento, y Salud. Quito: Abya Yala. We are withholding this ms from publication for political purposes. Its sensitivity is great in the current ideological situation and could be damaging to peoples served by the program it describes. Manuscript completed Del Mito al Creación.

Commissioned Lo Quichua de la Amazonía Ecuatoriana. In, Guía Etnográfica. Fernando Santos and Frederica Barclay, Editors. Quito and Lima: Flacso. 250 pp. manuscript. Work 85% complete but suspended pending FLACSO reorganization in publication plans. The Guía has 15 volumes commissioned; the first was published in 1993, the second in 1995, and the third in 2000. Monograph re-commissioned in 2000 for receipt of manuscript in 2002.

Biography

Norman Whitten: La humanidad real de indios y negros. Fernando Ituburu, 2010, La Águila bajo el sol: Entrevistas a cinco *ecuatorianistas* de Estados Unidos (pofile of North American Ecuatorianists). Guayqauil: Centro Ecuatoriano Norteamericano de Guayaqui: CEN Publicaciones, pp 67-86, 153-154.

Journal Articles and Book Chapters

1960 Notes on Negro folk medicine. Folk Healthways, Vol. 1, No. 2:5-8. University of Pittsburgh.

1961 Events and statuses involved in a configuration of occult behavior. Research Previews, Institute for Research in Social Science, University of North Carolina, Chapel Hill, Vol. 8, 3:9-15.

1962a Contemporary patterns of malign occultism among Negroes in North Carolina. Journal of American Folklore, Vol. 75, No. 297:311-325. Reprinted in Mother Wit from the Laughing Barrel: Readings in the Interpretation of Afro-American Folklore (Alan Dundes, editor). Englewood Cliffs: Prentice Hall, 1972:402-418.

1962b Sociocultural change in northwest Ecuador. Research Previews, Institute for Research in Social Science, University of North Carolina, Chapel Hill, Vol. 9, No. 3:9-18.

1964 Towards a classification of West Alaskan social structure. Anthropological Papers of the University of Alaska, Vol. 21, No. 2:79-91.

1965a Anthropological research in Colombia. ICMRT Progress Report, March. Tulane University, Universidad del Valle. 119-125.

1965b Power structure and sociocultural change in Latin American communities. Social Forces, Vol. 43, No. 3:320-329.

1966 (with Aurelio Fuentes C.); ¡Baile Marimba! Negro folk-music Northwest Ecuador in Journal of the Folklore Institute. Special Latin American Edition, Vol. 3, No. 2:168-191.

1967a Afro-Hispanic music from western Colombia and Ecuador. Monograph accompanying Ethnic Folkways L.P. Record No. FE 4376. 8 pp.

1967b Música y relaciones sociales en las tierras bajas colombianas y ecuatorianas del Pacífico: Estudio sobre microevolución sociocultural. América Indígena, Vol. 17, No. 4:635-655.

1968 Personal networks and musical contexts in the Pacific Lowlands of Colombia and Ecuador. Man: Journal of the Royal Anthropological Institute of Great Britain and Ireland, Vol. 3, No. 1:50-63. Reprinted in Afro-American Anthropology: 203-217; Peter Hammond, ed. Social and Cultural Anthropology: Selected Readings, New York: Macmillan, 1975:368-384.

1969a Strategies of adaptive mobility in the Colombian-Ecuadorian litoral, American Anthropologist, Vol. 71, No. 2:228-242. Reprinted in Afro-American Anthropology: 329-344.

1969b The ecology of race relations in northwest Ecuador. Journal de la Société des Americanistes, Vol. 54:223-235. (Paris—special Afro- American issue edited by Roger Bastide).

1970a Network analysis and processes of adaptation among Ecuadorian and Nova Scotian Negroes. Chapter 8:339-402, 609-612, In Marginal Natives: Anthropologists at Work (Morris Freilich, editor), New York: Harper & Row.

1970b Ecología de las relaciones raciales al noroeste del Ecuador. América Indígena, Vol. 30, No. 2:345-358.

1970c Network analysis in Ecuador and Nova Scotia: Some critical remarks. Canadian Review of Sociology and Anthropology, Vol. 7, No. 4:269-280. (Special edition devoted to network analysis.)

1970d (with George Talbot) Afro-Americans. In, Afro-American Anthropology, 32 pp "photographic essay." (between pp. 22 and 23).

1970e (with John F. Szwed) Introduction. In, Afro-American Anthropology, pp. 23-60.

1972 (with Dorothea S. Whitten) Social strategies and social relationships Annual Review of Anthropology, 1. Palo Alto: Annual Reviews Incorporated, pp. 247-270.

1973 The ecology of race relations in northwest Ecuador. Chapter in Dwight Heath (ed.) Contemporary Societies and Cultures of Latin America. New York: Random House, pp. 327-340.

1974a (with Alvin W. Wolfe) Network Analysis. Chapter 23 in Handbook of Social and Cultural Anthropology (John J. Honigmann, editor) Chicago: Rand McNally, pp. 717-746.

1974b Ritual enactment of sex roles in the Pacific Lowlands of Ecuador-Colombia. Ethnology, Vol. 13, No. 2. Reprinted in Old Roots in New Lands: African Heritage and the Black Experience in Latin America and the Caribbean. (Ann Pescatello, editor) 1977, Westport, Connecticut: Greenwood Press, 243-261 and in Whitten and Torres, and in Blackness in Latin America and the Caribbean: Social Dynamics and Cultural Transformations. Vol, I. Bloomington: Indiana University Press.

1975a (with Nina S. de Friedemann) La cultura negra del litoral ecuatoriano y colombiano: un modelo de adaptación étnica. Revista Colombiana de Antropología. Bogotá, Colombia, 17:75-115.

1975b Jungle Quechua ethnicity: an Ecuadorian case study. In the following books: Resource Competition and Ethnicity in Plural Societies (Leo Despres, editor) Migration and Ethnicity (Helen Safa, editor); Bartolomé de las Casas: A Commemoration (Elias Sevilla, editor); and Social Change in the Andes and Amazonia (David Browman, editor). The Hague: Mouton (World Anthropology Series). Despres and Safa volumes published October, 1975; Sevilla in 1977, other 1978.

1976 Introduction. In Afro-American Ethnohistory in Latin America and the Caribbean, pp. 1-2.

1977a Introducción. In, Temas sobre la Continuidad y Adaptación Cultural Ecuatoriana. Quito: Prensa de la Universidad Católica. pp. 15-21.

1977b Etnocidio ecuatoriano y etnogénesis indígena: resurgencia amazónica ante la colonización andina. In Norman E. Whitten, Jr., Marcelo F. Naranjo and José Pereira, eds., Temas Sobre la Continuidad y Adaptación Cultural Ecuatoriana. Quito: Prensa de la Universidad Católica. pp. 169-213.

1977c Anthropology. Encyclopedia Britannica Book of the Year, for 1976. pp. 128-130.

1977d (with Dorothea S. Whitten). Report of a process linking basic science research with an action-oriented program for research subjects. Human Organization, Vol. 36, No. 1:101-105. Reprinted in Survival

International Review 2(4): 5-8, 1977.
1978a (with Dorothea S. Whitten) Ceramics of the Canelos Quichua. Natural History. October, Vol. 87, No. 8:90-99, 152. Reprinted in Survival International Review.
1978b Ecological Imagery and Cultural Adaptability: the Canelos Quichua of Eastern Ecuador. American Anthropologist, Vol. 80. No. 4:836-859.
1979a Soul Vine Shaman. Monograph to accompany L.P. Record by the same title. 8 pp. Urbana: Sacha Runa Research Foundation Occasional Papers, No. 5.
1979b Structure and transformations of contemporary Canelos Quichua spirit relationships. In Udo Oberem, ed. Festschrift for H.C. Hermann Trimborn. Bonn: Antropos.
Accepted for publication: The Ecuadorian Oriente: an Ethnic Interface. In Joseph B. Casagrande, ed., Handbook of Ecuador. New Haven: Human Relations Area Files Press. Available in mimeograph form as Sacha Runa Research Foundation Occasional Papers, No. 1, expanded version, up-dated for 1978 published as IWGIA Document.
1981a (with Dorothea S. Whitten) Cerámica y simbolismo del Centro Oriente Ecuatoriano. Miscelanea Antropológica, Boletín de los Museos del Banco Central. Guayaquil, pp. 120-135.
1981b (with the assistance of Kathleen Fine) Introduction. In, Cultural Transformations and Ethnicity in Modern Ecuador, pp. 1-41.
1981c Afterword. In, Cultural Transformations and Ethnicity in Modern Ecuador, pp. 776-797.
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1993c Review of: Ayahuasca Visions: The Religious Iconography of a Peruvian Shaman, by Luis Eduardo Luna and Pablo Amaringo. American Anthropologist.

1995 A Well-Disciplined Diet. American Ethnologist. May.

1996a Review of: Life and Death in Early Colonial Ecuador, by Linda A. Newson. American Ethnologist.

1996b Review of: Indigenous Peoples and Democracy in Latin America. Edited by Donna Van Lee Cotti. Cultural Survival Quarterly.

2001a Review of: Afro-Creole: Power, Opposition, and Play in the Caribbean. by Richard D.E. Burton. Plantation Society in the Americas: an Interdisciplinary Journal of Tropical and Subtropical History and Culture.

2001b Review of: Music, Race and Nation: *Música Tropical* in Colombia. by Peter Wade. Bulletin of Latin American Research.

2002 Review of: The Native Leisure Class: Consumption and Cultural Creativity in the Andes. by Rudi Colloredo-Mansfeld. American Ethnologist.

2003 Review of: African Roots/American Cultures: Africa in the Creation of the Americas, by Sheila Walker, editor. American Anthropologist, September.

2004a Review Essay: Where Violence Reigns and Terror Rules. Law in a Lawless Land: Diary of a *Limpieza*, by Michael Taussig. New York: The New Press. Journal of Latin American Anthropology. 9 (1): 221-225.

2004b Review of: Histories and Historicities in Amazonia, Neil L. Whitehead, Editor. Lincoln: University of Nebraska Press. Ethnohistory 51 (2): 450-453.

2004c Review of: Trekking Through History, by Laura M. Rival. Tipití: The Journal of the Society for the Anthropology of Lowland South America. Vol. I (2):

2004d Review of: Indians, Oil, and Politics: A Recent History of Ecuador, by Allen Gerlach. Willmington: Scholarly Resources. Hispanic-American Historical Review.

2004e Review Article of: The Root of Roots, or How Afro-American Anthropology Got Its Start, by Richard Price and Sally Price. Chicago: Prickly Paradigm Press. New West Indian Guide 78 (3 & 4): 308-310.

2004f Review of Streams of Gold, by John Tweedy. 59.5 minute VHS Video Cassette. The Journal of Latin American Anthropology 9)2):

2005a Review of Race, Nature and Culture: An Anthropological Perspective, by Peter Wade. Journal of the Royal Anthropological Institute, 10(4): 927-28.

2005b Review of Death, Dismemberment, and Memory in Latin America, edited by Lyman L. Johnson. Journal of Latin American Anthropology, 10 (1):

2005c (with Dorothea Scott Whitten) *Causáunchimi!* Illinois International Newsletter, 2-page centerfold.

2006 Review of: Holy Intoxication to Drunken Dissipation: Alcohol Among Quichua

Speakers in Otavalo, Ecuador. Barbara Y. Butler. Journal of Latin American Anthropology, 11 (2):

2007a Review of: Blacks of the Rosary: Memory and History in Minas Gerais, Brazil. Elizabeth. W. Kiddy. The Bulletin of Latin American Research, 26 (1), pp. 155-157.

2007b Review of: Remembering of the Hacienda: Religion, Authority, and Social Change in Highland Ecuador. Barry Lyons. Journal of Latin American and Caribbean Anthropology 12 (2): 533-536.

Manuscripts, Theses, Reports, Guest Lectures, Papers Read at Professional Meetings and Symposia

1961 Aspects and Origins of Negro occultism in Piedmont Village. M.A. thesis, University of North Carolina at Chapel Hill.

1963a Negro kinship and social mobility in northwest Ecuador. Paper presented at the AAA meetings, San Francisco, November.

1963b ¡Baile Marimba! Negro Folk music in northwest Ecuador. Paper presented at the American Folklore Society meetings, Detroit, December.

1964a An analysis of social structure and change: profile of a northwest Ecuadorian town. Ph.D. thesis, University of North Carolina at Chapel Hill (described in Vol. 26 of dissertation abstracts).

1964b Witchcraft, psychiatry, and medicine among Negroes in North Carolina. Paper presented to the Duke University Department of Psychiatry colloquium, Durham, North Carolina, January 25.

1966a Adaptations to socioeconomic change in northwest Ecuador. Paper presented to the University of Illinois anthropology colloquium series, Urbana, March.

1966b Music and social relationships in the Pacific Lowlands of Colombia and Ecuador. Paper presented at the AAA meetings, Pittsburgh, November.

1967a Strategies of adaptive mobility in the Colombian-Ecuadorian littoral. Paper presented at the Central States Anthropological Society meetings, Chicago, April, as part of a symposium entitled "Social Stratification in Latin America."

1967b Adaptation and adaptability as processes of microevolutionary change in New World Negro communities. Paper presented at the AAA meetings, Washington, D.C., November, as part of a symposium entitled "Negroes in the New World: Problems in Theory and Methods."

1969a Aspects of black religion in western Ecuador and eastern Canada. Lecture (with tapes and slides) delivered at "Focus: Black America" series, Indiana University, January14.

1969b Regularities in Afro-American social structure: an anthropological perspective. Lecture delivered at the African Studies Center, Michigan State University, as part of program: "Africans in the New World," April 16.

1969c An anthropological perspective on black studies: social organization. Lecture delivered at the Southern Illinois University anthropology colloquium series, Carbondale, May 10. (Mimeographed)

1969d Network analysis in Ecuador and Nova Scotia: some critical remarks.

Central States Anthropological Society plenary session, "International Comparisons of Urban Networks," Milwaukee, May. 1969e The ecology of race relations in northwest Ecuador. Paper presented at the AAA meetings, New Orleans, November.

1969f Anthropology and "black studies": toward a productive relationship. Colloquium given at the University of Illinois, Urbana, December 5.

1970a Discussion of: Raymond T. Smith, "Caribbean Family and Kinship Structure." Conference on Continuities and Discontinuities in Afro-American Societies and Cultures. Sponsored by the Social Science Research Council. Mona, Jamaica, April 2-4. (Mimeographed)

1970b Black subculture in northern South America. Paper presented at Stanford University seminar on "Africa and the New World: Historical Perspectives." Palo Alto, April 15.

1971 Ritual Enactment of Sex Roles in the Pacific Lowlands of Ecuador-Colombia. Paper presented at the AAA meetings, New York City, November, as part of symposium "Ritual and Social Form", Hans Buechler, Chairman.

1973 Jungle Quechua Ethnicity: an Ecuadorian Case Study. Presented five times between September 1 and September 7, at the IXth International Congress of Anthropological and Ethnological Sciences, Chicago, in the following sessions: Resource Competition and Ethnicity in Complex Societies (Leo Despres, Chairman), Migration and Ethnicity (Helen Safa, Chair), Bartolomé de las Casas Commemoration (Elias Sevilla, chairman), the Fates of Indigenous Peoples (Sam Stanley, Chairman), and Social Change in the Andes and Amazonia (David Browman, Chairman).

1974 The Central States Anthropological Society: structure and operation; past, present, future. CSAS special colloquium, March 27, Chicago.

1975a Ecuadorian ethnocide and indigenous ethnogenesis: Amazonian resurgence amidst Andean colonialism. Duke University Ethnicity Colloquium Series, February 27.

1975b Mathematical mythology and social exchange: towards a qualitative perspective on social networks. Mathematical Social Science Board (MSSB) Advanced Research Symposium on Social Networks. Hanover, New Hampshire, September 17-21.

1976a Ecological imagery and cultural adaptability: the Canelos Quichua of east-central Ecuador. AAA symposium: "Jivaroan Ecology," Michael J. Harner, Chairman, Washington, D.C.

1976b Report of the President, Sacha Runa Research Foundation. Mimeograph available.

1976c Medical Care Delivery and Human Subjects. Talk given to first Seminar in School of Social Sciences, University of Illinois, November 8.

1977a Modern Medicine, Traditional Crafts, and Applied Anthropology. The Sacha Runa of Eastern Ecuador. Lecture with accompanying exhibit presented to the St. Louis Anthropological Society, March 18-19.

1977b Report of the President, Sacha Runa Research Foundation. Mimeograph available.

1978a Health Care Delivery and its Problems in Eastern Ecuador. Address given at the Symposium, "Amazonia: Extinction or Survival?", April 13, Madison, Wisconsin. Mimeograph available.

1978b The Association's Positions and Potentials Regarding Activist Concerns and Policy-Oriented Activity. Table Talk Luncheon, AAA meetings, Los Angeles, November 17, 12:00-2:00.

1978c Report of the President, Sacha Runa Research Foundation. Mimeograph available.

1979a Indigenous Knowledge and Nationalist Folly. Paper delivered at the Latin American Studies Association Meetings, Pittsburgh, April.

1979b Report of the President, Sacha Runa Research Foundation. Mimeograph available.

1979c Lessons in Technology from Amazonian Peoples. University of Illinois YMCA-YWCA Friday Forum, October 12. Tape available, WILL Radio, Urbana.

1979d Progress Report on Paramedical Training No. 1. Submitted to Survival International, 28 pp. Mimeo available.

1979e Discussion of papers presented at the symposium "Women and Change: The Ecuadorian Case." Grace Schubert and Louisa Stark, Organizers and chairpersons. AAA meetings, Cincinnati, December 1.

1980a Pragmatics and Symbolism: Productive Dialectic or Stultifying Polarity? Colloquium given at the University of Florida, 15 February.

1980b Report of the President, Sacha Runa Research Foundation. Mimeograph available.

1981a Nationalist Centralization and Ethnic Resurgence in Amazonian Ecuador. Lecture given at the Museum Consortium Series, Southern Illinois University, Carbondale, 6 February.

1981b Nationalist Centralization and Ethnic Resurgence in Ecuador's Heartland and Frontier. Prepared for prior distribution for critical discussion at the University of Oklahoma's Annual Meetings on the Frontier. Norman, 10-12 April. 110 pp., mimeo available.

1981c Research in Ecuador. Table Talk Luncheon, AAA Meetings (sponsored by LAAG), December, Los Angeles.

1981d Report of the President, Sacha Runa Research Foundation. Mimeograph available.

l982a Amazonian Ecuador. Talk presented at public "round table" on Amazonia. Gainesville, Fla., Amazonian Symposium, 9 February.

1982b (with Dorothea S. Whitten) Aesthetic Resurgence in Amazonian Ecuador. Paper prepared in conjunction with exhibit and Symposium on Amazonia, Gainesville, FL. Mimeograph available.

1982c Amazonian Ceramics from Ecuador. Lecture presented at the University Museum, Southern Illinois University, Carbondale, March.

1982d Towards a Conceptualization of Power in Amazonian Ecuador. Paper presented in Plenary Session of the American Ethnological Society meetings, Lexington, Kentucky, April. Mimeograph available.

1982e Ethnic Duality of the Canelos Quichua. Paper presented in the symposium "Jivaroan Ethnic Relations," International Congress of Americanists, Manchester, England, September. Mimeograph available.

1982f Report of the President, Sacha Runa Research foundation. Mimeograph available.

1982g (with Dorothea S. Whitten) Ceramics and Symbolism from Ecuador's

Rainforest. Lecture with 125 slides given at the Lakeview Museum of Natural History, Peoria, December.

1982h "Indian Identity", and "Indian Territoriality": Concepts forged on the Anvil of Domination. Paper delivered at the AAA symposium on Lowland South America, Washington, D.C.

1983a (with Wendell S. Williams, Dorothea S. Whitten, et. al.) Characterization of Decorated Pottery from the Rainforest of Ecuador. Paper delivered at the 23rd International Archaeometry Symposium, Naples, Italy, March.

1983b (with Wendall Williams, Dorothea S. Whitten, et. al.) Ceramic Analysis of Thin-Walled, High-Strength Pottery from the Upper Amazon. Paper delivered at the American Ceramic Society, April.

1983c Vehicles of Power in a Mobile Society. Lecture given at the inauguration of the William Hammond Mathers Museum, Indiana University, April.

1983d Report of the President, Sacha Runa Research Foundation, Mimeograph available.

1984a Canelos Quichua Arts: Context and Change in the Rainforest of Amazonian Ecuador. Logan Museum of Anthropology. Lecture and slides in conjunction with the opening of an exhibition celebrating the museum's 90th anniversary, March 15.

1984b Discussion of Invited Session (17 papers) "From History to Myth in Highland and Lowland South America." American Anthropological Association Annual Meeting, Denver, 17 November.

1984c Report of the President, Sacha Runa Research Foundation, Mimeograph Available.

1984d (with John Isaacson and Dorothea S. Whitten) Technical Analysis of Canelos Quichua pigments, clays, and resins. ATAM working paper.

1984e "Two Nicaraguas", Lecture delivered at UIUC YMCA-YWCA Friday Forum Series, December 7. Tape available.

1985a Indomestizaje and Indigenous Power in Ecuador. Latin American Studies Association Symposium, "Ecuador since 1972: The Political Economy of Petroleum." David Scott Palmer and David Schodt, Chairs and Osvaldo Hurtado, Discussant. Albuquerque, NM: 14 April.

1985b Two Nicaraguas. Latin American Studies Association Round table on Nicaragua. John Booth, Chair. Albuquerque, NM: 15 April.

1985c (with Dorothea S. Whitten) "Our Beauty, Our Knowledge: Expressive Culture of the Canelos Quichua of Ecuador." Bloomington, IL, Annual meeting of the Midwest Latin Americanist Association, Nov. 1.

1985d (with Dorothea S. Whitten) "Our Beauty, Our Knowledge: Expressive Culture of the Canelos Quichua of Ecuador." American Anthropological Association Meetings, Washington, D.C., December.

1985e Discussion of Invited Symposium (18 papers) "Ritual and Domination in South American Societies," Mary-Elizabeth Reeve, Chair. Washington, D.C., American Anthropological Association Annual Meeting December.

1985f Co-Director of Workshop on "Getting a Job in Academia." American Anthropological Association Annual Meeting.

1985g Report of the President, Sacha Runa Research Foundation. Mimeograph available.

1986a (with Dorothea S. Whitten) "Our Knowledge, Our Beauty: Expressive

Culture of the Canelos Quichua of Ecuador. Logan Museum, Beloit College, 6-7 April: included workshop on use of video in ceramic arts

1986b Indomestizaje and Marxist Rhetoric in Ecuador. Paper presented at the Symposium on Class, Ethnicity, and Peasantry in Latin America. York University, March, 45 pp. Mimeo available.

1986c The Future of Anthropology. Position paper commissioned by the Wenner-Gren Foundation for Anthropological Research. New York, March, 10 pp. Mimeo available.

1986d Cosmology, Value, and Power in Canelos Quichua Economics. Paper delivered as the final presentation at the symposium, "Cosmology, Values, and Inter-Ethnic Contact in South America, Terence Turner, Chair. AAA Annual Meetings, Philadelphia, December.

1986e Report of the President. Sacha Runa Research Foundation.

1987a Presentación (to the exhibition "¡Causaunchimi!") 10 March, Quito.

1987b Presentación (to the exhibition "Arte, Cultura, y Poder) 8 May, Puyo.

1987c Desde el Yachaj Sami Yachachina hasta la Antropología Critica: Comentario sobre el libro Rucuyaya Alonso y la Historia Social y Económica del Alto Napo 1850-1950. FLACSO 13 August, Quito.

1987d Amazon Cosmos and Ecology, Lecture delivered at the Heard Museum, 25 October.

1987e Workshop in Video and Visual Anthropology. Arizona State University, 26 October.

1987f Report of the President. Sacha Runa Research Foundation.

1988a Imagery, Power, and Creativity. Lecture delivered at the College of William and Mary. February.

1988b Introduction to symposium Imagery and Creativity. Krannert Art Museum Auditorium, 30 April.

1988c From Myth to Creation. Three Separate Gallery Lecture Tours. Krannert Art Museum. 17 April - 22 May.

1988d Report of the President. Sacha Runa Research Foundation.

1989a (with Dorothea S. Whitten) Development and the Competitive Edge: Canelos Quichua Arts in a Modern World. Presentation (including video) at the Symposium, "Redefining the 'Artisan': Traditional Techniques in Changing Societies." University of Iowa, Center for International and Comparative Studies, April 14-16.

1989b Report of the President, Sacha Runa Research Foundation.

1989c (with Dorothea S. Whitten) Ecuadorian art and ecology. Focal Point. (Public Television Program).

1990a Final Discussant (of session) "The Politics of Contact and Anthropological Theory. American Anthropological Association Annual Meeting, New Orleans (Friday).

1990b First Discussant (of session) Rethinking Native Amazonia. American Anthropological Association Annual Meeting, New Orleans (Saturday).

1991a "The Indigenous Uprising in Ecuador, 1990: an Analysis of Culture, Race and Social re-ordering," presented at the symposium Andean Crises: Traditional Dilemmas and Contemporary Challenges (March 26-29), Gainesville, Florida.

1991b "1992: Nationalism, Ethnic-Bloc Formation, and Racialist Ideologies," invited lecture delivered at the Monday Afternoon Advanced Seminar in Anthropology at the University of Chicago on 1 April.

1991c "The Ecuadorian Levantamiento Indígena of 1990: An analysis of Culture, Race, and Social Re-ordering." Presented at the Latin American Studies Association Session, De-mythologizing the Political Cultures of Coercion and Terror in Latin America on Friday, 5 April, in Washington, D.C.

1991d (with Arlene Torres) "Blackness in Latin America and the Caribbean: Social Dynamics and Cultural Transformations." Noon lecture co-sponsored by the Program on Afro-American Studies and the Center for Latin American and Caribbean Studies.

1992a "1492-1992: Symbolism of Nationalism, Ethnic-Bloc Formation, and Racialist Ideologies." Lead presentation for the "Friday Forum" Series "500 years in the Americas. University YMCA at the University of Illinois, 31 January.

1992b "1492-1992: Symbolism of Nationalism, Ethnic-Bloc Formation, and Racialist Ideologies." Lead presentation for the symposium "Ethnogenesis in the Americas". Chicago: American Association for the Advancement of Science,10 February.

1992c (with Dorothea S. Whitten) "500 Years of Canelos Quichua Continuity." Guest Lecture. Southern Illinois University Museum. 5 April.

1992d "Killing the Yumbo II: Amazonian Ritual and Power in Quito, 1992." American Anthropological Association Annual Meetings, 5 December, San Francisco. 1993a "Alternative Modes of Ecological Interpretation in Multicultural Settings." Paper given at the LASPAU Symposium: Real World Responses to Agenda 21. Friday, 19 March, Smithsonian Institution.

1993b Report of the President. Sacha Runa Research Foundation.

1994a Arte, La Cultura Indígena, y los Mundos de Arte en Museos Modernos. Day-long presentation at the Museo Nacional de Antropología, Arqueología y Historia, Lima, Peru, 8 January.

1994b Commentary on the papers in a Symposium on the Pacific Lowlands of Colombia. Atlanta, Latin American Studies Association. March.

1994c El Levantamiento Indígena de 1990 y el Simbolismo de 1992. Primer Simposio Etnohistórico de Relaciones Andinos-Tierras Bajas (amazónico y costa pacífica). Popayán, Colombia. October.

1994d Cultural Anthropology in the Late Twentieth Century. Guest Presentation in the Symposium on the State of Anthropology: Five Field Update. Association of Community Colleges Special Session. American Anthropological Association Annual Meeting, Atlanta. November.

1995 Report of the President. Sacha Runa Research Foundation.

1996a Report of the President. Sacha Runa Research Foundation.

1996b & c Indigenous and Black Social Movements in the Americas. Association of Agriculuralists, UIUC, March. International Studies Symposium, April. In section entitled "Ethnic Fragmentation."

1996d Cultural Ecology and Cosmology in Middle and South America. Commentary on the Symposium in honor of Johannes Wilbert. American Anthropological Association, San Francisco. November.

1996e (with Dorothea S. Whitten and Alfonso Chango) La Paradigma de Multinacionalidad y la Red de Salud en el Ecuador. Primer Congreso

Ecuatoriano de Antropología. Quito, Ecuador, 28-31(illustrated with nine color transparencies of indigenous Andean art) October 29.

1997a (with Dorothea S. Whitten and Alfonso Chango). Multiculturality and the Imagery of Health Networks in Ecuador. Twenty fifth meeting of the Mid-West Association of Andeanists. Madison, Wisconsin, February.

1997b Indigenous Social Movements, Aesthetics, and Health Networks in Ecuador. University of Pennsylvania Monthly Symposium on Latin America. Center for Latin American Studies, University of Pennsylvania. April 3.

1997c (with Rachel Corr) Los Imágenes de "Lo Negro" en las Fiestas indígenas de Sud America. 49th Congreso de Americanistas, 11 July, Quito, Ecuador.

1997d On Ecocide and Ethnocide in Contemporary Amazonia. American Anthropological Association Annual Meeting. Invited Session on "Petroleum and Mining in Amazonia Today. Organized and Chaired by Les Sponsel.

1998a (with Rachel Corr) Braided Paradigms in Native American and African American Diasporic Arts and Representations. Symposium: "Identity and the Arts in Diaspora Communities." University of Illinois at Urbana-Champaign, 12-14 November.

1998b Report of the President, Sacha Runa Research Foundation. November.

1998c Los paradigmas mentales de la conquista y el nacionalismo: La Formación de los conceptos de las "razas" y las transformaciones del racismo. Quito: Flacso. Conference on "Entender el Racismo: El Caso de Ecuador," sponsored by UNICEF. November 14-20 (delivered 20 November).

1999a Comment on "Conservation and Conflict: State and Peasantry in Revolutionary Ethiopia, by Dessalegn Rahmato. Conference on Peasants in Comparative and Interdisciplinary Perspective, University of Illinois at Urbana-Champaign, Allerton Conference Center, 9 April.

1999b Comment on paper by Richard Handler, Crossing the Boundaries between History and Anthropology. Urbana: Illinois Center for the Humanities, 16 September.

1999c The ideology of Mestizaje/Creólité in the Greater Caribbean Region: Cultural Performances, Ritual Dramas, and Political Events. Symposium on Mestizaje/Creólité: Topologies of Race in the Circum-Caribbean, Organized by Andrew Apter and Robin Derby. Chicago, 2-3 October.

1999d With Dorothea Scott Whitten.From Local to Cosmopolitan: The Transformations of an Ecuadorian Art Form. AAA meeting, Chicago, November, in a Symposium organized by Michael Chibnik on Aesthetics and Arts in Latin America.

2000a Elite and Subaltern Political Imaginaries in the Transition from the Colonial to the Republican Order: Critical Remarks. Symposium on "Political Cultures in the Andes, 1750-1950. Organized by Nils Jacobsen. NEH funded. Urbana, Illinois, 23 March-26 March.

2000b African Diaspora Studies, 1959-2000: A Personal Reflection. Brief (15 minutes) presentation made Saturday, April 10, at the conference celebrating the 30th year of the Afro-American Studies and Research Program at the UIUC.

2001b Cultural Diversity and Artistic Expressions in Amazonian and Andean Ecuador. Northwestern University Center for Latin American Studies, invited lecture. April.

2001c Ethnogenesis and Cultural Transformations in Amazonian Ecuador and the Ecuadorian Nation-State. Paper presented a the Latin American Studies Association (LASA) Conference, Washington, DC. Session chaired by León Zamosc. September 6.

2001d Symbolic Inversion and Urban Transformations: Discussion of session chaired and organized by Rachel Corr. November 27, American Anthropological Association Annual Meeting, Washington, DC.

2002 Dark Shamanic Performance Reconsidered. Discussant of session organized and chaired by Neil Whitehead. American Anthropological Association (AAA) Annual Meeting.

2003a Masculinity and Multiculture. Discussant of session organized and chaired by Mary Weismantel. Latin American Studies Association (LASA) Annual Meeting, Dallas.

2003b From Mestizaje to Interculturality: Ecuadorian Transformations. Joint Area Center Symposium (JACS) on "Interculturality in a Globalizing World," UIUC, November 14, 2003.

2004a What are *you* doing here? Association of Senior Anthropologists session the American Anthropological Association Annual Meeting, Atlanta, December.

2004b (with Dorothea Scott Whitten), *Yachaj Sami Yachachina:* Shaman Class Lessons from Amazonian Ecuador. Poster session on Amazonian Shamanism sponsored by the Society for Visual Anthropology and the Society for the Anthropology of Lowland South America (SALSA). American Anthropological Association Annual Meeting, Atlanta, December.

2005 Guest Lecture: The Structure of Power and the Spirit World of the Canelos Quichua. Arizona State University Title VI FLAS Field School, Cotacachi Foundation, Napo-Ecuador, 18 July.

2006a American Ethnologist: The early years, a history. University of Iowa workshop on 30 years of the American Ethnologist. Iowa City: March 3-4.

2006b (with Dorothea Scott Whitten) Introduction to Rain Forest Visions. Spurlock Museum Celebratory Opening, 12 March.

2006c The *Longue Durée* of Racial Fixity and the Conjunctures of Racial Fluidity. American Anthropological Association Annual Meetings in the session *Entre 'lo Indio' y 'lo negro':* Interrogating the effects of Latin America's New Afro-Indigenous Multiculturalisms. San José, American Anthrological Association Annual Meeting. (I also chair this session).

2006d Commentary, on the session organized by Kathleen Fine-Dare, American Anthrological Association Annual Meeting, San José, CA, 14 November.

2008a Interculturality and the Indigenization of Modernity: A View from Amazonian Ecuador. Keynote address for the Southeastern Society of Amazonian and Andean Studies. Boca Raton, Florida, September 20.

2008b Final Discussant, Symbolic Affinities, Pragmatic Engagements: Shaping Latin American Ethnology through the Collaborative Work of Norman and Dorothea Scott Whitten. Two sessions, six hours. AAA Annual Meeting, Organized by Michelle Wibbelsman and Kathleen Fine, Chaired by Linda Seligmann and Arlene Torres. San Francisco, November.

2009a From the American Ethnologist to Interpretations of Culture in the New

Millennium. Central States Anthropological Society, Urbana, Illinois, 9 April.

2009b Expanding a Shamanic Purview in Amazonian Ecuador. in the session "Consciousness, Agency and Authenticity in Shamanic Identity and Ritual: Expanding the Range of the Sound of Rushing Water. AAA Annual Meeting, Philadelphia. December 5.

2010 Ethnogenesis, Symbolic Inversion, and Festivity Revisited. In the session "Carnival in the New World." AAA Annual Meeting, New Orleans,

Tributes to Deceased Colleagues

1982 Joseph Casagrande and Anthropological Research, Memorial Service: Joseph Bartholomew Casagrande, 1915-1982. Smith Music Hall, UIUC, September 30.

1984 Tribute from a Colleague. In Memoriam: Dr. Marshall E. Durbin. Graham Chapel, Washington University, St. Louis, February 11.

1996 Obituary: Iria d'Aquino. Anthropology Newsletter.

2004 Obituary: Ronald Stutzman. Anthropology Newsletter, January.

Annex 5

APPENDIX 2

Curriculum Vitae of Dr. William T. Vickers, Ph.D

Annex 5

October 2010

CURRICULUM VITAE

Name: William T. Vickers

Present Position: Professor Emeritus of Anthropology
Department of Global and Sociocultural Studies
Florida International University
Miami, Florida 33199

Home Address: 4325 N.W. 75th Street
Gainesville, Florida 32606-4100

Telephone: Home (352) 376-4914

Internet Address: vickersw@fiu.edu

Marital Status: Married to Edite Vargas de Souza Vickers

Education:

1993	National Science Foundation Chautauqua Short Course entitled, "Aggression and the Animal Kingdom (Humans Included)," Temple University
1976	Ph.D., Anthropology, University of Florida
1976	Ph.D. Certificate in Latin American Studies, University of Florida
1973	Summer program, "Man and Environment," Leiden University, The Institute of Social Studies, The Hague, and the University of Florida
1972	Summer program in Latin American literature, Georgetown University and Pontificia Universidad Católica del Ecuador
1971	National Science Foundation Field School in Ethnography and Linguistics, Ixmiquilpan, Hidalgo, Mexico, Washington State University and The Catholic University of America
1971	M.A. bypass by examination, Department of Anthropology, University of Florida
1967	B.A., Psychology, Jacksonville University
1964	Certificate, Peace Corps Training, University of Denver

Dissertation:

1976 Cultural Adaptation to Amazonian Habitats: The Siona-Secoya of Eastern Ecuador. Ann Arbor: University Microfilms International. (348 pp.)

Publications:

Books, Monographs, Edited Works

1989 Los Sionas y Secoyas: Su Adaptación al Ambiente Amazónico. Quito and Rome: Ediciones Abya-Yala and MLAL. Second Printing 1996.

1984 (with Timothy Plowman) Useful Plants of the Siona and Secoya Indians of Eastern Ecuador. Fieldiana Botany No. 15. Chicago: Field Museum of Natural History.

1983 (coedited with Raymond B. Hames) Adaptive Responses of Native Amazonians. New York: Academic Press.

1978 (coedited with Glenn R. Howze) Social Science Education for Development. Symposium Proceedings from the 1978 Annual Meeting of the Society for Applied Anthropology. Tuskegee Institute, Alabama: Tuskegee Institute Center for Rural Development.

Journal Articles, Book Chapters, Review Articles

Submitted Preface. In Demography, Household Economics, and Land and Resource Use of Five Indigenous Populations in the Northern Ecuadorian Amazon. Flora Lu, Richard E. Bilsborrow, and Ana Isabel Oña. Quito: Ediciones Abya-Yala.

2007 La Historia Temprana del Turismo en las Comunidades Secoya. In Caminando en el Sendero: Hacia la Conservación del Ambiente y la Cultura Secoya. Stella de la Torre and Pablo Yépez, eds., pp. 53-68. Quito: Fundación Vihoma.

2005 Etnobotánica, Conservación, y Supervivencia Cultural. In Al Inicio del Sendero: Estudios Etnobotánicos Secoya. Pablo Yépez, Stella de la Torre, Carlos Cerón, and Walter Palacios, eds., pp. 13-32. Quito: Editorial Arboleda.

2003 The Modern Political Transformation of the Secoya. In Millennial Ecuador: Critical Essays on Cultural Transformations and Social Dynamics. Norman E. Whitten, Jr., ed., pp. 46-74. Iowa City: University of Iowa Press.

2002 Sexual Theory, Behavior, and Paternity among the Siona and Secoya Indians of Eastern Ecuador. In Cultures of Multiple Fathers: The Theory and Practice of Partible Paternity in Lowland South America. Stephen Beckerman and Paul Valentine, eds., pp. 221-245. Gainesville: University Press of Florida.

Journal Articles, Book Chapters, Review Articles.....cont'd

2001 Ecuador's Strategic Policies toward Indigenous Communities in Sensitive Border Areas. In Ethnicity and Governance in the Third World. John Mukum Mbaku, Pita Ogaba Agbese, and Mwangi S. Kimenyi, eds., pp. 195-211. Aldershot, United Kingdom: Ashgate Press.

1998 The Religious Ethnography of Lowland South America. Reviews in Anthropology 27(2):109-121.

1997 Stratégies de gestion des ressources par les Indiens Siona et Secoya. In L'Alimentation en forêt tropicale: interactions bioculturelles et perspectives de développement, Volume II, Bases culturelles des choix alimentaires et stratégies de développement. C.M. Hladik, A. Hladik, H. Pagezy, O.F. Linares, G.J.A. Koppert et A. Froment, eds., pp. 731-758. Paris: UNESCO.

1994a From Opportunism to Nascent Conservation: The Case of the Siona-Secoya. Human Nature 5(4):307-337.

1994b The Health Significance of Wild Plants for the Siona and Secoya. In Eating on the Wild Side: The Pharmacologic, Ecologic, and Social Implications of Using Noncultigens. Nina L. Etkin, ed., pp. 143-165. Tucson: The University of Arizona Press.

1994c Siona-Secoya. In Encyclopedia of World Cultures, Volume VII, South America. Johannes Wilbert, ed., pp. 306-309. Boston: G.K. Hall and Company.

1993a Changing Tropical Forest Resource Management Strategies among the Siona-Secoya Indians. In Tropical Forests, People and Food: Biocultural Interactions and Applications to Development. Man in the Biosphere vol. 13. C.M. Hladik, A. Hladik, O.F. Linares, H. Pagezy, A. Semple and M. Hadley, eds., pp. 463-478. Paris and London: UNESCO/The Parthenon Publishing Group.

1993b The Anthropology of Amazonia. Latin American Research Review 28(1):111-127.

1992a Las Religiones Siona-Secoya e Inka. In II Tomo de las Religiones Amerindias: 500 Años Después. Juan Bottasso, ed., pp. 185-199. Quito, Ecuador: Ediciones Abya-Yala.

1992b Rural Communities in South America: Recent Studies. Reviews in Anthropology 20:301-306.

1991 Hunting Yields and Game Composition over Ten Years in an Amazon Indian Territory. In Neotropical Wildlife Use and Conservation. J. G. Robinson and K. H. Redford, eds., pp. 53-81. Chicago: The University of Chicago Press.

Journal Articles, Book Chapters, Review Articles.....cont'd

1990 Siona-Secoya and Inca Religions: A Comparison of Sacred Systems in the Amazon and Andes. In Looking Through the Kaleidoscope: Essays in Honor of Charles Wagley. P.L. Magee and J. Wilson, eds., pp. 63-69. Florida Journal of Anthropology Special Publication No. 6. (Gainesville).

1989a Patterns of Foraging and Gardening in a Semisedentary Amazonian Community. In Farmers as Hunters: The Implications of Sedentism. Susan Kent, ed., pp. 46-59. Cambridge: Cambridge University Press.

1989b Traditional Concepts of Power among the Siona-Secoya and the Advent of the Nation-State. The Latin American Anthropology Review 1(2):55-60.

1989c Tecnología de Subsistencia Horticultura entre los Siona y Secoyas. Hombre y Ambiente 10:7-46. (Quito, Ecuador)

1989d A Martyred Environmentalist. Hemisphere 1(2):23-24.

1988a Game Depletion Hypothesis of Amazonian Adaptation: Data from a Native Community. Science 239:1521-1522.

1988b Processes and Problems of Land Demarcation for a Native Amazonian Community in Ecuador. Law and Anthropology, Internationales Jahrbuch für Rechtsanthropologie 3:203-245. (Vienna)

1988c La Dimensión Territorial de la Adaptación de los Siona-Secoya y los Encabellados. Hombre y Ambiente 6:53-94. (Quito, Ecuador)

1987a (with Raymond B. Hames) Teorias sobre las Respuestas Adaptivas de los Nativos de la Amazonía. Hombre y Ambiente 3:45-89. (Quito, Ecuador)

1987b Farewell to Amazonia? How to Invest in its Future. Caribbean Review 15(3):26-27, 38.

1986 Comment on Weights, Measurement, and Swidden. Culture and Agriculture 29:8-10.

1985 Ideación como Adaptación: Creencias Tradicionales y la Intervención Moderna en la Religión de los Siona-Secoya. En Amazonía Ecuatoriana: La Otra Cara del Progreso, Segunda Edición. Norman E. Whitten, Jr., ed., pp. 229-253. Quito, Ecuador: Ediciones Abya-Yala.

1984a The Faunal Components of Lowland South American Hunting Kills. Interciencia 9(6):366-376.

Journal Articles, Book Chapters, Review Articles.....cont'd

1984b Indian Policy in Amazonian Ecuador. In Frontier Expansion in Amazonia. Marianne Schmink and Charles Wood, eds., pp. 8-32. Gainesville: University of Florida Press.

1984c Relaciones Laborales entre Indios y Blancos en el Ecuador. Extracta de Cultural Survival Quarterly 2:22-25. Lima, Peru: Centro de Investigación y Promoción Amazónica.

1983a Tropical Forest Mimicry in Swiddens: A Reassessment of Geertz's Model with Amazonian Data. Human Ecology 11(1):35-45.

1983b Development and Amazonian Indians: The Aguarico Case and Some General Principles. In The Dilemma of Amazonian Development. Emilio F. Moran, ed., pp. 25-50. Boulder, Colorado: Westview Press.

1983c Indian-White Labor Relations in Amazonian Ecuador. Cultural Survival Quarterly 7(4):39-41.

1983d (with Raymond B. Hames) Introduction. In Adaptive Responses of Native Amazonians. Raymond B. Hames and William T. Vickers, eds., pp. 1-26. New York: Academic Press.

1983e The Territorial Dimensions of Siona-Secoya and Encabellado Adaptation. In Adaptive Responses of Native Amazonians. Raymond B. Hames and William T. Vickers, eds., pp. 451-478. New York: Academic Press.

1982a (with Raymond B. Hames) Optimal Diet Breadth Theory as a Model to Explain Variability in Amazonian Hunting. American Ethnologist 9(2):358-378.

1982b Informe Preliminar Sobre las Culturas Siona, Secoya y Cofán y su Situación de Tenencia de Tierra. In Informe para la Delimitación de Territorios Nativos Siona-Secoya, Cofán y Huaorani. Jorge Uquillas, ed. Quito, Ecuador: Ediciones INCRAE.

1981a Ideation as Adaptation: Traditional Belief and Modern Intervention in Siona-Secoya Religion. In Cultural Transformations and Ethnicity in Modern Ecuador. Norman E. Whitten, Jr., ed., pp. 705-730. Urbana: University of Illinois Press.

1981b The Jesuits and the SIL: External Policies for Ecuador's Tucanoans through Three Centuries. In Is God an American: An Anthropological Perspective on the Missionary Work of the Summer Institute of Linguistics. Søren Hvalkof and Peter Aaby, eds., pp. 50-61. Copenhagen and London: International Work Group for Indigenous Affairs and Survival International.

Journal Articles, Book Chapters, Review Articles.....cont'd

1980a Ethnological Methods, Results, and the Question of Advocacy in Andean Research. Latin American Research Review 15(3):229-239.

1980b An Analysis of Amazonian Hunting Yields as a Function of Settlement Age. In Studies in Hunting and Fishing in the Neotropics. Raymond B. Hames, ed. Working Papers on South American Indians 2:7-29.

1980c Die Jesuiten und das SIL: Aussenpolitik für Ecuadors Tucanoaner wahrend dreier Jahrhunderte. In Ist Gott Amerikaner. Søren Hvalkof und Peter Aaby, hrsg., pp. 113-134. Bornheim-Merton, West Germany: Lamuv Verlag.

1979a Native Amazonian Subsistence in Diverse Habitats: The Siona-Secoya of Ecuador. Studies in Third World Societies 7:6-36.

1979b Development Without Them. Caribbean Review 8(2):50-53.

1978a Social Science Education for Development: Chimera or Fait Accompli? In Social Science Education for Development. William T. Vickers and Glenn R. Howze, eds., pp. 1-17. Tuskegee Institute, Alabama: Tuskegee Institute Center for Rural Development.

1978b Comment on Food Taboos, Diet and Hunting Strategy: The Adaptation to Animals in Amazon Cultural Ecology, Eric Barry Ross. Current Anthropology 19(1):27.

1975a El Mundo Espiritual de los Sionas. Periplo 1(4):12-23. (Madrid)

1975b Meat is Meat: The Siona-Secoya and the Hunting Prowess-Sexual Reward Hypothesis. Latinamericanist 11(1):1-5. University of Florida Center for Latin American Studies.

1973 Environment, Production, and Subsistence: Economic Patterns in a Rural Otomi Community. In Ethnological Field Training in the Mezquital Valley, Mexico. Michael Kenney and H. Russell Bernard, eds., pp. 143-162. Washington, D.C.: The Catholic University of America.

1972 Indians, Oil, and Colonists: Contrasting Systems of Man-Land Relations in the Aguarico River Valley of Eastern Ecuador. Latinamericanist 8(2):1-3. University of Florida Center for Latin American Studies.

Book Reviews

2006 Review of The Ecology of Power: Culture, Place, and Personhood in the Southern Amazon, A.D. 1000-2000. Michael J. Heckenberger. American Anthropologist 108(3):593-594.

1999a Review of Floods of Fortune: Ecology and Economy along the Amazon. Michael Goulding, Nigel J.H. Smith, and Dennis J. Mahar. American Anthropologist 101(4):40-41.

1999b Review of Challenging Fronteras: Structuring Latina and Latino Lives in the U.S. Mary Romero, Pierrette Hondagneu-Sotelo, and Vilma Ortiz, eds. Ethnic and Racial Studies 22(6):1068-1069.

1994 Review of Native Society and Disease in Colonial Ecuador. Suzanne Austin Alchon. Medical Anthropology Quarterly 8(1):123-125.

1993 Review of Radical Ecology: The Search for a Livable World. Carolyn Merchant. American Anthropologist 95(3):783-784.

1992 Review of War of Shadows: The Struggle for Utopia in the Peruvian Amazon. Michael F. Brown and Eduardo Fernandez. Hispanic American Historical Review 72(4):614-615.

1990 Review of Indigenous Peoples and Tropical Forests: Models of Land Use and Management from Latin America, Jason W. Clay, Land Rights and Indigenous Peoples: The Role of the Inter-American Commission on Human Rights, Shelton H. Davis, and International Amazonia: Its Human Side, Yolanda Butts and Donald J. Bogue. American Anthropologist 92(4):1044-1045.

1989 Review of In the Eyes of the Beholder: Leadership and the Social Construction of Power and Dominance Among the Matsigenka of the Peruvian Amazon. Dan Rosengren. The Latin American Anthropology Review 1(2):70.

1988 Review of Rucuyaya Alonso y la Historia Social y Economica del Alto Napo, 1850-1950. Blanca Muratorio. Hispanic American Historial Review 68 (3):604-605.

1987 Review of The Archaeology of West and Northwest Mesoamerica. Michael S. Foster and Phil C. Weigand, eds. South Eastern Latin Americanist 30(3-4)43-44.

1984a Review of Fishers of Men or Founders of Empire: The Wycliffe Bible Translators in Latin America. David Stoll. American Ethnologist 11(1):200-201.

1984b Review of Aztec Art. Esther Pasztory. Caribbean Review 13(4):50-51.

Book Reviews.....cont'd

1981 Review of Peasants, Primitives, and Proletariats: The Struggle for Identity in South America, and Spirits, Shamans, and Stars: Perspectives from South America. David L. Browman and Ronald A. Schwartz, eds. American Ethnologist 8(2):398-400.

1980 Review of Village Society and Labor Use, Biplab Dasgupta, and Assessing Village Labor Situations in Developing Countries, John Connell and Michael Lipton. American Anthropologist 82(1):167.

1977 Review of The Shaman and the Jaguar: A Study of Narcotic Drugs Among the Indians of Colombia. Gerardo Reichel-Dolmatoff. Hispanic American Historical Review 57(2):370-371.

Publications in Popular Media

1993 The Other Side of Brazil's Gold Mines (letter to the editor). The Miami Herald Saturday, October 2, 1993:26A.

1991 A Secoya Shaman of the Northwest Amazon. Nature Conservancy 41(1): cover photograph.

1990 Looking for Indians. The Sociology-Anthropology Maxi-Journal 3:77-80. (Miami)

1986 Ecuador: A Country of Varied Faces, Cultures. International Herald-Tribune Tuesday, January 28, 1986:7, 9. (Paris)

1978a The Politics of Economic Non-Growth: Kaminsky's Views Won't Do. The Sentinel December 12, 1978:3. (Miami)

1978b Indians on the Amazon (letter to the editor). Time February 13, 1978:1. (Foreign Editions)

1977 Family Types Differ (guest editorial). The Auburn-Opelika News Tuesday, February 1, 1977:4. (Opelika, Alabama).

Papers Presented:

2009 Ecuador =s History and Strategic Culture. Paper presented to the Ecuador Strategic Culture Workshop. Applied Research Center and Latin American and Caribbean Center, Florida International University, Miami, Florida (November 5).

Papers Presented.....cont'd

2005 The Issue of People in Parks: Current Debates and Some Ecuadorian Cases. Paper presented to the Florida International University Conference entitled AIndigenous Rights and the Environment in Latin America,≅ Miami, Florida (April 18).

2001 Discourses on Contact and Development from the Encabellado Homeland. Paper presented to the 2001 Annual Meeting of the American Society for Ethnohistory, Tucson, Arizona (October 18).

1998a Development-Related Changes in Native Amazonian Diets and their Potential Health Effects. Paper presented to the 97th Annual Meeting of the American Anthropological Association, Philadelphia, Pennsylvania (December 4).

1998b Big Oil versus Indians in the Upper Amazon: The Ecuadorian Case. Presentation to the Stanford University Crossroads Conference entitled "Culture, Ecology, and Conservation in Amazonia," Palo Alto, California (November 12).

1998c The Structure and Meaning of Siona-Secoya Gardens: A Diversity of Cultivars for Body and Soul. Presentation to the Stanford University Department of Anthropological Sciences Workshop entitled, "Comparative Ecology of Swiddens," Palo Alto, California (November 14).

1998d Environmental Impacts of Oil Development in the Siona-Secoya Territory. Presentation to La Casa de la Cultura forum entitled, "Analysis of the Occidental Petroleum-Secoya Negotiations in the Light of Ecuador's New Constitution," Quito, Ecuador (October 16).

1998e Ecuador's Strategic Policies toward Indigenous Communities in Sensitive Border Areas. Paper presented to the XXI International Congress of the Latin American Studies Association, Chicago, Illinois (September 26).

1997a The Slippery Slope: Oil Corporations and Indigenous Politics in Northeastern Ecuador. Paper presented to the 96th Annual Meeting of the American Anthropological Association, Washington, D.C. (November 19).

1997b Oil Development and Native People in Ecuador. Paper presented to the 9th Annual International Conference of the Society for Ecological Restoration, Fort Lauderdale, Florida (November 13).

1997c Sexual Theory, Behavior, and Paternity among the Siona-Secoya of Eastern Ecuador. Paper presented to the 49th International Congress of Americanists, Quito, Ecuador (July 9).

Papers Presented.....cont'd

1997d The New Invaders: Siona-Secoya Responses to Thirty Years of Tourism. Paper presented to the XX International Congress of the Latin American Studies Association, Guadalajara, Mexico (April 18).

1995 Políticas militares hacia los indígenas del Oriente Ecuatoriano: Un doble modelo de la presencia del estado. Presentation to the "Grupos étnicos en la frontera" International Roundtable Seminar, Pontificia Universidad Católica del Ecuador, Quito, Ecuador (March 18).

1994a Cambios sociales y económicos en la Amazonía Ecuatoriana: La nueva organización política de los Sionas y Secoyas en la sociedad fronteriza. Presentation to the Interamerican Studies Seminar, Pontificia Universidad Católica del Ecuador, Quito, Ecuador (November 15).

1994b La etnobotánica de los Sionas y Secoyas: El significado del yagé o ayahuasca (Banisteriopsis caapi). Presentation to the Interamerican Studies Seminar, Pontificia Universidad Católica del Ecuador, Quito, Ecuador (November 10).

1994c Cambios en la cultura Siona-Secoya. Presentation to a public conference of the Facultad Latinoamericana de Ciencias Sociales (FLACSO), Quito, Ecuador (November 9).

1994d La cultura de los Sionas y Secoyas del Nororiente Ecuatoriano. Presentation to the Interamerican Studies Seminar, Pontificia Universidad Católica del Ecuador, Quito, Ecuador (November 8).

1994e Cultural Survival and Resistance in the Upper Amazon. Presentation to a public conference of the Institute for Science and Interdisciplinary Studies, Hampshire College, Amherst, Massachusetts (August 30).

1993 From Opportunism to Nascent Conservation: The Case of the Siona-Secoya. Paper presented to the 92nd Annual Meeting of the American Anthropological Association, Washington, D.C. (November 19).

1991a The Health Significance of Wild Plants to the Siona and Secoya Indians, Northwest Amazon. Paper presented at the 90th Annual Meeting of the American Anthropological Association, Chicago, Illinois (November 23).

1991b Changing Strategies of Tropical Forest Resource Management among the Siona-Secoya Indians. Paper presented to the UNESCO Symposium, "Food and Nutrition in the Tropical Forest: Biocultural Interactions and Applications to Development," Paris, France (September 13).

Papers Presented.....cont'd

1990 The Sinangöe Kofán: The Case of a Park and a People. Paper presented at the 89th Annual Meeting of the American Anthropological Association, New Orleans, Louisiana (November 30).

1989 Traditional Concepts of Power Among the Siona-Secoya and the Advent of the Nation-State. Paper presented to the XV International Congress of the Latin American Studies Association, Miami, Florida (December 4).

1988 Indigenous People and Parks in Amazonian Ecuador. Presentation to the international conference entitled "Tropical Rainforests: Strategies for Wise Management," Florida International University, Miami (January 29).

1987a Hunting Yields and Game Composition in an Amazon Indian Territory. Paper presented to the Neotropical Wildlife Symposium, Program for Studies in Tropical Conservation, University of Florida, Gainesville (December 8).

1987b Ten-Year Hunting Yield Trends in a Native Amazonian Community. Paper presented at the 86th Annual Meeting of the American Anthropological Association, Chicago, Illinois (November 18).

1985a The Magical Plants of the Siona and Secoya Peoples, Northwest Amazon. Presentation to the Anthropology Colloquium, School of American Research, Santa Fe, New Mexico (November 20).

1985b Economic and Ritual Use of Plants by the Siona and Secoya Indians of the Northwest Amazon. Presentation to the Fairchild Tropical Garden Research Seminar, Miami, Florida (March 19).

1985c Geopolitics, Border Effects, and Cultural Refugia: Problems the Siona and Secoya Never Asked For. Presentation to the Latin American Colloquium, Center for Latin American Studies, University of Florida, Gainesville (January 24).

1984a Andean and Amazonian Religion: Shared Concepts, Differential Elaboration, and the Consequences of the Conquest. Paper presented at the 83rd Annual Meeting of the American Anthropological Association, Denver, Colorado (November 17).

1984b Investigaciones antropológicos entre los Secoyas del Ecuador y Perú. Presentation to the Anthropology Colloquium, Sección de Antropología, Universidad Nacional Mayor de San Marcos, Lima, Peru (August 23).

Papers Presented.....cont'd

1984c La situación actual de los Sionas y Secoyas en Ecuador y Perú. Presentation to the Anthropology Colloquium, Centro Amazónico de Antropología y Aplicación Práctica, Lima, Peru (August 22).

1982 Perspectives on Indian Policy in Amazonian Ecuador. Paper presented at the 31st Annual Conference of the Center for Latin American Studies, University of Florida, Gainesville (February 8).

Abstracted in Latinamericanist 17(3):1. (1982)

1980a Tropical Forest Mimicry in Swiddens. Paper presented at the 79th Annual Meeting of the American Anthropological Association, Washington, D.C. (December 6).

1980b Agricultural Development and Ecological Change in Amazonian Ecuador. Paper presented at the Annual Meeting of the Latin American Studies Association, Bloomington, Indiana (October 18).

1979a Sex Roles and Social Change in Amazonian Ecuador. Paper presented at the 78th Annual Meeting of the American Anthropological Association, Cincinnati, Ohio (December 1).

1979b An Analysis of Amazonian Hunting Yields as a Function of Settlement Age. Paper presented at the XLII International Congress of Americanists, Vancouver, British Columbia, Canada (August 13).

1978a Witchcraft and Warfare in the Ecology of a Northwest Amazon Culture. Paper presented at the 77th Annual Meeting of the American Anthropological Association, Los Angeles, California (November 18).

1978b Social Science Education for Development: Chimera or Fait Accompli? Paper presented at the 1978 Annual Meeting of the Society for Applied Anthropology, Merida, Yucatan, Mexico (April 3-8).

1977 External Models and Native Adaptations: Missionaries and Tropical Forest Indians in Ecuador. Paper presented at the 76th Annual Meeting of the American Anthropological Association, Houston, Texas (December 1).

Abstracted in Boletín de Antropología Ecuatoriana 4:11. Quito: Pontificia Universidad Católica. (1978)

Papers Presented.....cont’d

1976a Native Amazonian Subsistence in a Changing Habitat: The Siona-Secoya of Ecuador. Paper presented at the 75th Annual Meeting of the American Anthropological Association, Washington, D.C. (November 18).

1976b The Tribal Hallucinogens of Lowland Ecuador: External Policy Versus Native Structure. Paper presented at the Annual Meeting of the Latin American Studies Association, Atlanta, Georgia (March 28).

Abstracted in <u>The Ethno-Pharmacology Society Newsletter</u> 1(4):6-7. (1978)

1975a Problems of Research in Latin America: The Ecuadorian Case. Paper and documents presented to a special workshop of the American Anthropological Association on "Problems of Research in Latin America," San Francisco, California (December 2).

1975b Hallucinogens and Witchcraft Among the Siona-Secoya. Conference and film presented to the Latin American Colloquium, Center for Latin American Studies, University of Florida (May 28).

1975c Visiones del yagé: El mundo espiritual del los Sionas y Secoyas. Presentation to a public conference of the Instituto Nacional de Antropología y Historia, Quito, Ecuador (April 1).

<u>Discussantships and Sessions Organized</u>:

2008 Invited discussant for the panel entitled ASymbolic Affinities, Pragmatic Engagements: Shaping Latin American Ethnology Through the Collaborative Work of Norman and Dorothea Scott Whitten: Part 2≅ at the 107th Annual Meeting of the American Anthropological Association, San Francisco, California (November 23).

2005 Invited discussant for the panel entitled AAboriginal Hunting and the Original State of Nature: Were Amerindian Harvests Sustainable?≅ at the 104th Annual Meeting of the American Anthropological Association, Washington, D.C. (December 3).

2000a Invited discussant for the panel entitled "Ethnobotany Goes Public: 'Herbal Remedies' in an Anthropological Context" at the 99th Annual Meeting of the American Anthropological Association, San Francisco, California (November 18).

2000b Invited discussant for the panel entitled "Ecotourism and Sustainability: Cooperation for the New Millennium" at the XXII International Congress of the Latin American Studies

Association, Miami, Florida (March 17).

Discussantships and Sessions Organized.....cont'd

1998 Organized five panels (and evaluated 26 panels and 19 travel funding proposals) as Chair of the Environment Section of the XXI International Congress of the Latin American Studies Association, Chicago, Illinois (September 24-26).

1995 Organized symposium and reception in honor of Secoya leaders Elias Piyahuaje and Isolina Siquihua at Florida International University, Miami (November 1)

1990 Invited respondent for the conference entitled, "Economic Catalysts to Ecological Change," at the 39th Annual Conference of the Center for Latin American Studies, University of Florida, Gainesville (February 9-10).

1988a Organized the panel entitled "People of the Forest" (with participation by Dr. Darrell A. Posey and Kayapó leaders Payaka and Kube-i) at the international conference entitled "Tropical Rainforests: Strategies for Wise Management," Florida International University, Miami (Jan 29).

1988b Invited moderator for the panel entitled, "Indigenous Reserves and Rainforest Conservation," at the international conference entitled "Tropical Rainforests: Strategies for Wise Management," Florida International University, Miami (January 29).

1987 Invited discussant for the panel entitled, "Conflict and Compromise: Perspectives on the Practice of Anthropology," at the 86th Annual Meeting of the American Anthropological Association, Chicago, Illinois (November 21).

1985 Invited discussant for the International Workshop on Comparative Development in the Amazon, Lima, Peru (May 27-29).

1982 Invited discussant for the exhibition entitled, "Nineteenth Century Photographs of Latin America and Latin American Life" (photographs collected by H.L. Hoffenberg), Lowe Art Museum, University of Miami, Miami, Florida (November 4).

1979a Invited discussant for the panel entitled, "Cooperatives and Collectives," at the 78th Annual Meeting of the American Anthropological Association, Cincinnati, Ohio (December 1).

1979b Invited discussant for a presentation by Dr. Walter Goldschmidt on, "Origins of the Future," Broward Community College. Sponsored by the Florida Endowment for the Humanities (May 30).

Discussantships and Sessions Organized.....cont'd

1978 Organized the panel entitled "Social Science Education for Regional Development" for the 1978 Annual Meeting of the Society for Applied Anthropology, Merida, Yucatan, Mexico (April 3-8).

1977 Invited discussant for the film, "The Sound of Rushing Water," at the Annual Meeting of the Southeastern Conference of Latin American Studies, Tuskegee, Alabama (April 23).

Research:

1998-00 Field research on the negotiations between the Occidental Petroleum Corporation and the Secoya Indians of eastern Ecuador concerning the exploration for oil on native lands.

1997 Field research among the Siona and Secoya Indians of eastern Ecuador, with emphasis on native responses to frontier development (March, July).

1996 Field research among the Siona and Secoya Indians of eastern Ecuador, with emphasis on the evolution of native communal organizations (June-July).

1995 Field research on the situation of the Shuar Indians during the Peru-Ecuador border war in collaboration with the Pontificia Universidad Católica del Ecuador (March).

1994 Field research among the Siona and Secoya Indians of eastern Ecuador, with emphasis on native communal organizations and frontier development (September-December).

1990-91 Field research among Siona and Secoya Indians of eastern Ecuador, including census (December-January).

1985-91 Analysis of large data base on Amazonian human ecology, with emphasis on resource use patterns and sustainablility.

1984 Comparative Human Ecology of the Secoya Indians of Peru in collaboration 1984 the Instituto de Investigaciones de la Amazonía Peruana (IIAP) and the Zona Agraria XXII of Peru's Ministry of Agriculture (July-August).

1980 Native Lands Demarcation Project in collaboration with Cultural Survival, Inc., Cambridge, Mass., and the National Institute for Agrarian Reform and Colonization, the National Forestry Institute, and the National Institute for the Colonization of the Amazon Region of Ecuador (June-September).

Research.....cont'd

1979 Field research project entitled, "Cultural and Ecological Adaptation in the Amazon," in eastern Ecuador (June-August).

1977 Chair of Research Committee for Tuskegee Institute-U.S. Agency for International Development 211(d) grant entitled, "Comprehensive Planning for Rural Development." (Funded in amount of $750,000)

1973-75 Dissertation research on the human ecology of the Siona-Secoya Indians of Ecuador.

1972 Ethnographic survey of the Aguarico River of Ecuador in cooperation with the National Institute of Anthropology and History of Ecuador (May-September).

1971 Studies on the economic patterns and human ecology of an Otomi Indian community of the Mezquital Valley, Hidalgo, Mexico (June-August).

Honors:

Grants and Fellowships

1998a Travel Grant, Department of Anthropological Sciences, Stanford University, Palo Alto, California

1998b Research and Travel Grant, Institute for Science and Interdisciplinary Studies, Amherst, Massachusetts and La Casa de la Cultura, Quito, Ecuador

1997 Research and Travel Grant, Institute for Science and Interdisciplinary Studies, Amherst, Massachusetts

1995 Research and Travel Grant, Pontificia Universidad Católica, Quito, Ecuador

1994a Fulbright Scholar award for research project "Five Hundred Years of Survival and Adaptation: The Cultural History of the Encabellado Indians of Ecuador"

1994b Travel Grant, Institute for Science and Interdisciplinary Studies, Amherst, Massachusetts

1993 Fellowship, National Science Foundation Chautauqua Short Course, Temple University

1991 Travel Grant, Man in the Biosphere Program, UNESCO

1988	Faculty Research Fellowship, Center for Multilingual and Multicultural Studies, Florida International University

Grants and Fellowships.....cont'd

1985-86	National Endowment for the Humanities Fellowship for sabbatical research, School of American Research, Santa Fe, New Mexico
1984a	Florida International University Foundation Fellowship for summer research in Peru
1984b	Small grant from the Amazon Research and Training Program, University of Florida for research in Peru
1984c	Faculty Research Grant from the Latin America and Caribbean Center, Florida International University for summer research in Peru
1980a	Cultural Survival, Inc. grant for research on native lands demarcation in Ecuador
1980b	Faculty Research Grant from the Latin America and Caribbean Center, Florida International University, for research on development policies in Ecuador
1979a	Florida International University Foundation Fellowship for research on the human ecology of the Siona-Secoya Indians of Ecuador
1979b	Faculty Research Grant from the Latin America and Caribbean Center, Florida International University, for research on the human ecology of the Siona-Secoya Indians of Ecuador
1978-79	College of Arts and Sciences Faculty Development Grant, Florida International University, for the preparation of ethnographic materials for the Museum of the Central Bank, Ecuador
1975-76	National Institute of Mental Health Research Fellowship for research on the medical system of the Siona and Secoya Indians, Ecuador
1973-74	Doherty Fellowship for Advanced Study in Latin America, Princeton University, for dissertation research on human ecology of Siona-Secoya Indians, Ecuador
1973	Awarded Fulbright-Hayes Doctoral Research Abroad Fellowship (declined in favor of Doherty Fellowship)
1971-73	NDEA Title IV Fellowship for graduate studies

1971 National Science Foundation Fellowship for study and research in Mexico

Other Honors

1999 PEP Award (for sustained excellence as a professor), State University System of Florida
1997 TIP Award (for teaching excellence), State University System of Florida
1990 Outstanding Achievement and Performance Award, Florida International University
1976 Phi Beta Kappa (honor society)
1976 Phi Kappa Phi (honor society)
1971 Honors, Master's Comprehensive Examination
1967 Psi Chi (honor society in psychology)

Languages:

English (fluent)
Spanish (excellent speaking and reading abilities, good writing ability)
Portuguese(good reading ability, fair speaking ability)
German (fair reading ability)
Siona-Secoya (fair speaking ability)

Professional Organizations:

Fellow, American Anthropological Association
Fellow, Society for Applied Anthropology
Member, American Association for the Advancement of Science
Member, American Ethnological Society
Member, Latin American Studies Association
Member, South Eastern Council on Latin American Studies
Member, Southern Anthropological Society
Associate, Current Anthropology

Areas of Major Research Interest:

Human Ecology (emphasis on human subsistence systems and natural resource use)
The Social Contexts of Development and Modernization
Latin American Ethnology (emphasis on Amazon and Andes)
Tribal and Peasant Societies
Human Aggression and Warfare
Theoretical Anthropology

Courses Taught:

Introduction to Anthropology, Introduction to Sociology, Introduction to Latin America, Anthropological Theories, Research Methods, Cultural Ecology, Comparative Cultures of Latin America, Ecological Anthropology, Explorations in Visual Anthropology, Graduate Colloquium in Comparative Sociology, Man in the Amazon, Peasant Societies, Applied Anthropology, Culture and Personality, The Anthropology of Warfare and Violence, Seminar in International Development, Seminar on Latin America, Environmental Studies Colloquium.

Dissertation and Thesis Committees:

Chair, Ph.D. dissertation committees	2
Member, Ph.D. dissertation committees	7
Chair, M.A. thesis committees	3
Member, M.A. thesis committees	16

Academic Service:

Chairperson, Department of Sociology and Anthropology, FIU (1982-85)
Graduate Director, Department of Sociology and Anthropology, FIU (1988-91)
Advisory Council, Latin America and Caribbean Center, FIU (1978-2004)
Charter Member, FIU Phi Beta Kappa Chapter (Epsilon of Florida), FIU (2000-2001)
Member, Constitution and Bylaws Committee, Phi Beta Kappa Chapter, FIU (2000-2001)
Chairperson, Departmental Personnel Committee, FIU (2000-2001)
Member, Graduate Program Committee, Department of Sociology and Anthropology, FIU (1991-2004)
Member, Graduate Program Committee, Latin America and Caribbean Center, FIU (1997-2004)
Affiliated Faculty Member, Environmental Studies Department, FIU (1995-2004)
Advisory Council, Environmental Studies Program, FIU (1980-1995)
Program Chair, Environment Section, XXI International Congress of the Latin American Studies Association, Chicago, Illinois (1998)
Associate Editor, Caribbean Review (1986-1990)
Contributing Editor, Caribbean Review (1978-82)
Faculty Senate, FIU (1979-81)
Provost's Ad Hoc Committee to Investigate an Allegation of Faculty Academic Misconduct, FIU (1992)
Provost's Search and Screen Committee for Director of the Center for Multilingual and Multicultural Studies, FIU (1990)
Dean's Graduate Program Review Committee for the Department of Economics, FIU (1993-94)
Dean's Selection Committee for College of Arts and Sciences Faculty Development Grants, FIU

(1984-85)
Dean's Ad Hoc Advisory Group on Multilingual-Multicultural Center, FIU (1980)
Member, Foreign Language and Area Studies Advisory Board (FLAS), FIU (1998-2000)

Academic Service.....cont'd

College of Arts and Sciences Budget Committee, FIU (1978-81)
Chairperson, Departmental Faculty Advancement and Recruitment Committee, FIU (1993-94; 1986-87)
Chairperson, Departmental Ad Hoc Teaching Merit Criteria Committee, FIU (1999-2000)
Member, Departmental Personnel Committee, FIU (1999-2000)
Member, Departmental Ad Hoc Service Merit Criteria Committee, FIU (1999-2000)
Member, Chairperson's Nomination Committee, FIU (2000)
Member, Departmental Ad Hoc Recruitment Committee, FIU (1996-97)
Member, Departmental Faculty Advancement and Recruitment Committee, FIU (1995-96; 1992-93; 1978-79)
Chairperson, Departmental Curriculum Committee, FIU (1988-90; 1979-80)
Member, Special Departmental Committee on Faculty Assignment and Evaluation, FIU (1995-96)
Departmental Task Force on Undergraduate Course Scheduling, FIU (1993)
Search and Screen Committee, Environmental Studies Program, FIU (1996-97; 1990-91)
Advisory and Planning Committee for the international conference entitled, "Tropical Rainforests: Strategies for Wise Management," Florida International University (January 27-31, 1988)
Curriculum Development Project in Latin American Studies, FIU (1979)
Assisted FIU's Center for Labor Research design a study on manpower requirements in Dade and Broward counties (1979)
Helped prepare a proposal that was successful in winning NDEA Title VI funding for the Latin America and Caribbean Studies Center, FIU (1979)
Library Coordinator for the Latin American and Caribbean Studies Center, FIU (1978-79)
Chairperson, Departmental Search Committee, Tuskegee Institute (1977-78)
Chairperson, Departmental Self-Study Committee, Tuskegee Institute (1977-78)
Local Arrangements Committee for the 1978 Annual Meeting of the Southeastern Conference of Latin American Studies, Tuskegee Institute

Referee and Reviewer for Advances in Economic Botany, American Anthropologist, American Ethnologist, Antropológica, BioScience, Biotropica, Conservation Biology, Current Anthropology, Ethnohistory, Human Ecology, Human Organization, Interciencia, Journal of Ecological Anthropology, Journal of Ethnobiology, Journal of Forest History, Journal of Latin American Anthropology, Latin American Research Review, Medical Anthropology Quarterly, Science, Social Science and Medicine, The Florida Scientist, Urban Anthropology, Columbia University Press, Harcourt-Brace Publishers, School of American Research Press, Summer Institute of Linguistics Press, University of Arizona Press, University of Florida Press, University of Iowa Press, Charles A. Lindbergh Fund, Council for the International Exchange of Scholars (Fulbright Fellowships), Council on International Education, Idaho Board of Education Fellowships, L.S.B. Leakey Foundation, National Endowment for the Humanities, National

Geographic Society Committee for Research and Exploration, National Science Foundation, Social Science Research Council, U.S. "Man and the Biosphere" Program, Weatherhead Foundation, Wenner-Gren Foundation, Wildlife Conservation International.

Community Service:

President, The Siona-Secoya Foundation, Inc., a tax-exempt charitable organization for the support of educational and self-help projects in the Siona and Secoya communities of Ecuador, Peru, and Colombia. The Foundation has supported an oral history and textbook project, a medical assistance program, a bridge construction project, a museum exhibition for a Secoya artist, and supplied tools, computers, printers, and typewriters for community projects and tribal organizations (1994-present)

International observer for the negotiations between the Organización Indígena Secoya del Ecuador (OISE) and the Occidental Exploration and Production Company concerning the exploration for oil on native lands in eastern Ecuador, including authorship of a report entitled "Report on the Negotiations between the Secoya People of Ecuador and the Occidental Exploration and Production Company" (1998-2000)

Consultant to the Secoya Survival Project, Institute for Science and Interdisciplinary Studies, Amherst, Massachusetts (1996-2000)

Consultant to the Miami Museum of Science for its exhibition entitled, "Tribal Spirits: Indians of the Americas" (1998)

Consultant to the Earth Trust Foundation, Malibu, California, concerning the prospects for establishing an ocelot and margay reserve in eastern Ecuador (1997)

Member, Specialist Group on the Sustainable Use of Wild Species, Species Survival Commission, World Conservation Union (IUCN) [1992-95]

Consultant for Sierra Club Legal Defense Fund study of Conoco Ecuador Ltd.'s operational plans for road construction and oil drilling in the "Block 16" tract, including authorship of a social and environmental impact assessment entitled, "Declaration Concerning the Planned Road Construction through the Yasuni National Park and Huaorani Indian Territory" (1990)

Consultant to the American Museum of Natural History, New York for a permanent exhibit on manioc (Manihot esculenta Crantz) cultivation in the Hall of South American Peoples (1985)

Prepared four slide programs (with text) on various aspects of Amazonia (ecology, native adaptations, colonization, and the activities of multinational corporations) for the University of Illinois Library, Urbana (1982-83).

Consultant on native land demarcation for the Siona, Secoya, and Kofán peoples (and the management policies of the Cayambe-Coca National Park) to Ecuador's Ministry of Agriculture, Institute of Agrarian Reform and Colonization, Office of Forestry Development, Institute for Colonization of Ecuador's Amazon Region, and Cultural Survival, Inc. (1980-81).

Community Service.....cont'd

Prepared a photographic archive and interpretive text on Siona-Secoya culture for the National Institute of Anthropology and History of Ecuador (1978-79).

Invited participant in the "Amazonia: Extinction or Survival?" Symposium, University of Wisconsin, Madison and assisted in the formulation of policy recommendations that were forwarded to the Subcommittee on International Development of the Committee on International Relations, U.S. House of Representatives (1978).

Numerous public presentations on various anthropological topics (anthropology as a profession, the teaching of anthropology, indigenous rights, Latin America, tropical ecology, conservation) at high schools, community colleges, universities, conservation organizations, senior citizen's groups, etc.; various radio, television, and press interviews.

<u>Employment</u>:

2004-present	Professor Emeritus of Anthropology Department of Sociology and Anthropology Florida International University, Miami
1989-04	Professor of Anthropology Department of Sociology and Anthropology Florida International University, Miami
1981-89	Associate Professor of Anthropology Department of Sociology and Anthropology Florida International University, Miami
1982-85	Chairperson Department of Sociology and Anthropology Florida International University, Miami
1978-81	Assistant Professor of Anthropology Department of Sociology and Anthropology Florida International University, Miami
1976-78	Assistant Professor of Anthropology Department of Sociology Tuskegee Institute, Tuskegee, Alabama

Employment.....cont'd

1970-71	Graduate Research Assistant Department of Anthropology University of Florida, Gainesville
1967-69	Social Work Specialist U.S. Army Hospital Hunter Army Airfield, Savannah, Georgia
1963-65	Peace Corps volunteer Ecuador

References:

Dr. Robert L. Carneiro, Curator of Anthropology
American Museum of Natural History
Central Park West at 79th Street
New York, New York 10024 Tel. (212) 769-5375

Dr. John G. Robinson
International Programs
Wildlife Conservation Society
185th Street and Southern Boulevard
Bronx, New York 10460 Tel. (718) 220-5100

Dr. David Lee, Professor
Department of Biological Sciences
Florida International University
Miami, Florida 33199 Tel (305) 348-3111

Dr. Alex Stepick, Professor
Department of Sociology and Anthropology
Florida International University
Miami, Florida 33199 Office (305) 348-2247
Home (305) 665-3280

Annex 5

APPENDIX 3

Curriculum Vitae of Michael Cepek, Ph.D.

Annex 5

Michael Lewis Cepek

Assistant Professor

Department of Anthropology
University of Texas at San Antonio
One UTSA Circle
San Antonio TX 78249-0649
USA

E-mail: michael.cepek@utsa.edu

Office phone: (210) 458-5700

Fax: (210) 458-7811

Cell phone: (708) 334-9351

EDUCATION

2006: Ph.D., University of Chicago, Department of Anthropology. *The Cofán Experiment: Expanding an Indigenous Amazonian World*.

1999: M.A., University of Chicago, Department of Anthropology. *The Amazonian Struggle for Territory: Environment, Way of Life, and the Indigenous-Environmentalist Alliance*.

1996: B.A., University of Illinois at Urbana-Champaign, Department of Anthropology. *Reorganization and Resistance: Petroleum, Conservation, and Cofán Transformations.*

FELLOWSHIPS AND HONORS

2007 – present: Fellow of the Division of Environment, Culture, and Conservation, Field Museum of Natural History.

2007: Winner of the University of Chicago Department of Anthropology's *Sol Tax Dissertation Prize* (annual award for the dissertation that best "combines highest intellectual merit with relevance to anthropology and action").

2006 – 2007: Andrew W. Mellon Postdoctoral Fellow, Macalester College.

2004 – 2005: Charlotte W. Newcombe Doctoral Dissertation Fellow, Woodrow Wilson Foundation.

2003: Mark Hannah Watkins Post-Field Fellow, University of Chicago.

1997 – 2003: Century Fellow, University of Chicago.

1997 – 2000: National Science Foundation Graduate Research Fellow.

1996: Graduated Summa Cum Laude, with University Honors, with Highest Department Distinction, University of Illinois at Urbana-Champaign.

1996: Patricia O'Brien Award for Best B.A. Thesis in Anthropology, University of Illinois at Urbana-Champaign.

1992 - 1996: Phi Beta Kappa Honor Society, Chancellor's Scholar (Campus Honors Program), Cohn Scholars Honors Program, Roger W. Rogers Scholar, Edmund J. James Scholar, Golden Key Honor Society, Alpha Lambda Delta Honor Society, Phi Eta Sigma Honor Society, University of Illinois at Urbana-Champaign.

PEER-REVIEWED PUBLICATIONS

In preparation. Invited review essay on *Mobility and Migration in Indigenous Amazonia* (Miguel Alexiades, ed.), *Customizing Indigeneity: Paths to a Visionary Politics in Peru* (Shane Greene), *Of Passionate Curves and Desirable Cadences: Themes on Waiwai Social Being* (George Mentore), and *Strange Enemies: Indigenous Agency and Scenes of Encounter in Amazonia* (Aparecida Vilaca). *Journal of Latin American and Caribbean Anthropology*.

Submitted for review: "The Loss of Oil: Constituting Disaster in Amazonian Ecuador." For a special volume on "Discourses of Loss in Amazonia." *Journal of Latin American and Caribbean Anthropology*.

Submitted and accepted by volume editors: "A White Face for the Cofán Nation?: Randy Borman and the Ambivalence of Indigeneity." To be published in an edited volume along with other invited papers from "Performing Indigeneity: Historic and Contemporary Displays of Indigeneity in Public Spaces," a workshop at the University of Iowa, 2009.

Under advance contract and out for review. *A Possible Forest: Identity, Environment, and the Cofán Experiment*, a book manuscript. University of Texas Press.

In press: "Foucault in the Forest: Questioning Environmentality in Amazonia." *American Ethnologist* 38(2).

2009: "The Myth of the *Gringo* Chief: Amazonian Messiahs and the Power of Immediacy." *Identities: Global Studies in Culture and Power* 16(2):227-248.

2008: "Bold Jaguars and Unsuspecting Monkeys: The Value of Fearlessness in Cofán Politics." *Journal of the Royal Anthropological Institute* 14:331-349.

2008: "Essential Commitments: Identity and the Politics of Cofán Conservation." *Journal of Latin American and Caribbean Anthropology* 13(1):196-222.

1999: "Nature, Value, and Rent: Fernando Coronil's *The Magical State*." *The Chicago Anthropology Exchange* 29:51-66.

OTHER PUBLICATIONS

In press: "The Cofán." *Native Peoples of the World: An Encyclopedia.* Mesa Verde Publishing.

2010: "Can Nature be Governed?: Design, Practice, and Power in Environmental Conservation." Invited review essay on *Virtualism, Governance and Practice: Vision and Execution in Environmental Conservation* (James G. Carrier and Paige West, editors) and *Green Encounters: Shaping and Contesting Environmentalism in Costa Rica* (Luis A. Vivanco). *Focaal: European Journal of Anthropology* 58:131-134.

2010: Review of *Vital Enemies: Slavery, Predation, and the Amerindian Political Economy of Life* (Fernando Santos-Granero). *Bulletin of Latin American Research*.

2008: Review of *Puyo Runa: Imagery and Power in Modern Amazonia* (Norman E. Whitten, Jr., and Dorothea Scott Whitten). *Anthropological Quarterly* 81(3):733-735.

2008: Review of *I Foresee My Life: The Ritual Performance of Autobiography in an Amazonian Community* (Suzanne Oakdale). *Journal of Anthropological Research* 64(1):93.

2005: Review of *Crude Chronicles: Indigenous Politics, Multinational Oil, and Neoliberalism in Ecuador* (Suzana Sawyer). *Tipití: Journal of the Society for the Anthropology of Lowland South America* 3(1):79-82.

2001: (with Roberto Aguinda, Felipe Borman, and Hugo Lucitante) A'ingae introduction for *RBI 03: Ecuador: Serranías Cofán—Bermejo, Sinangoe*, Field Museum of Natural History/Fundación para la Sobrevivencia del Pueblo Cofán/Federación Indígena de la Nacionalidad Cofán del Ecuador.

PAPERS PRESENTED

2010: "Circulating Disaster: Oil and the Political Life of 'Destruction' in Contemporary Ecuador." Annual Meeting of the American Anthropological Association, New Orleans, LA.

2010: "The Cofán Experiment." Workshop on Society, Culture, and Environment, University of Texas, San Antonio, TX.

2010: "Reclaiming Amazonia's Indigenous-Environmentalist Alliance? Pressing Questions and Possible Responses." Invited paper delivered at the Sixth Sesquiannual Meeting of the Society for the Anthropology of Lowland South America, San Antonio, TX.

2009: "Oil as End and Opening: The Questionable Constitution of Disaster in Amazonian Ecuador." Annual Meeting of the American Anthropological Association, Philadelphia, PA.

2009: "Foucault in the Forest: Questioning Environmentality in Amazonia." Workshop on Society, Culture, and Environment, University of Texas, San Antonio, TX.

2009: "A White Face for the Cofán Nation?: Representation, Indigeneity, and the Peculiar Case of Randy Borman." Invited paper delivered at "Performing Indigeneity: Historic and Contemporary Displays of Indigeneity in Public Spaces," a conference at the University of Iowa, Iowa City, IA.

2009: "Manuela Carneiro da Cunha: Scholar, Mentor, Friend." Invited paper delivered at the Retirement Gala for Manuela Carneiro da Cunha. University of Chicago, Chicago, IL.

2008: "Imagining the Universal: Creation and Destruction in Shamanic Practice." Annual Meeting of the American Anthropological Association, San Francisco, CA.

2008: "Lessons and Questions: Reflections on a Decade of Collaboration with Cofán Conservationists." Invited Presentation, Division of Culture, Environment, and Conservation, Field Museum of Natural History of Chicago, Chicago, IL.

2007: "Weird Science: An Indigenous Critique of Scientific Conservation in Amazonian Ecuador" (as part of a panel that I organized, *Interpreting Activism in Amazonia: Indigenous Perspectives on the Inequalities of Advocacy*). Annual Meeting of the American Anthropology Association, Washington D.C.

2007: "The Myth of the *Gringo* Chief: Amazonian Messiahs and the Power of Immediacy." Workshop on Society, Culture, and Environment, University of Texas, San Antonio, TX.

2007: "Essential Commitments and Contractual Selves: Identity and the Politics of Cofán Conservation." Invited Anthropology Department Lecture, University of Texas, San Antonio, TX.

2007: "Of Worlds and Their Creators: Difference and Power in Cofán Politics." Fifth Sesquiannual Meeting of the Society for the Anthropology of Lowland South America, Santa Fe, NM.

2006: "Oil Wells and Woolly Monkeys: Living and Working in the Amazon Rainforest." Spradley Society Lecture, Macalester College, St. Paul, MN.

2005: "Conservation, Science, and Environmental Politics." Office of Environmental Conservation Programs, Field Museum of Natural History of Chicago.

2005: "The Work of Science: Articulating the Environment in Amazonian Ecuador." Anthropology Department Lecture, Macalester College, St. Paul, MN.

2005: "Environmental Politics and the Cofán Contractual Self." Annual Meeting of the American Anthropology Association, Washington D.C.

2005: "The Ingenuous Monkey and the Suspicious Jaguar: Value and the Object of Cofán Politics." Fourth Sesquiannual Meeting of the Society for the Anthropology of Lowland South America, Estes Park, CO.

2005: "The Work of Science: Articulating the Environment in Amazonian Ecuador." Workshop on Science, Technology, Society, and the State, University of Chicago.

2004: "Identity, Collectivity, and Difference." Workshop on the Anthropology of Latin America, University of Chicago.

2004: "The Development of a Political Agent." Interdisciplinary Christianities Workshop, University of Chicago.

2003: "Elements of an Ethnographic Approach to the Study of Political Mobilization: Value, Identity, and Collectivity in the 'Cofán Experiment.'" Annual Meeting of the American Anthropology Association, Chicago, IL.

2003: "Being *A'i*, Being Cofán." Workshop on the Anthropology of Latin America, University of Chicago.

2002: "Am I Cofán?: Identity and Transculturation in the Ecuadorian Amazon." Fulbright Commission Public Forum, Quito, Ecuador.

2000: "The Value of Marx." Annual Meeting of the American Anthropology Association, San Francisco, CA.

2000: "Nature and Commodity in Fernando Coronil's *The Magical State*." Annual Meeting of the Central States Anthropology Society, Bloomington, IN.

2000: "The Amazonian Struggle for Territory: Environment, Way of Life, and the Indigenous-Environmentalist Alliance." Workshop on the Anthropology of Latin America, University of Chicago.

1999: "The Indigenous Right to Territory in the Age of the 'Global Ecological Imaginary.'" University of Chicago Conference on Globalization, Chicago, IL.

1999: "Concrete Reason and the Myth-Prince: Gramsci's Solution to the Irrationalist Dilemma of Sorel's Nietzschean Politics." Annual Meeting of the Central States Anthropology Society, Chicago, IL.

TEACHING POSITIONS

2007 – present: *Assistant Professor*, University of Texas at San Antonio—designed and taught "Introduction to Anthropology" (undergraduate), "Introduction to Cultural Anthropology" (undergraduate), "Political and Legal Anthropology" (undergraduate), "The Anthropology of Oil" (undergraduate), "Theory in Cultural Anthropology" (graduate), "Seminar: Environment, Culture, and Conservation" (graduate), and "Seminar: Economic Anthropology" (graduate).

2006 – 2007: *Mellon Postdoctoral Fellow*, Macalester College—designed and taught "Cultural Anthropology" and "Culture and Capital in Latin America's Margins."

2005: *Adjunct Instructor*, University of Illinois at Chicago—co-taught "Native Peoples of South America" with Dr. Waud Kracke.

2004: *Frederick K. Starr Lecturer*, University of Chicago—designed and taught "Shamanism and History in Western Amazonia."

2003: *Teaching Assistant*, University of Chicago—presented lectures, organized seminars, graded papers, and held office hours for "The Development of Social and Cultural Theory-II," a double-course for first-year graduate students in anthropology taught by Dr. Manuela Carneiro da Cunha.

1998: *Teaching Assistant*, University of Chicago—presented lectures, graded papers, and held office hours for "Kinship and Social Organization," a course for graduate and undergraduate students taught by Dr. Terence Turner.

1993 – 1996: *Voluntary Lecturer*, University of Illinois at Urbana-Champaign—presented lectures to elementary, high school, and university students on tropical conservation and indigenous rights issues for the University of Illinois Rainforest

Action Group.

WORK EXPERIENCE

2007 – present: *Fellow* of the Division for Environment, Culture, and Conservation, Field Museum of Natural History, Chicago—voluntary field- and office-work as an anthropological and linguistic advisor for Cofán-related projects carried out by the Office of Environmental Conservation Programs and the Center for Cultural Understanding and Change.

2003 – 2006: *Research Assistant-III*, Field Museum of Natural History, Chicago—field- and office-work as an anthropological and linguistic advisor in the Office of Environmental Conservation Programs, focusing on production of territorial management plans, logistical aid with scientific conservation projects, and development of didactic and scholarly materials concerning community-based conservation work in the Cofán territories of Amazonian Ecuador.

1997: *Research Intern*, Cultural Survival, Cambridge MA—created a global database of indigenous peoples' organizations, set up an online journal ("Active Voices"), and prepared an educational program on the relations between the petroleum industry and indigenous peoples in Amazonian Ecuador.

1993 – 1996: *President*, University of Illinois Rainforest Action Group, Champaign-Urbana IL—coordinated educational, fundraising, and protest activities for the University of Illinois Rainforest Action Group, an affiliate of the Rainforest Action Network.

FIELD RESEARCH

2010: Amazonian Ecuador, with the Field Museum (July).

2009: Amazonian Ecuador (June, July).

2008: Chicago (with Cofán and N. American researchers at the Field Museum) (July).

2007: Amazonian Ecuador, with the Field Museum (May, June).

2006: Amazonian Ecuador (July, August).

2005: Quito and Amazonian Ecuador, with the Field Museum (April, May).

2004: Amazonian Ecuador, with the Field Museum (March, April, June, December).

2003: Amazonian Ecuador, with the Field Museum (November, December).

2001 – 2002: Quito and Amazonian Ecuador (two continuous years).

1999: Amazonian Ecuador (August, September).

1998: Amazonian Ecuador (August, September).

1995: Amazonian Peru (July).

1994: Quito and Amazonian Ecuador (September – December).

FIELD RESEARCH GRANTS

2003 – 2010: (Most of my fieldwork during this period was funded with discretionary spending by the Field Museum of Natural History's Division of Culture, Environment, and Conservation, which worked with programmatic grants from such institutions as the Gordon & Betty Moore Foundation, the MacArthur Foundation, and the United States Agency for International Development. I now receive funds as a museum Fellow.)

2000 – 2001: Fulbright-International Institute for Education Grant.

2000: Fulbright-Hays Grant for Doctoral Dissertation Abroad (declined).

1999: Tinker Foundation Field Research Grant.

1998: Tinker Foundation Field Research Grant.

1995: University of Illinois Campus Honors Program Summer Research Grant.

WRITING GRANTS

2010: UTSA Faculty Development Leave.

ACADEMIC SERVICE

2010: Conference Co-Host, Sixth Annual Conference of the Society for the Anthropology of Lowland South America, San Antonio, Texas.

2009 – present: Book Review Editor for *Environment and Society: Advances in Research*.

2008 – present: Member of the Publications Committee, Society for the Anthropology of Lowland South America.

2007 – present: Secretary/Treasurer of the Society for the Anthropology of Lowland South America.

Referee: *Conservation and Society, Current Anthropology, Development and Change, Ethnohistory, The Journal of Latin American and Caribbean Anthropology, The Journal of Consciousness Studies.*

UNIVERSITY SERVICE

2009 – present: Coordinator for Doctoral Program Recruitment and Advertising, University of Texas at San Antonio.

2007 – present: Faculty Advisor for Lambda Alpha, the National Collegiate Honors Society for Anthropology, University of Texas at San Antonio.

2007 – present: Department Webmaster, University of Texas at San Antonio.

2007 – present: Coordinator of Core Curriculum Assessments, University of Texas at San Antonio.

2007 – 2010: Department Representative to the Graduate Council, University of Texas at San Antonio.

MEMBERSHIP IN PROFESSIONAL SOCIETIES

American Anthropological Association.

American Ethnological Society.

Society for the Anthropology of Lowland South America.

Society for Latin American and Caribbean Anthropology.

Anthropology and Environment Section of the American Anthropological Association.

International Work Group for Indigenous Affairs.

LANGUAGES

English (speaking [excellent], reading [excellent], writing [excellent])

Spanish (speaking [good], reading [good], writing [good])

Annex 5

A'ingae (the Cofán langage) (speaking [good], reading [good], writing [fair])

REFERENCES

Dr. Terence Turner
(Professor of Anthropology, *emeritus*, Cornell University / University of Chicago)
115 Eddy St.
Ithaca NY 14850
tst3@cornell.edu
(Ithaca [office]: 607-255-3109)
(Ithaca [fax]: 607-273-1032)
(Ithaca [home]: 607-273-4840)
(*Contact Anne Chien, University of Chicago administrative assistant, to request a letter of recommendation: amchien@uchicago.edu)**

Dr. Norman E. Whitten, Jr.
(Professor of Anthropology, *emeritus*, University of Illinois at Urbana-Champaign)
507 Harding Dr.
Urbana IL 61801
nwhitten@uiuc.edu
(Department: 217-244-3514 [phone])
(Home: 217-344-1828 [land line], 217-649-2454 [cell phone])

Dr. Manuela Carneiro da Cunha
(Professor of Anthropology)
Department of Anthropology
University of Chicago
1126 E. 59th St.
Chicago IL 60637
mm-cunha@uchicago.edu
(Department: 773-702-8551 [phone], 773-702-4503 [fax])
(Chicago [home]: 773-643-0360)
(Brazil [phone]: 011 55 11 38 626-863)
(Brazil [fax]: 011 55 11 38 655-017)
(*Contact Anne Chien, University of Chicago administrative assistant, to request a letter of recommendation: amchien@uchicago.edu)**

Dr. John Kelly
(Professor of Anthropology)
Department of Anthropology
University of Chicago
1126 E. 59th St.
Chicago IL 60637
johnkelly@uchicago.edu

(Department: 773-702-8551 [phone], 773-702-4503 [fax])
(Chicago [home]: 773-493-2918)
(Poughkeepsie, NY [home]: 845-473-7445)
(*Contact Anne Chien, University of Chicago administrative assistant, to request a letter of recommendation: amchien@uchicago.edu)**

Annex 6

Charles A. Menzie, Ph.D. & Pieter N. Booth, M.S., *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," As Presented in: Counter-Memorial of the Republic of Colombia, Appendix* (Jan. 2011)

Exponent®

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"

As Presented in: Counter-Memorial of the Republic of Colombia, Appendix

Prepared by

Charles A. Menzie, Ph.D., and
Pieter N. Booth, MS

Annex 6

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"

As Presented in:

Counter-Memorial of the Republic of Colombia, Appendix

Prepared for

Republic of Ecuador

Prepared by

Charles A. Menzie, Ph.D., and
Pieter N. Booth, MS

Exponent
15375 SE 30th Place, Suite 250
Bellevue, Washington 98007

January, 2011

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Contents

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Executive Summary

The authors have reviewed the Counter-Memorial (Republic of Colombia 2010) and the comments by Dobson (2010) on our Menzie et al. (2009) report. The Counter-Memorial and Dobson (2010) assert that Menzie et al. (2009) describe potential harmful impacts of the spray program but do not support those assertions with a risk assessment, and in particular, that Menzie et al. (2009) do not provide an assessment of exposure. In this report, we first provide a reassessment of hazards that relies on previously unavailable flight-path data for flights occurring within 10 km of the Ecuador-Colombia border. Next, we examine major sources of uncertainty that were not considered appropriately by Dobson (2010) or in earlier studies by Solomon et al. (2005). Finally, we describe methods for managing uncertainty in risk management and argue that such methods are clearly applicable to the present case.

Flight-path data were used to develop realistic projections of spray drift and consequent hazards posed to sensitive plant species (Hansman and Mena 2011; Giles 2011; and Weller 2011). The results of these analyses indicate that spray drift could produce adverse impacts to sensitive plants 10 km or more from the site of application. The re-analysis of exposure based on actual, rather than hypothetical, flight-path data clearly indicates that spray drift from Colombia's aerial spraying program has resulted in a significant hazard. Our analysis of all available information confirms our earlier conclusions; in particular, we identify sources of uncertainty that have not been considered by Solomon et al. (2005) or by Dobson (2010) and that have substantial risk management implications.

We now know that flight-related protocols for spray applications were commonly violated. The violations would tend to result in greater spray drift. However, there are several other important sources of uncertainty that Solomon et al. (2005) and Dobson (2010) do not consider:

- Common meteorological conditions such as wind gusts and temperature inversions were not controlled for adequately and can result in farfield transport of spray droplets.

- The composition of the spray mixture is unknown, and it may contain substances that are more toxic than those present in formulations used for toxicity testing.
- Communities near the Ecuador/Colombia border consist largely of impoverished subsistence farmers who are more vulnerable than other populations due to limited access to health care, good nutrition, clean water, and sanitation.
- Particular aspects of the ecology of Ecuador present unique and important exposure pathways to many species, including endangered species.
- Little is known about the sensitivity of Ecuador's plant and animal species, and some species and populations may be particularly vulnerable due to their population status or life histories.
- Colombia has not attempted to measure glyphosate residue near the border with Ecuador, and thus, actual exposure is not known.

Each of these sources of uncertainty taken alone mandates the use of an abundance of caution in managing risk. Moreover, with over 100,000 spray events occurring within 10 km of Ecuador's border border during the period 2000 to 2008, it is highly likely that an unexpected event occurred that is not predicted by modeling, and which will result in more extreme exposure. This concept, called extreme value theory, is an important and recognized element of risk assessment and cannot be ignored. In the face of large uncertainty such as that inherent in the aerial spray program, risk managers use various approaches for reducing the possibility of harm:

- Incorporating additional uncertainty or "safety" factors into the risk assessment, and thus, lowering exposure concentrations deemed to be protective (and therefore erring on the side of caution).
- Implementing management actions that minimize risk by minimizing exposure (e.g., institutional controls) or through other actions.

Buffer zones are a common risk management strategy for protecting vulnerable human populations and ecosystems. Buffer zones have been used to limit the potential for harm in a variety of management settings, including pesticide application on agricultural fields, around industrial facilities to insulate human populations and natural areas from air emissions, and around sensitive habitats (riparian areas, wetlands, national parks or other protected areas) to minimize impacts from nearby human activities. The exposure analysis presented in this report clearly shows that, under realistic spray-drift conditions, deposition rates that are harmful to sensitive plants can readily extend over distances of 10 km or more. Buffer zones at the scale of 10 km have been employed elsewhere. Considering the high degree of uncertainty associated with the aerial spray program, a buffer zone equal to or greater than 10 km would be consistent with accepted risk management practice to ensure protection from adverse effects.

The remainder of this report is presented in three sections:

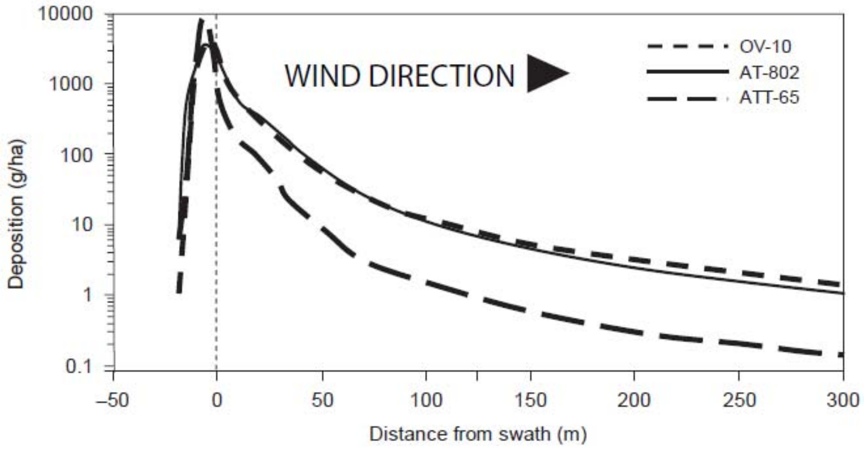
- **Section 1**— The Menzie et al. (2009) Hazard Assessment is Validated by New Drift Modeling Based on Field Data and Dose Response Study
- **Section 2—** Uncertainties Associated with Health and Environmental Effects of the Colombian Herbicide Spray Program.
- **Section 3—** Managing Uncertainty for Risk-Based Decision Making.

January 2011

1 The Menzie et al. (2009) Hazard Assessment is Validated by New Drift Modeling Based on Field Data and Dose-Response Study

The Counter-Memorial and Dobson (2010) take issue with Menzie et al. (2009) by asserting that Menzie et al. describe potential harmful impacts of the spray program but do not support those assertions with a risk assessment, and in particular, that Menzie et al. do not provide an assessment of exposure. Dobson (2010) refers to Menzie et al. (2009) as providing “speculation” regarding the potential for harm, but in their own risk assessment, they fail to acknowledge major sources of uncertainty associated with the aerial spray program. Instead, they paint a picture of certainty regarding how the program was conducted and conclude that resultant environmental and human health impacts are negligible or low. Dobson (2010) does not consider the fact that, at the time Menzie et al. (2009) was prepared, Colombia had not made information publicly available that is critical to development of an informed and reliable assessment of exposure. Hewitt et al. (2009) conducted an exposure analysis, as did Dobson (2010), but these authors also lacked actual data, forcing them to assume that all of the operational parameters documented by Colombia were strictly adhered to. These authors made no effort to independently verify whether those assumptions were accurate. Furthermore, Dobson (2010) does not try to resolve differences between adverse effects reported by people in Ecuador and predicted risks, despite the fact that this is standard practice in carrying out a causal analysis of reported harm. Ecuador has obtained the relevant flight-path data, making it possible to complete an exposure analysis, and such an analysis is presented by Hansman and Mena (2011), Giles (2011), and Weller (2011). This body of work fully supports the conclusions reached by Menzie et al. (2009), as described below.

Both Colombia and Ecuador agree that the exposure pathway for spray drift from Colombia to Ecuador is complete and that the only dispute concerns the amount of spray and the potential for harm associated with those amounts. Dobson (2010) describes the pattern of drift using a drift model by Hewitt et al. (2009) that is based on operational parameters stated by Colombia. Figure 1 from Dobson (2010) depicts this modeling.



Dobson, Figure 1, adapted from Hewitt et al. (2009). Deposition rates for spray drift (g/ha on a log scale) for different aircraft types at representative flight speeds.

As indicated by Figure 1, Dobson (2010) acknowledges that even when Colombia's spraying program protocols are observed (which was assumed to be true by Hewitt et al. 2009), there will be long-distance drift of the fraction of spray that consists of very small droplets. He states: *"The long tail in the plot in Figure 1 predicts that a very small proportion of the spray, the finest droplets, will drift for long distances.*" However, based on the drift modeling of Hewitt (2009), Dobson (2010) concluded that the amount of herbicide deposition was not sufficient to cause harm in Ecuador.

Colombia and Ecuador concur that the exposure pathway from Colombia to Ecuador is complete; that is, that at least some droplets from Colombia's aerial spraying can drift for long distances. The dispute is over whether resulting exposures will be sufficient to cause harm.

The conclusion by Dobson (2010) that not enough deposition will reach Ecuador to cause adverse impacts relies on at least one critical fallacy: he assumes that the herbicide is sprayed by Colombia in a manner consistent with the assumptions made by Hewitt et al. (2009). Menzie et al. (2009) pointed out that this might not be the case, for a variety of reasons, and viewed this as a source of significant uncertainty in the risk assessment conducted by Solomon et al. (2005). Specifically, Menzie et al. (2009) explained that the likelihood of spray drift is increased under a variety of potential or likely scenarios, including:

- Pilots failing to recognize or adhere to operational and environmental constraints for spraying, including failure to adhere to spray release heights, due to terrain, height of vegetation, or hostilities
- Variable wind speeds and thermal inversions
- Decreased droplet size.

Studies of spray drift conducted in the United States have shown that, depending on environmental factors, a substantial portion of the spray can leave the target area as spray drift and can be carried for miles beyond the target area (Currier et al. 1982; Murray and Vaughn 1970; Westra and Schwartz 1989; Robinson and Fox 1978). Hansman and Mena (2011), analyzed the flight records for the spraying program, and showed that violations of the spray protocols were pervasive, thereby proving that the assumptions in Hewitt et al. (2009) are incorrect. By extension, use of such assumptions in an exposure assessment or risk assessment led to the erroneous conclusion by Dobson (2010) that risks are low or negligible.

Hansman and Mena (2011) analyzed data from 114,525 aerial eradication spray events conducted by Colombia within 10 km of the border between Colombia and Ecuador from January 2000 to January 2008. The objective of the analysis was to assess compliance with territorial and operational restrictions identified in Colombia’s Environmental Management Plan and with other limitations imposed at various times by the Colombian government. Their analysis revealed, among other things, that:

- Of the spray events for which data were recorded, 96% (89,124 of 92,643 spray events) were flown higher than the 25-m maximum ceiling referred to in Colombia's submission to the Inter-American Commission on Human Rights, and 17% (16,143) were higher than the 50-m altitude ceiling referred to in the Counter-Memorial.

- Of the spray events for which data were recorded, 69% (75,841 of 110,418 spray events) were flown faster than the 265-km/hr (165-mph) "maximum operational speed," and 10% (11,113) exceeded the 333-km/hr "worst case scenario" referenced in the Counter-Memorial.
- The 225-km/hr (140-mph) maximum speed reported by Colombia to the Inter-American Commission on Human Rights was exceeded in 98% (108,563) of the spray events.
- With respect to application rate, at least 27,429 documented spray events exceeded the 23.65-L/ha maximum application rate established by Colombia's Environmental Management Plan.
- With respect to the time of day, a total of 24,540 spray events were recorded within 10 km of the Ecuador border during nighttime hours (8 pm to 4 am) when temperature inversions are most likely to occur.

These actual operational conditions during the aerial spray program within 10 km of the Ecuador border are in sharp contrast with the assumptions made by the Hewitt et al. (2009) drift modeling. The implication is that actual spray drift is greater than that predicted by Hewitt et al. (2009). This implication is confirmed by applying the spray drift model used by Dobson (2010) and Hewitt et al. (2009) incorporating actual operational data from Colombia's spray program. Giles (2011) performed just such an analysis, the results of which show that quantities of herbicide are likely to be deposited long distances from the site of application, including deep into Ecuador. Weller (2011) provides an analysis of dose-response for plants using modeling results from Giles (2011) and concludes that, under a scenario based on actual spray parameters, sensitive plants can be injured 1 km from the spray path under a single application, and up to 10 km from the spray path under four or more applications. Thus, a re-analysis of exposure based on actual, rather than hypothetical, flight path data indicates that spray drift from Colombia's aerial spraying program can produce a significant exposure hazard. Even though Menzie et al. (2009) did not have access to actual flight data, these authors applied a reasoned and responsible uncertainty analysis of key assumptions and arrived at the same conclusion.

Thus, the analyses presented here and referenced herein fully support the conclusions reached by Menzie et al. (2009).

2 Uncertainties Associated with Health and Environmental Effects of the Colombian Herbicide Spray Program

In Section 1, we showed that the hazard assessment provided in Menzie et al. (2009) has been verified by the spray-drift modeling and dose-response evaluation carried out by Giles (2011) and Weller (2011). In this section, we show that numerous sources of uncertainty suggest that the actual effects could be significantly worse than those estimated by the exposure and effects assessments presented by Giles (2011) and Weller (2011). We reach this conclusion by examining each source of uncertainty and demonstrating how reasonable and responsible assumptions would result in higher estimates of exposure or estimates of increased sensitivity of environmental receptors and humans. Finally, we address how the importance of these uncertainties, taken in the context of standard scientific practice and accepted environmental regulatory frameworks, demand the incorporation of safety factors into Colombia's risk management protocols.

These additional uncertainties, each of which could increase the likelihood and extent of harm, include the following:

- **Meteorology—** Application protocols dictate that spraying should occur only under conditions that minimize the potential for spray drift. However, no data are available to confirm that this practice was followed; such data would include temperature, humidity, and wind direction and speed during each spray event. Therefore, there is no basis on which to assume compliance with these parameters. Further, the extent to which spraying occurred during high-wind events and/or during thermal inversions is not known. It has been demonstrated, however, that spraying occurred at night, in violation of protocol, a time when thermal inversions are common. The implication of spraying during high winds and during thermal inversions is that the spray is carried away from the target area. This increases the likelihood of significant deposition in Ecuador.

- **Composition of the spray mixture—** The spray mixture has changed over time, and the spray mixtures used historically are reportedly more toxic than the mixture that Colombia asserts it currently uses. In fact, the Counter-Memorial states that the mixture was changed in 2005 due to the risk it posed to human eyes. In addition, the complete composition of the various spray mixtures that Colombia has used (including its current one) has not been disclosed.
- **Vulnerability of human populations in the Ecuador-Colombia border region—** Residents of the remote communities near the Ecuador/Colombia border, which consist largely of impoverished subsistence farmers, are subject to a variety of stresses that render them more vulnerable than other populations that have greater access to health care and to good nutrition, clean water, and sanitation. These conditions contribute to a higher vulnerability to additional stresses, such as adverse impacts due to exposure to herbicide.
- **Ecology of Ecuador—** The analysis presented by Solomon et al. (2005) and Dobson (2010) assume that the characteristics of species in Ecuador are similar to Europe and North America. This leads them to neglect to consider important exposure pathways. As a result, they likely underestimate the exposure and risk to many species in Ecuador, including endangered species.
- **Sensitivity of species to spray mixtures and increased vulnerability of some species and populations—** Dobson (2010) uses species sensitivity distributions based almost exclusively on plant species that are crops and on frogs that do not occur in the Ecuador-Colombia border area. Toxicity data are provided for a small fraction (less than 2%) of the frog species in Ecuador, and there is no reason to believe that the tested species are representative, much less that they are among the most sensitive species in Ecuador. Thus, there is substantial uncertainty concerning the sensitivity of Ecuadorian species, as well as the ability to extrapolate from species with different characteristics to Ecuadorian ones.

- **Measurements of exposure—** Uncertainty is also present because there are no direct measurements of glyphosate residue near the border with Ecuador that are close in time and distance to spray events.

- **Colombia's Dismissal of Reported Adverse Effects—** Colombia's failure to consider the possibility that the reports of harm may be accurate, and thus that its risk assessment was flawed, is contrary to accepted environmental regulatory practice.

- **Extreme Adverse Events Not Anticipated by Modeling—** Although modeling is necessarily constrained by anticipated conditions, actual field conditions may sometimes be radically different from the model's assumptions, resulting in potentially extreme exposure events.

2.1 Meteorology: Uncertainties Arising from Variations in Weather Conditions

Spray drift is influenced by meteorological conditions, including temperature, humidity, and wind speed and direction (Menzie et al. 2009). Further, factors such as thermal inversions, especially when combined with adverse wind conditions, can cause spray drift to travel well beyond intended targets.

Colombia acknowledges the important influence of meteorological conditions on spray drift, and states that measures are implemented to ensure that spraying does not occur during conditions that favor drift. Specifically, the Counter-Memorial states at paragraph 4.61:

> *Following an assessment of whether the minimum requisite security and weather conditions – including temperature, wind direction and speed and relative humidity – are present in the areas to be sprayed, the operations begin.*

The Counter-Memorial criticizes the observation by Menzie et al. (2009) that localized wind conditions can increase the risk of off-target deposition by arguing that it:

> *seeks to infer local circulation conditions on the basis of notions of general circulation of the atmosphere. But local conditions are random in character, depending on the time of year, time of day, etc. To determine a local wind circulation pattern, it is necessary to have actual data obtained from direct measurements from both land and air (radio scanning) meteorological stations, which the Menzie Report does not provide, but which are checked in situ prior to each spray mission.*

Colombia's statement supports rather than refutes the uncertainty identified in Menzie et al. (2009). This is especially clear when Colombia states that "*local conditions are random in character,*" and that:

> *it is necessary to have actual data obtained from direct measurements from both land and air (radio scanning) meteorological stations, which the Menzie Report does not provide, but which are checked in situ prior to each spray mission.*

We agree with the underlying premise that it is critical to know local meteorological conditions while spraying. However, this supports Ecuador, not Colombia. The evidence indicates that Colombia does *not* measure weather conditions at the site of application. There are no data provided in the flight records, and Colombia has not indicated that its spray aircraft are equipped with meteorological instruments that could provide the pilots with current weather conditions at the site of application. To the contrary, Colombia has stated that weather conditions are observed at the airport, which may be located many kilometers from the site of application**.** Consequently, Colombia's statement that weather conditions are checked "*in situ*" is meaningless. Indeed, Colombia routinely violates the protocols that are within the pilots' control (e.g., altitude of release, speed of the plane, application rate, time of day of application), and therefore, it is very unlikely that they would adhere to weather-related protocols that are beyond their ability to measure, much less control.

With respect to thermal inversions, which occur frequently in the border region and are especially conducive to long-distance drift, the flight records support the conclusions of Menzie et al. (2009) that there is a significant risk of spraying during an inversion. The Counter-Memorial states with respect to inversions:

> *for a thermal inversion to occur, very particular local meteorological conditions are needed, such as clear sky at night and calm winds so that the soil cools down faster than the air located above it. Even when this phenomenon does occur, it is of short duration because it usually starts to disappear from the very moment the sun comes up. It would have little or no influence on drift because spraying operations take place after sunrise.*

Again, there is agreement regarding the underlying premise that inversions are common in the area near the border. The only reason given for there being no risk of spraying during an inversion is that, according to the Counter-Memorial, spray operations take place only during the daytime. Leaving aside the fact that inversions can also happen during the daytime, the Counter-Memorial assumes that the pilots follow protocols with respect to the time of day when spraying is permitted. However, Hansman and Mena (2010) show that the spray program was not restricted to daytime—24,540 spray events were recorded within 10 km of the Ecuador border between 8 p.m. and 4 a.m. As noted in the Counter-Memorial, this is when temperature inversions are most likely to occur.

In summary, substantial uncertainties are associated with meteorological conditions, and the available data show that Colombia did not comply with protocols designed to prevent spraying during inversions. As a result, spray drift is likely to be worse than predicted by the drift modeling of Giles (2011).

2.2 Uncertainties Arising from Variable and Unknown Composition of the Herbicide Mixture

Dobson (2010) restates several assertions that have been made by Colombia, including that:

- The spraying in Colombia currently uses a mixture of a commercial formulation of glyphosate (Glyphos as Gly41) consisting of 44% glyphosate, 1% Cosmo-Flux 411F, and 55% water.
- The Glyphos formulation uses predominantly POEA as its surfactant, although the POEA content of Glyphos/Gly41 is lower than that of Roundup.
- Based on information provided to Dobson (2010), Gly41 does not contain organosilicone surfactants.
- Speculation by Menzie et al. (2009) regarding the presence of other herbicides, fungal plant pathogens, or other additives, seems unfounded based on published information on the spray mixtures actually used.

Each of these assertions assumes that the information provided to Dobson (2010) with respect to the formulation of the herbicide mixture was accurate. Dobson (2010) fails to acknowledge conflicting information about the spray mixtures used by Colombia, including information reported by Colombia itself. Moreover, the failure by Colombia to provide a precise description of each spray formulation that has been used contributes to a high level of uncertainty regarding the potential for adverse effects and consequently calls for a higher level of caution than otherwise would be warranted.

In particular, we highlight the following regarding the spray mixture:

- The only surfactant that Colombia admits to using in the Counter-Memorial is polyethoxylated tallow amine, or POEA. The term POEA refers to a *category* of chemicals, not a single chemical. POEA has been demonstrated in controlled laboratory experiments to be more toxic than glyphosate. Without any information about *which* POEA surfactant was used in the spray mixtures, it is impossible to establish the toxicity of that constituent. Even Dobson (2010) acknowledges that POEA is a "worst case for surfactant toxicity" and "has been identified as a major contributor to the aquatic toxicity of glyphosate formulations."

- Dobson (2010) states that the "formulation uses *predominantly* POEA as its surfactant." This implies that there are *other* surfactants in addition to POEA, and their presence has not been acknowledged nor have they been identified by Colombia. The presence of other surfactants is also mentioned in multiple reports by the U.S. EPA and the U.S. State Department.
- Colombia has not revealed the full composition of CosmoFlux 411-F.
- The Counter-Memorial states that Colombia changed the formulation in 2005 from Roundup SL to Gly41, because Roundup SL was too damaging to human eyes. The assessments conducted by Hewitt et al. (2009) and Dobson (2010) considered a formulation referred to as "Glyphos." They asserted, without explanation, that Gly41 is Glyphos. Leaving aside whether that assertion is accurate, their assessment of the risks of Gly41/Glyphos cannot be applied to the use of Roundup SL.

In addition to the uncertainty regarding the actual composition of surfactants, Colombia has acknowledged that the spray mixture also contains 1,4-dioxane, which is considered by the U.S. EPA to be a probable human carcinogen (U.S. EPA 2009).

Perhaps of greatest concern from a toxicological standpoint is that, in its 14 July 2001 diplomatic note, Colombia informed Ecuador that the spray mixture contains dioxin. The term dioxin refers to a family of chemicals with similar structure and mode of action. Dioxins are persistent, bioaccumulative compounds that exhibit a wide range of carcinogenic and non-cancer effects in animals. Evidence suggests that dioxin may produce adverse effects in humans, even at background levels. To the extent that this occurs in a population, any additional exposure above background levels can be expected to exacerbate effects or result in additional adverse impacts. The lack of quantitative information, beyond Colombia's statement in 2001 verifying the presence of dioxin in the spray mixture, adds to the uncertainty regarding potential effects to human health and the environment from exposure to the herbicide. Accordingly, the human health impacts of exposure to the spray could be much worse than predicted by assessing only exposure to a glyphosate-based herbicide.

In summary, as we demonstrated previously in Menzie et al. (2009), there are significant uncertainties associated with the toxicity of the various herbicide mixtures that Colombia used in the aerial spray program. Nothing in Dobson (2010) undermines that conclusion.

2.3 Uncertainties Arising from the Greater Vulnerability of Human Populations along the Ecuador/Colombia Border

Another reason why Colombia's drift modeling and related exposure analysis likely underestimate the risk posed by the spray program is the vulnerability of the inhabitants of the Ecuador/Colombia border region. These include indigenous peoples and non-indigenous subsistence farmers. Colombia acknowledges the vulnerable position of these communities, stating in its Counter-Memorial that *"these groups of Ecuadorians live in precarious hygienic conditions and only have limited access to medical facilities."*[1] Colombia, however, views these conditions solely as factors that could provide alternative explanations for their reported harms. It does not acknowledge, contrary to standard risk regulation practice, that these are vulnerable populations for whom especially precautionary measures are needed. In that regard, Colombia's approach is inconsistent with the generally accepted approach to regulating the risk of environmental harm. Because Ecuadorian families living along the border with Colombia fit definitions of vulnerable populations, the potential for cumulative risks must be considered and a precautionary approach adopted as a risk management principle.

More specifically, because the relevant populations live in relatively poor sanitary conditions and have relatively poor nutrition, they are more susceptible to the negative effects of the spray drift. Acknowledging and addressing this special vulnerability is a standard part of environmental risk regulation. U.S. EPA (2003) defines vulnerability using attributes developed

1 Counter-Memorial, para. 7.37.

by Kasperson (2000). Two attributes relevant to the assessment of risks to Ecuadorian farmers and their families include:

- **Susceptibility or sensitivity**—An increased likelihood of sustaining an adverse effect.
- **Differential ability to recover from the effects of the stressor**—This is linked to the coping systems and resources an individual, population, or community may have.

In concert with the U.S. EPA, the National Environmental Justice Advisory Council (NEJAC 2004), which includes representatives of community, academia, industry, environmental, indigenous, and state/local/tribal governments, describes "vulnerability" in the following terms:

> *Vulnerability recognizes that disadvantaged, underserved, and overburdened communities come to the table with pre-existing deficits of both a physical and social nature that make the effects of environmental pollution more, and in some cases unacceptably, burdensome. As such, the concept of vulnerability fundamentally differentiates disadvantaged, underserved, and overburdened communities from healthy and sustainable communities.*

Vulnerable populations may require an additional degree of environmental protection because they are already stressed. For example, the NEJAC explains that the vulnerability of a population "*provides the added dimension of considering the nature of the receptor population when defining disproportionate risks or impacts.*" Similarly, the U.S. EPA recognizes that certain populations are more vulnerable than others, and that the risks of chemical exposure must be considered within the overall context of the at-risk community (U.S. EPA 2003). Accordingly, a risk assessment is incomplete if it fails to take into account the vulnerability of the population, including the *cumulative risks* to which they may be subjected.

U.S. EPA (2003) defines cumulative risk as the combined risks from aggregate exposures to multiple agents or stressors.[2] According to U.S. EPA (2003):

> *[First]… assessments involving a single chemical or stressor are not "cumulative risk assessments" under this definition. Second, there is no limitation that the "agents or stressors" be only chemicals; they may be, but they may also be biological or physical agents or an activity that, directly or indirectly, alters or causes the loss of a necessity such as habitat. Third, this definition requires that the risks from multiple agents or stressors be combined. This does not necessarily mean that the risks should be "added," but rather that some analysis should be conducted to determine how the risks from the various agents or stressors interact. It also means that an assessment that covers a number of chemicals or other stressors but that merely lists each chemical with a corresponding risk without consideration of the other chemicals present is not an assessment of cumulative risk under this definition.*

The approach to cumulative risk assessment described by the U.S. EPA is at variance with the single-stressor analysis performed by Solomon et al. (2005) and Dobson (2010). Their failure to adopt a cumulative approach is especially problematic, because Colombia acknowledges that the relevant communities in Ecuador have characteristics that make them particularly vulnerable.

2.4 Uncertainties Arising from Lack of Knowledge about Ecuador's Ecological Conditions

Solomon et al.(2005) and Dobson (2010) also likely underestimate the potential for significant adverse impacts to Ecuador, because their assessment methodology was based only on an

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2 A stressor is a physical, chemical, biological, or other entity that can cause an adverse response in a human or other organism or ecosystem. Exposure to a chemical, biological, or physical agent can be a stressor, as can the lack of, or destruction of, some necessity, such as a habitat. The stressor may not cause harm directly, but it may make the target more vulnerable to harm by other stressors. A socioeconomic stressor, for example, might be the lack of needed health care, which could lead to adverse effects. Harmful events, such as automobile crashes, could also be termed stressors. Risks from different types of stressors can be calculated using widely differing methods, including probabilistic estimates of disease via dose-response relationships, and looking up rates in statistical tables of historical events, among others.

assessment of exposure pathways present in Europe and North America; they failed to consider possible additional pathways relevant to species in Ecuador.

We identified this as a significant source of uncertainty in Menzie et al. (2009). Although Dobson (2010) responded to our comments, he failed to appreciate our principal criticism of Colombia's approach to ecology, which was that because many Ecuadorian frog species exhibit different life histories from temperate-zone frogs, that difference is important for assessing the potential for harm. In particular, Menzie et al. (2009) discussed several aspects of anuran life history that may put certain species at increased risk of exposure; many of these life history characteristics are not shared by the species tested by Bernal et al. (2009a,b). These include diurnal habits; parental care; breeding and development in very small and ephemeral pools of water, including in canopy-dwelling bromeliads; and laying eggs on the surfaces of leaves.

Of particular importance is the fact that some frog species in Ecuador exhibit parental care, unlike species in temperate environments (like North America and Europe), which do not. The disruption of this aspect of reproduction was not part of the assessment protocols adopted by Solomon et al. (2005). Thus, the possibility that these species could be affected by *direct exposure* to *undiluted spray* droplets was not accounted for.[3]

Dobson (2010) refers to toxicity testing by Bernal et al. (2009a,b) with death as an endpoint for eight frog species described as "Colombian." The extent to which these studies are representative of the fauna of Ecuador bears consideration. The eight species tested represent less than 2% of the Ecuadorian frog species and do not represent the range of life histories exhibited by Ecuadorian frogs. Following is a summary of the breeding behavior of the species tested by Bernal et al (2009a,b) (http://www.iucnredlist.org).

- ***Rhinella granulosa*—**Eggs and larva develop in ponds and can be found in very small and shallow puddles.

[3] Dobson's (2010) only acknowledgement of a difference in ecology was an exposure estimate in which he estimated exposure to tadpoles using a mixing (dilution) depth of water of 7.5 cm versus 15 cm used by Solomon et al. (2005). But this calculation does not address the particular pathway of direct exposure to adult and larval frogs to *undiluted* spray droplets, or the potential adverse physiological response due to the high permeability of amphibian skin, or the behavioral responses to a substance that is known to be a significant skin irritant. This mismatch between assessment methods and ecology is a source of uncertainty that is not addressed in the risk evaluations of Solomon et al. (2005) or Dobson (2010).

- ***Rhinella marina*—**Eggs and larvae develop in slow-moving water or still, shallow waters of ponds, ditches, temporary pools, reservoirs, canals, and streams.
- ***Rhinella margaritifera*—**Eggs and larvae develop in temporary pools and streams.
- ***Centrolene prosoblepon*—**Eggs are laid on leaves overhanging the water of streams.
- ***Dendropsophus microcephalus*—**Eggs are laid on leaves overhanging the water of temporary and permanent pools.
- ***Hypsiboas crepitans*—**Eggs and larvae develop in temporary pools at the beginning of the rainy season.
- ***Scinax ruber*—**Eggs and larvae develop in temporary pools and in roadside ditches and shallow, temporary ponds.
- ***Engystomops pustulosus*—**Eggs are laid in foam nests, and larvae develop in any natural or human-made temporary ponds or puddles.

The species tested by Bernal et al. (2009a,b) lay their eggs directly in standing water, in slow-flowing water, or on the surface of leaves where they drop into standing or flowing surface water. By contrast, many species in Ecuador exhibit very different reproductive behavior that places them at increased risk of exposure to undiluted spray droplets. For example, Hylids lay their eggs in water that collects in holes in trees, bromeliads, or other water-holding plants, or they brood their eggs on the back of the female. The family Hemiphractidae contains direct-developing frogs that bear the developing eggs on the back until they hatch. Dendrobatidae are diurnal and lay their eggs in moist places, including on leaves, in plants, among exposed roots, and in leaf litter. The eggs of Dendrobatid frogs are actively guarded, and when hatched, the tadpoles wriggle onto the backs of the adults and are then carried to a suitable pool of standing water (including in plants), where the larva remain until metamorphosis. In some species, each tadpole is placed in a separate tree hole or other small water-containing enclosure, and females or both parents visit the tadpoles periodically, with the female depositing unfertilized eggs at each visit to feed the tadpole. Because of the lower potential for dilution and dissipation, in addition to diurnal activity and parental behavior, all Ecuadorian frog species that lay their eggs in confined "bodies of water" (such as water trapped in small tree holes and plants) are at a higher risk of exposure to higher concentrations of herbicide than frogs that lay eggs in larger pools, ponds, or streams (like the frogs tested by Bernal et al. 2009a,b).

Ecuadorian frogs may also be more vulnerable to undiluted spray droplets for other reasons as well. Adult frogs that are active during the day, such as Dendrobatids in Ecuador, are more likely to be exposed directly to spray droplets than nocturnally active frogs, insofar as spraying is supposed to occur only during daylight hours. (However, as we have shown, Colombia also sprays at night, in violation of the spray protocols.) Among the Dendrobatids alone, 43 species are listed by the International Union for the Conservation of Nature (IUCN) in Ecuador, including one critically endangered and one endangered species documented to be present in the border area (see Table 1).

Further, Ecuadorian species that exhibit parental care (e.g., members of the families Hemiphractidae and Dendrobatidae, among others)—especially those whose adults actively guard egg masses—are at increased risk from direct, undiluted exposure to both larvae and adults during breeding and over the entire larval development stage, a period that often lasts as long as 60 days. Solomon et al. (2005) or Dobson (2010) never considered any of these exposure pathways.[4]

In sum, the methods employed by Solomon et al. (2005) and Dobson (2010) are likely to underestimate exposure, because their assessments assume dilution in water— rather than direct contact with skin—and because they assume that mortality is the only relevant toxicological endpoint and ignore other endpoints, such as skin irritation and disruption of behavior.

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4 These behaviors may also increase the susceptibility of adult frogs to toxic spray drift, because they are already exposed to stressors such as high levels of solar radiation, dry air currents, and high temperatures that may provoke elevated evaporative water loss.

2.5 Uncertainties Arising from Differential Sensitivity of Species

Solomon et al. (2005) and Dobson (2010) rely on species sensitivity distributions as a tool for assessing potential risks to animals and plants. The underlying concept is that toxicological data for species tested in the laboratory can be used to derive exposure concentrations that are protective for species in the field. This is a standard approach; however, its reliability depends, in part, on how well the data represent the relevant exposure routes, toxicological endpoints, and species. As described above, there is uncertainty in the risk evaluations, because Solomon et al. (2005) and Dobson (2010) have not considered all relevant exposure pathways and effects endpoints. In addition to those flaws, Solomon and Dobson (2010) also failed to consider the full range of sensitivity of Ecuadorian species. We previously argued (Menzie et al. 2009) that the approach used by Solomon et al. (2005) was unlikely to capture the range of sensitivities for species living in Ecuador. Nothing in Dobson (2010) has caused us to change that conclusion.

2.5.1 Risks to Amphibians (frogs)

Dobson (2010) presents the following steps in risk assessment for amphibians:

1. Conduct laboratory toxicity tests on species
2. Calculate the protective concentration
3. Compare the protective concentration with the exposure estimate
4. Determine the distance from the spray line beyond which no adverse effects are expected.

Dobson (2010) derives what he concludes are protective exposure concentrations in water and terrestrial environments by relying on analysis of the available toxicity literature for glyphosate formulations on anuran species, and in particular on two studies (Bernal et al. 2009a,b) that tested “Colombian” species. However, the process described by Dobson (2010) for developing protective exposure concentrations 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.

Bernal et al. (2009a) exposed eight species of frog to glyphosate plus Cosmo-Flux in water in the laboratory.[5] Bernal (2009b) exposed four species of frog to glyphosate plus Cosmo-Flux in outdoor microcosms intended to simulate field conditions in aquatic and terrestrial environments.[6] The species were ostensibly selected as being representative of Colombian species, and are called "Colombian" species by Bernal et al. (2009a,b) and Dobson (2010).

All of the species tested by Bernal et al. (2009a,b) have wide distributions and are known to use a wide range of habitats. For example, the cane toad *R. marina* occurs in northern Mexico, throughout Central America, and over most of the Amazon Basin. With the exception of *C. prosoblepon* and *E. pustulosus*, which are restricted to Central America and northern Colombia and Ecuador, the remaining test species have ranges that extend throughout most of the Amazon basin and even to northern Argentina (e.g., *R. margaritifera*).

The Colombian anuran fauna is estimated at 748 species, and the Ecuadorian anuran fauna is estimated at 494 species (http://amphibiaweb.org). IUCN lists the conservation status for 449 frog species in Ecuador. These species occur in 15 families and include 44 species of Bufonidae, 48 species of Centrolenidae, 81 species of Hylidae, and 7 species of Leiuperidae. The species tested by Bernal et al. (2009a,b) represent only about 25% of the frog families that occur in Ecuador, and a mere 7% of Bufonidae, 2% of Centrolenidae, 4% of Hylidae, and 14% of Leiuperidae.

Moreover, the families tested by Bernal et al. (2009a,b) do not include the family with the most species of anurans in Ecuador—Strabomantidae—with 159 species listed by IUCN (http://www.iucnredlist.org). Of the eight species tested by Bernal et al. (2009a,b), four are not known to occur along the Colombia/Ecuador border (*D. microcephalus*, *H. crepitans*, *R. granulosa*, and *E. pustulosus*) and are thus of questionable value for deriving a species sensitivity relationship for that geographic area. Significantly, the *most sensitive* species tested

5 In particular, Bernal et al. (2009a) tested three frogs in the family Hylidae (*Scinax ruber*, *Dendropsophus microcephalus*, *and Hypsiboas crepitans*), three frogs in the family Bufonidae (*Rhinella granulosa*, *R. marina*, *and R. margaritifera* [*a.k.a. typhonius*]), one Centrolenidae (*Centrolene prosoblepon*); and one Leiuperidae (*Engystomops pustulosus*).

6 The four species are *R. granulosa*, *R. marina*, *H. crepitans*, and *S. ruber*.

in terrestrial exposures of adults was *C. prosoblepon*, a species that *is* documented to occur along the Ecuador-Colombia border.

As shown in Table 1, of the 449 Ecuadorian frog species listed by IUCN, 35 are listed as critically endangered, and another 73 are listed as endangered. Of these, 4 critically endangered species have been documented in the border area, and 15 endangered species have been documented in the border area. In contrast, all of the test species used by Bernal et al. (2009a,b) are widespread and abundant and thus are listed by IUCN as "Least Concern." These species are also presented in Table 1.

Table 1. Status of selected species documented to be present in the border area and species tested by Bernal et al. (2009a,b)

Family	Genus/Species	IUCN Status[a]	Tested by Bernal et al. (2009a,b)	Documented in Border Area
Bufonidae	*Andinophryne colomai*	CR	No	Yes
	Atelopus lynchi	CR	No	Yes
	Rhinella granulosa	LC	Yes	No
	R. marina	LC	Yes	Yes
	R. margaritifera	LC	Yes	Yes
Centrolenidae	*Centrolene ballux*	CR	No	Yes
	C. prosoblepon	LC	Yes	Yes
Dendrobatidae	*Hyloxalus delatorreae*	CR	No	Yes
	H. toachi	EN	No	Yes
Hemiphractidae	*Gastrotheca cornuta*	EN	No	Yes
	G. espeletia	EN	No	Yes
	G. orophylax	EN	No	Yes
Hylidae	*Ecnomiohyla phantasmagoria*	EN	No	Yes
	Dendropsophus microcephalus	LC	Yes	No
	Hypsiboas crepitans	LC	Yes	No
	Scinax ruber	LC	Yes	Yes
	Hyloscirtus pantostictus	EN	No	Yes
	H. psarolaimus	EN	No	Yes
Leiuperidae	*Engystomops pustulosus*	LC	Yes	No
Strabomantidae	*Hypodactylus brunneus*	EN	No	Yes
	H. elassodiscus	EN	No	Yes
	Pristimantis colomai	EN	No	Yes
	P. degener	EN	No	Yes
	P. festae	EN	No	Yes
	P. loustes	EN	No	Yes
	P. ocreatus	EN	No	Yes
	P. scolodiscus	EN	No	Yes

[a] CR – critically endangered; EN – endangered; LC – least concerned

Both Solomon et al. (2005) and Dobson (2010) fail 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. The failure to address this issue is perhaps most egregious at paragraph 79 of Dobson (2010), which cites a study by Lynch and Arroyo (2009) as concluding that "*several species of frogs are at risk from the coca growing itself (habitat* *destruction and use of a range of pesticides), possibly with a contribution from the eradication programmes*." Dobson (2010) then concludes, "*The chances of similar risk to species in Ecuador exposed only to drifted spray is much lower and, in my opinion, negligible*." However, Dobson (2010) selectively cites Lynch and Arroyo (2009), ignoring their conclusion that *the effects of coca production and aerial eradication sprays have placed several species of frogs at risk [including] Pristimantis Colomai and Pristimantis degener*" [emphasis added]. Both of these endangered species are documented to be present in Ecuador near the Colombian border. Although Dobson (2010) describes the potential of populations to be resilient, including the ability to recover from local extinctions, he fails to consider the lack of such compensating mechanisms in species with limited distributions and small population sizes. For such species, mortality or reproductive failure in even a relatively few individuals can result in extinction.

In sum, based on a comparison of the species tested by Bernal et al. (2009a,b) to the anuran fauna in Ecuador, it is not reasonable to conclude that the eight species selected by Bernal et al. (2009a,b) are representative of the anuran fauna of Ecuador. Moreover, the lack of representativeness is exacerbated by the failure to consider the potential for exposure and toxicity to endangered species.

2.5.2 Risks to Plants

Dobson (2010) refers to species sensitivity distributions as a basis for judging risks to plants. The flaws that we describe for the assessment of risks to amphibians are also evident in Dobson's (2010) approach to plants. Dobson (2010) considers only risks to crops as relevant to risks to all plant species, including non-crop species, even though the vast majority of plants in Ecuador are not crops (Balslev 2011). Indeed, he explicitly states, "*The studies cited by Menzie et al. (2009) as supporting long-term effects of glyphosate refer to direct application of glyphosate to forests to control non-productive vegetation and are not relevant to likely effects of spray drift.*" This perspective cannot be correct, not least because "non-productive vegetation" (i.e., Ecuador's natural fauna) is critically important for its biodiversity.

Hewitt et al. (2009) does not consider the full range of sensitivity of plant species, especially the native plants of Ecuador. Instead, they obtained toxicity data on 21 plant species that were tested against formulated glyphosate. These included 18 that are typical North American and European crops. Although some of these plants may be adaptable to growing in the tropics (e.g., corn and onions), neither Hewitt et al. (2009) nor Dobson (2010) considered the uncertainty associated with extrapolating data for crop species in North America and Europe to the diverse native plant biota of Ecuador. It is highly likely that among the thousands of plant species in Ecuador (2,549 plant species are listed by IUCN for Ecuador) there are numerous species that are more sensitive than the 21 crop species considered by Hewitt et al. (2009). At the very least, the uncertainty associated with extrapolating the dose-response information related to the species relied upon by Hewitt et al. (2009) to the crops and natural flora in Ecuador provides a compelling reason for adopting protective exposure concentrations and establishing a sufficiently broad buffer zone.

Dobson's (2010) approach is flawed for another reason as well: he failed to account for the increased efficacy achieved by Colombia's inclusion of Cosmo-Flux 411F in the herbicide formulation. Menzie et al. (2009) observed that research by the U.S. Department of Agriculture indicates that Cosmo-Flux causes a four-fold increase in efficacy, and suggested that this should be applied across the spectrum of plants, not just to the targeted coca crops. Dobson (2010) agreed with much of our analysis:

> [Menzie et al. (2009)] *state, correctly, that the addition of extra surfactant Cosmo-Flux (as an adjuvant in the tank mix) increases the potency of the glyphosate formulation to coca plants fourfold. They also state, correctly, that the increased potency is due to surfactant effects on the waxy cuticle of the coca leaf; glyphosate penetrates to the sensitive inner tissues of the plant via the damaged cuticle. They also state, correctly, that plants other than coca will, therefore, be more susceptible to the herbicide spray enhanced with the adjuvant.*

Despite these areas of agreement, Dobson (2010) argues that Cosmo-Flux would not have a four-fold increase in efficacy for all plants, because:

> *Plants with cuticular protection comparable to the coca will be killed more effectively with the enhanced spray; with increased potency of approximately fourfold. Those with greater protection than coca would show a less than four-fold increase in potency and might show little or no increased toxicity. Those with no protective coating on the leaves would show no increased toxicity – it is only possible to die once and the application rate of spray in terms of the glyphosate itself remains constant for all formulations/adjuvants.*

Dobson (2010), however, has missed the essential point, which is that the addition of Cosmo-Flux reduces by a factor of four the amount of herbicide that must be deposited on a plant to cause harm. While it is true that plants for which a particular dose is lethal even without Cosmo-Flux will die regardless of whether the surfactant is present, when Cosmo-Flux is added, the same plant will be killed at one-fourth the dose. This has important implications for plants exposed to herbicide via spray drift, because it increases the distance from the site of application at which injury will occur.

2.6 Uncertainties Arising from Lack of Exposure Data

We are not aware of Colombia having measured exposure to the herbicide spray near the border with Ecuador. No such data are presented by Solomon et al. (2005) or Dobson (2010). The lack of measured data on glyphosate deposition obtained in the field is another significant source of uncertainty that Colombia fails to consider.

In fact, obtaining measurements of glyphosate residue is inherently difficult and unreliable. To be useful, attempts to measure glyphosate residue must be contemporaneous with or immediately subsequent to the application of the herbicide mixture. The samples must also be taken from media where the chemical occurs as a residue. Even then, the level of residue in water or soil is of limited utility in assessing exposure, because exposure to droplets suspended in the air is not necessarily reflected in concentrations of glyphosate in water or soil samples. Therefore, while the presence of glyphosate in environmental media may be an indicator that environmental exposures have occurred, the absence of residues does not mean that exposures have not occurred. Further, with respect to water concentrations, the likelihood that aerial exposure will be reflected in water or sediments is very low, because the droplets of herbicide mix into the water column and are adsorbed to plants and suspended sediments. This reduces concentrations to below detectable levels, especially when sampling occurs later than immediately after the time of deposition.[7]

2.7 Uncertainties Arising from Colombia's Dismissal of Reported Adverse Effects

Many people in Ecuador report that they were exposed to spray from Colombian aircraft. At the very least, their reports call into question the certainty with which Colombia has asserted that the spray program poses negligible risks to Ecuador.

Colombia's failure to consider the possibility that the reports of harm may be accurate, and thus that its risk assessment was flawed, is contrary to accepted environmental regulatory practice. When an unexpected result is reported, the proper procedure is to carry out a causal analysis. In that regard, whereas risk analysis is a forward-looking exercise that begins with a set of assumptions and makes predictions about the likelihood of different types of effects, causal analysis operates in reverse. It begins with observed harm and then attempts to identify its causes. This evaluation necessarily requires considering whether one or more of the assumptions made in the risk analysis are incorrect. This is logical: if a causal analysis were constrained by assumptions made in a risk assessment, it might prove impossible to identify the root cause of the reported harm if the cause is inconsistent with assumptions on which the risk analysis is based. Indeed, were causal analysis forbidden to question risk analysis assumptions, evaluators could not have examined—and hopefully uncovered—the causes of such diverse occurrences as the Challenger explosion[8] or the recent financial crisis,[9] and unexpected

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7 Moreover, glyphosate is not persistent in the environment due to chemical degradation. The half-life (the time required for the concentration or amount to decrease by one-half) is on the order of days for water (http://www.epa.gov/safewater/pdfs/factsheets/soc/tech/glyphosa.pdf), and the average half life in soil is on the order of 47 to 60 days (http://www.speclab.com/compound/c1071836.htm; http://extoxnet.orst.edu/pips/glyphosa.htm; http://www.epa.gov/safewater/pdfs/factsheets/soc/tech/glyphosa.pdf) but can be even faster in conditions that favor biodegradation, such as the warm, moist soils of Ecuador.

8 The explosion of the space shuttle pointed out the failures in the risk assessment concerning the safety of these missions. The physicist Richard Feynman pointed out some of the missed assumptions in a famous presentation before Congress. He did this by illustrating what happened to the elasticity of the rubber "O" rings when they were submerged in ice water.

exposure pathways such as those for chemicals in sediments.[10] These examples underscore the importance of working backward from the observed harms to better understand the causes of those harms. For this reason, causal analysis is a standard part of environmental regulatory regimes.

There is strong testimonial evidence that the people and resources in Ecuador have experienced harms. The authors of this report interviewed Ecuadorians at several locations along the border and concluded that the interviewed individuals were, in fact, likely exposed to herbicide drift from aerial spraying. The impacts they reported include, among other things, obvious crop failure, foliar damage, and death of coffee plants on hillsides facing the spraying activity. They also reported acute toxic effects such as irritation of the eye and throat. In addition, numerous similar accounts of such effects are documented (Menzie et al. 2009). These accounts support a conclusion that actual exposure within Ecuador occurred because, among other things:

- The reported harm occurred in temporal proximity to the reported spraying.
- The reported symptoms are consistent with the types of acute toxic effects expected from exposure to the herbicides used by Colombia.
- Similar accounts were reported by people from many different locations near the border.

Suter et al. (2010) describe the methodology that the U.S. EPA uses to identify possible causes of an observed impairment or harm (U.S. EPA 2000). U.S. EPA's cumulative risk framework and causal analysis begins with the experience of the affected communities and examines the factors that could have produced the reported events and harmful effects. In that regard, it has adopted a methodology for assessing observed adverse harms that applies criteria to evaluate possible causes. The methodology does not require satisfaction of all criteria, although the

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9 See for example, Zeckhauser, Richard. Causes of the Financial Crisis: Many Responsible Parties. HKS Faculty Research Working Paper Series RWP10-016, April 2010. This work shows how the risk assessments failed to consider extreme events that contributed to the crisis.

10 See for example, Thibodeaux, Louis. 2005. Recent advances in our understanding of sediment-to-water contaminant fluxes: The soluble release fraction. Aquatic Ecosystem Health & Management; Jan 2005, Vol. 8, No. 1, pp. 1–9. Risk assessments had been assuming that the chemicals in question would bind to and travel with the sediments.

strength of the evidence increases as more criteria are satisfied. To address these uncertainties, we used a causal analysis approach that builds evidence for ruling in or out possible candidate causes of the experienced events, based on the following categories of information:

- **Spatial Co-occurrence—**This refers to the degree to which reported exposures or effects occur near reported spray events. This also allows for the presence of exposure and effects gradients with distance from these events.
- **Temporal Co-occurrence—**This refers to the degree to which reports of exposure or effects are coincident or shortly follow evidence of spray events.
- **Biological Gradient—**This refers to the existence of a decreasing gradient of effects with distance from the spot of highest exposure.
- **Presence of Potentially Complete Pathways—**This refers to the ability to connect spray events and their locations to locations and receptors that are reported to be exposed.
- **Consistency of Association—**This refers to the commonality of reported spray events, exposure, and observed effects among communities along the border and with other communities near similar types of events.
- **Experiment—**This refers to whether controlled experiments have demonstrated a relationship between the exposure and an effect.
- **Plausibility—**This refers to the degree to which reported exposures or effects could have been related to a spray event. An aspect of this involves examining the extent to which reported effects are consistent with exposures to herbicide mixtures containing glyphosate.
- **Specificity—**This refers to the degree to which the reported effects are specific to or diagnostic of exposure to a particular constituent in an herbicide mixture.

- **Consistency of Evidence—**This refers to the concept that confidence in the argument for or against a candidate cause is increased when many types of evidence consistently support or weaken it.
- **Coherence of Evidence—**This refers to whether a conceptual or mathematical model can explain any apparent inconsistencies among the lines of evidence.

Table 2 lists the U.S. EPA criteria for judging causal information and applies them to reports by Ecuadorians that they were adversely affected by aerial spraying in Colombia.

Table 2. Criteria for judging the weight of evidence associated with claims by Ecuadorians on the border regarding adverse effects due to aerial spray drift from Colombia

Criterion for Judging Causal Evidence	Observations Related to Strength of Evidence
Spatial Co-occurrence	The Ecuadorians who report experiencing drift inhabit areas very near where spraying occurred.
Temporal Co-occurrence	Individuals report seeing aerial spraying immediately prior to experiencing spray drift and shortly before developing adverse health impacts and observing impacts to plants and animals.
Biological Gradient	Actual exposures are not known, so this cannot be characterized. However, the complaints are from residents in the border region close to the spray locations.
Complete Exposure Pathway	Modeling by both Hewitt et al. (2009) and Giles (2011) indicates that aerial spray could be transported into Ecuador. The only issues in dispute are the level of exposure and its resultant effects.
Consistency of Association	The same type of effects were reported by Ecuadorians located far apart, from different ethnic groups (e.g., Awá, Cofan, Kichwa, Afro-Ecuadorians), and in different years.
Experiment	The reports relate to historical experience; no specific experiments have been performed.
Plausibility	Colombia did not follow protocols for spraying that were designed to minimize spray drift. This increases the plausibility that Ecuadorians were exposed to drift in amounts sufficient to cause adverse impacts to human health and the environment.
Specificity	Menzie et al. (2009) and Dobson (2010) concur that the herbicide mixture used by Colombia can produce the types of acute toxic effects to plants reported by Ecuadorians. They also concur that the herbicide mixture can cause, among other things, acute eye and skin irritation. They differ only in whether the exposure concentrations were high enough to have caused these effects.

Criterion for Judging Causal Evidence	Observations Related to Strength of Evidence
Consistency of Evidence	The evidence is consistent. Menzie et al. (2009) and Dobson (2010) differ only on whether the exposure concentrations were sufficiently high to cause the effects.
Coherence of Evidence	The alleged inconsistency raised by Colombia is that its drift modeling suggests that an insufficient amount of herbicide would reach Ecuador to cause adverse impacts. However, as demonstrated by Hansman and Mena (2011), Giles (2011), and Weller (2011), when modeling reflects actual spray conditions (e.g., flight speed and height as recorded by the aircraft), sufficient amounts of herbicide can reach Ecuador.

According to the U.S. EPA, the first four criteria outlined in Table 2—*co-occurrence, temporality, biological gradient,* and *complete exposure pathway*—form the strongest basis for causal inference. Elimination of a cause typically involves clear demonstration that one or more of these criteria have not been satisfied.[11] In this case, three of the criteria are satisfied, as indicated in Table 2. The fourth—biological gradient—is not amenable to evaluation, because there are no measurements. We conclude that, based on U.S. EPA methodology, aerial spray cannot be eliminated as a cause for the observed adverse effects in Ecuador.

In addition to these four criteria, the U.S. EPA considers others factors, which are also included in Table 2. As noted in Menzie et al. (2009), common complaints made by Ecuadorians near the border include irritation of the eyes, throat, and skin. Dobson (2010) agrees[12] that the types of effects most commonly reported in Ecuador are consistent with exposure to herbicide:

> *Irritation of the eyes and skin are indeed the most common and consistent effects reported by people claiming exposure to glyphosate sprays, not only in Ecuador*

[11] The U.S. EPA also states, "*A stressor can be confidently eliminated if case-specific measurements clearly show that a necessary step in the causal chain of events has not occurred.*"

[12] Dobson (2010) goes on to dismiss the Exponent (2009) literature review on this subject with the illogical argument that most of the data on reported effects either indicate mild irritation or are derived for individuals applying the herbicide formulation. Dobson (2010) never explains why individuals who get spray droplets in their eye or mouth would not experience acute toxic effects. His main point seems to be that because studies have been done on applicators, those studies are not relevant to other people exposed to the same material. It is possible that Dobson (2010) is making an exposure argument—i.e., even though people are exposed to spray drift, the concentrations are too low or there are not enough droplets. He does not state that and does not provide any dose-response information or exposure assessment. Because the Colombia risk assessment indicated that most of the spray would land on or near the applied areas, Dobson (2010) could be using that as the basis for his conclusion. However, as already discussed, Dobson (2010) is not relying on correct information when he relies on the assertions of Colombia.

and Colombia but also globally. The exposure is to a combination of glyphosate and surfactants found in commercial formulations plus the extra adjuvant in the Colombian spray programme. (Dobson, 2010)

Based on the foregoing application of the U.S. EPA criteria, we conclude that the available evidence supports the conclusion that spray drift was a cause of the adverse effects reported by people in Ecuador. The evidence indicates that the exposure is complete and that the reported adverse effects could indeed be related to exposures from Colombia. Accordingly, the alleged "certainty" claimed by Colombia that aerial spraying cannot be responsible for adverse impacts in Ecuador cannot be supported. To the contrary, the reported adverse effects, including irritation of the eyes, throat, and skin, are likely attributable to exposure to the spray mixture.

2.8 Uncertainties Related to the Likelihood of Extreme Adverse Events Not Anticipated by Modeling

Another reason why adverse impacts in Ecuador are likely underestimated by drift modeling concerns the fact that modeling is necessarily constrained by anticipated conditions. However, actual field conditions may sometimes be radically different than the model's assumptions. For example, the spray-drift model assumes a relatively light wind, even though strong gusts of wind will arise occasionally. If that were to occur in concert with spraying that takes place at a high rate of speed and during a temperature inversion, an extremely high rate of deposition could result far from the spray line.

Although such a confluence of events is unlikely to happen during any particular spray event, given the frequency with which Colombia has sprayed near Ecuador (more than 100,000 times between January 2000 and January 2009) it is likely that, on at least some occasions, such occurrences did indeed materialize. The exact set of circumstances that will give rise to the high chemical exposure cannot be anticipated, but the fact that it is likely to occur can and should be anticipated. This recognized analytic technique is known as extreme value theory, and it has great importance for risk management.[13] Because probability distributions include such

[13] Chavez-Demoulin, V., and A. Roehrl. 2004. Extreme value theory can save your neck. White paper available at http://www.approximity.com/papers/evt_wp.pdf

relatively rare but extremely adverse events, the phenomenon is also referred to as being the "long" or "fat tail" on the probability distribution curve. The consideration of fat-tailed probability distributions is particularly relevant to low-probability but extremely adverse events, such as natural disasters.[14] As discussed further in the section that follows, the adoption of a buffer zone of sufficient breadth is an important risk management tool to help guard against toxic exposure from these relatively rare but highly damaging events.

[14] Pisarenko, V., and M. Rodkin. 2010. Heavy-tailed distributions in disaster analysis. Advances in natural and technological hazards research. Volume 30. 190 p. ISBN: 978-90-481-9170-3. See also Malamud, B.D. 2004. Tails of natural hazards. Physics World 17:31–35.

3 Managing Uncertainty for Risk-Based Decision Making

Risk assessments link information on exposure and toxicity to derive estimates of risk (i.e., the potential for harm to people or the environment). Because risk assessments are models that provide predictions, the assumptions and model components have inherent uncertainties.

In the face of large uncertainty such as that inherent in the aerial spray program, risk managers use various approaches to reduce the possibility of harm:

- Incorporating additional uncertainty or "safety" factors into the risk assessment, thus lowering exposure concentrations deemed to be protective (and therefore erring on the side of caution).
- Implementing management actions that minimize risk by minimizing exposure (e.g., institutional controls) or through other actions.

As explained in this section, the inherent uncertainty in the assessment of risks to Ecuador is a primary reason for taking a precautionary approach to risk management.

Uncertainty occurs because of a lack of knowledge (U.S. EPA 2010a). As discussed earlier in this report, uncertainties are indicated when there are differences between predictions and actual experience. Uncertainties also arise when the assumptions made about exposure are not valid and the implications of violating the assumptions are not fully understood. As already discussed, Hansman and Mena (2010) have shown that Colombia's spray protocols are violated regularly. As indicated by Giles (2011) and Weller (2011), these violations would result in exposures that are substantially higher than those estimated in Colombia's risk assessment. The violations of the protocols are in sharp contrast with the claims made in the Counter-Memorial that protocols are followed strictly. The discrepancy between the assumptions made by Hewitt et al. (2009) and Dobson (2010) for estimates of spray-drift exposure and the reality of the situation is a good example of lack of knowledge and a source of uncertainty in the overall analysis. Moreover, the pervasive violations of protocols call into question other assertions that influence risk. One of these assertions is that the composition and associated toxicity of the spray mixture is known. As discussed earlier, while Colombia claims that the herbicide mixture is known and its toxicity understood, there remains considerable uncertainty about the composition of the spray mixture, both as currently used and as used historically. Additives that are not identified in historical mixtures or present in larger-than-stated amounts could cause the mixtures to be more toxic.

Uncertainties about exposure and toxicity are managed by putting into place systems to limit exposure. This typically involves deriving a margin of safety, the magnitude of which corresponds to the potential for harm and the degree of uncertainty. Margins of safety take into account, among other things, knowledge about the toxicity of the chemical, its exposure pathways, and the sensitivity or vulnerability of the exposed populations and environment. It also considers the degree to which the exposed populations are willing to accept risk for themselves or to their resources.

In many environmental regulatory regimes, including in the United States and Europe, environmental regulatory policy involves deriving "acceptable" exposure limits by applying uncertainty factors to known information about the levels of chemicals that have been shown to be safe. For certain ecological exposures, risk managers also use a statistical procedure to derive "acceptable" levels.

Uncertainty factors typically account for, among other things, variations in exposure or sensitivity between individual humans or between species, extrapolation of experimental data from animals to humans, extrapolation of data on subchronic effects to chronic effects, extrapolation of data on lowest-observed-adverse-effect levels (LOAELs) to no-observed-adverse-effect levels (NOAELs), and incomplete toxicity data bases (e.g., inappropriate or missing endpoints, insufficient species, species not representative or applicable, or the range of concentration did not identify a NOAEL) (Table 3). The associated uncertainty factors or modifying factors typically range from 1 to 10 and are multiplicative to create an overall uncertainty factor (Dourson et al. 1996). In the case of an incomplete database, Health Canada and the International Programme on Chemical Safety (IPCS)[15] employ uncertainty factors of 1 to 100. Multiplying the uncertainty factors together creates an overall uncertainty factor that yields protective levels that may be orders of magnitude below the levels that would otherwise have been shown to be acceptable. While the composite uncertainty factor for a chemical was typically limited to 100 two decades ago, it may now be as high as 10,000 for a chemical with a poor database.

15 The IPCS is a joint program of three Cooperating Organizations—WHO, ILO, and UNEP—which implements activities related to chemical safety. WHO is the Executing Agency of the IPCS, whose main roles are to establish the scientific basis for safe use of chemicals, and to strengthen national capabilities and capacities for chemical safety.

Table 3. Description of typical uncertainty and modifying factors in the development of subthreshold doses for several groups (from Dourson et al. 1996)[a]

Uncertainty Factors (UFs)[b]	Guidelines[c]	Agency: Health Canada	IPCS	RIVM	U.S. ATSDR	U.S. EPA
Interhuman (or Intraspecies)	Generally used when extrapolating from valid results from studies of prolonged exposure to average healthy humans. This factor is intended to account for the variation in sensitivity among humans and is thought to be composed of toxicokinetic and toxicodynamic uncertainties.	1–10	10 (3.16×3.16)	10	10	10
Experimental Animal to Human	Generally used when extrapolating from valid results of long-term studies on experimental animals when results of studies of human exposure are not available or are inadequate. This factor is intended to account for the uncertainty in extrapolating animal data to humans and is also thought to be composed of toxicokinetic and toxicodynamic uncertainties.	1–10	10 (2.5×4.0)	10	10	10
Subchronic to Chronic	Generally used when extrapolating from less than chronic results on experimental animals or humans. This factor is intended to account for the uncertainty in extrapolated from less than chronic NOAELs or LOAELs to chronic NOAELs or LOAELs.			10	NA[d]	<10
LOAEL to NOAEL	Generally used when extrapolating a LOAEL to a NOAEL. This factor is intended to account for the experimental uncertainty in developing a subthreshold dose from a LOAEL, rather than a NOAEL.			10	10	<10
Incomplete Database to Complete	Generally used when extrapolating from valid results in experimental animals when the data are "incomplete." This factor is intended to account for the inability of any single study to adequately address all possible adverse outcomes.	1–100	1–100	NA	NA	<10
Modifying Factor	Generally used upon a professional assessment of scientific uncertainties of the study and database not explicitly treated above (for example, the number of animals tested).	1–10	1–10	NA	NA	0 < to <10

[a] Sources: Dourson (1994), Jarabek (1994), IPCS (1994), Meek et al. (1994), Pohl and Abdin (1995), and Rademaker and Linders (1994).

[b] The maximum uncertainty factor used with the minimum confidence database is generally 10,000. See text for discussion.

[c] Professional judgment is required to determine the appropriate value to use for any given UF. The values listed in this table are nominal values that are used frequently by these agencies.

[d] ATSDR (Agency for Toxic Substances and Disease Registry) develops MRLs for specified durations of exposure, and generally does not extrapolate among durations. Therefore, an uncertainty factor for extrapolation between subchronic and chronic exposures is not used.

The level of protection appropriate for addressing uncertainty factors should account for the sensitivity of the relevant populations and environment. The U.S. Food Quality Protection Act (FQPA) provides an example of using an uncertainty factor for the explicit consideration of sensitive individuals, namely children (U.S. EPA 2002). It directs the U.S. EPA, in setting pesticide tolerances, to use an additional ten-fold margin of safety to protect infants and children, taking into account the potential for pre- and postnatal toxicity and the completeness of the toxicology and exposure databases.

3.1 Uncertainty Factors for Protection of Human Health

The need for special consideration of vulnerable populations in the development of protective levels is also reflected in the risk assessment approach used by the U.S. Agency for Toxic Substances and Disease Registry (ATSDR 2005), which identifies factors that contribute to sensitivity to environmental exposures and emphasizes the need to determine whether any special characteristics of the substance and/or of the exposed community might affect public health conclusions. These include:

- **Age—**Children differ from adults in their exposures and susceptibility to certain hazardous substances. Elderly populations may have significantly heightened susceptibility to certain contaminants because of lower functional capacities of various organ systems, reduced capacity to metabolize foreign compounds, and diminished detoxification mechanisms.
- **Sex—**Some substance-specific adverse health effects can be mediated by hormonal influences and other factors that are sex-linked. In addition, because of various physiologic modifications in the body that occur during pregnancy, pregnant women are often at significantly greater risk of adverse effects from exposure to beryllium, cadmium, lead, manganese, and organophosphate insecticides than the general population.
- **Genetic background or ethnicity—**Genetic factors can increase the risk of developing chemical-induced health effects. In addition, individual variability in the

induction of metabolic enzymes can cause people to respond differently to the same environmental exposure.

- **Health and nutritional status—**Understanding the location and characteristics of subgroups, such as the elderly and those of lower socioeconomic status, can help identify pre-existing health conditions, including nutritional deficiencies, that can influence the impact of exposure.

- **Cultural practices—**Various practices, such as ceremonies among indigenous peoples, subsistence fishing, and medicinal use of plants, can lead to increased exposures.

The U.S. EPA also emphasizes the need to be especially protective of populations that are disadvantaged. This is determined based on, among other things, health indicators such as infant mortality, birth weight, and the percent of the population living in poverty.

Both the ATSDR considerations and the U.S. EPA characteristics of communities requiring special protective measures are applicable to the relevant communities in Ecuador.

3.2 Uncertainty Factors for Protection of Fish, Wildlife, and Other Biota

Environmental regulatory regimes also use uncertainty factors to establish protective levels of exposure for fish, wildlife, and other ecological receptors. Again, the magnitudes of these uncertainty factors reflect information about the chemical's known toxicity and the nature of the receptor. U.S. EPA guidance on conducting ecological risk assessments (1998) states, "Empirically based uncertainty factors or taxonomic extrapolations may be used when adequate effects databases are available but the understanding of underlying mechanisms of action or ecological principles are [*sic*] limited." In practice, the U.S. EPA uses the most sensitive indicator species tested in risk assessments of pesticides, but in the case of endangered species, it acknowledges that there is uncertainty regarding the relationship of the endangered species' sensitivity and the most sensitive species tested (U.S. EPA 2004).

As discussed earlier in this report, there is a higher diversity of species in Ecuador than in temperate environments, where most of the toxicity studies have been conducted. In addition, there are numerous endangered species in Ecuador, including along the border with Colombia. One should therefore be especially protective when deriving exposure concentrations that may be deemed protective of Ecuadorian fish, wildlife, and other biota.

For example, the IUCN lists the conservation status for 449 species of frogs in Ecuador. These species occur in 15 families and include 44 species of Bufonidae, 48 species of Centrolenidae, 81 species of Hylidae, and 7 species of Leiuperidae. The risk acceptability (level of protectiveness) criteria applied by Dobson (2010) would imply that 23 Ecuadorian species can be placed at risk at the 96th percentile protection level, and 4 species at the 99th percentile protection level. This represents the risk of mortality to 50% of exposed individuals at standard application rates. To state the obvious, the risk assessment methodology employed by Colombia is not designed to protect the most sensitive biota, and certainly not all biota. Colombia does not know what the most sensitive or vulnerable species are and, as discussed earlier, gives no consideration for sensitivity below the tested range, sublethal effects, or to the special vulnerability of endangered species.

3.3 Buffer Zones as Risk Management Tools

Buffer zones are used as a risk management tool to minimize the likelihood of adverse effects from environmental contamination (and other stressors) to sensitive human populations and ecosystems. Examples of the establishment of buffer zones to manage risk include:

- Buffer zones around industrial facilities such as aluminum smelters to isolate human populations and natural areas from air emissions.
- Buffer zones to manage odors from certain agricultural practices such as pig farms and dairies.
- Buffer zones around loud industrial or commercial zones to minimize exposure to noise, dust, etc.

- Buffer zones for pesticide application on agricultural fields.
- Buffer zones around sensitive habitats (riparian areas, wetlands, national parks, or other protected areas) to minimize impacts from nearby human activities.

Buffer zones are also commonly established as a tool for ensuring the protection of sensitive species, areas of biodiversity, and integrated conservation and development projects. These include buffers designed to protect cultural/historical resource sites and biodiversity hotspots, such as national parks and unique ecosystems. According to Ebregt and De Greve (2000), the buffer-zone concept was already integrated into policy making and program planning of multi-lateral development organizations by the early 1970s, and evolved from the desire to protect conservation areas by minimizing potentially negative impacts from human activities. More recently, the integrated buffer-zone concept has been used in Integrated Conservation and Development Projects (ICDPs) on a larger scale and among a wider group of development organizations. The size of the buffer zone depends on the conservation and socio-economic objectives, the availability of land, and traditional land use systems, threats, and opportunities (Ebregt and De Greve 2000).

The buffer-zone concept has been given structure and definition through the United Nations Educational, Scientific and Cultural Organization's (UNESCO's) Man and Biosphere Programme.[16] Several programs, such as UNESCO's World Heritage Sites,[17] Biosphere Reserves, and International Union for Conservation of Nature (IUCN)[18] protected areas, use buffer zones as conservation tools. Examples of protected areas and their buffer zones include:

- Yasuní National Park in Ecuador, which contains one of the highest levels of plant and animal diversity on the planet, has a 10-km buffer zone to protect it from encroachment.

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16 http://www.unesco.org/new/en/natural-sciences/environment/ecological-sciences/man-and-biosphere-programme/

17 http://whc.unesco.org/en/list

18 http://www.iucn.org/what/tpas/biodiversity/

- Tambopata Department of Madre de Dios in Peru, a high-biodiversity lowland forest, has a buffer zone ranging from 2 to 25 km Wide.
- The Monarch Butterfly Biosphere Reserve in Mexico has a 12-km buffer zone to protect hibernating monarch butterflies.
- Batang Gadis National Park in Sumatra has a 10-km buffer zone to protect its biodiversity from encroachment and development (logging) pressures.

In the context of protecting against exposure to harmful substances, establishment of a buffer zone should consider the known harm caused by the substance, the likelihood of toxic exposure, the vulnerability and sensitivity of ecological receptors and humans, and the major sources of uncertainty described above. The exposure analysis presented in the first section of this report clearly shows that, under realistic spray-drift conditions, deposition rates that are harmful to sensitive plants can readily extend over distances of 10 km or greater. Considering the high degree of uncertainty associated with a thorough hazard assessment and risk assessment, it would be consistent with accepted risk management practice to ensure protection from adverse effects over at least that distance.

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Annex 7

Reinhard Joas, Ph.D., *The Development of the 2009 European Union Pesticides Directive With Particular Focus on Aerial Spraying* (Jan. 2011)

Annex 7

Prepared for the Government of Ecuador

The Development of the 2009 European Union Pesticides Directive With Particular Focus on Aerial Spraying

January 2011

BiPRO
Beratungsgesellschaft für integrierte Problemlösungen

Contents

1 Executive Summary

The purpose of this report is to provide an overview of the development, legislative process and effect of the European Union ban on the aerial spraying of pesticides. The report also considers Colombia's aerial spraying program in the context of the new EU Directive.

EU Directive 2009/128/EC entered into force on 25 November 2009. It sets mandatory rules for the use of pesticides in the EU, and has as its objective to reduce the risks and impacts of pesticide use on human health and the environment.

Among the measures introduced by the Directive is a general ban on the aerial spraying of pesticides, subject only to a limited ability to derogate in exceptional circumstances when certain conditions are present. This provision was included in the Directive following extensive discussions by EU institutions, Member States' representatives and numerous stakeholders. It reflects the consensus view at the EU level that the risks related to aerial spraying – the most important being adverse effects to non-target areas caused by spray drift – are not acceptable. Consequently, under the Directive, aerial spraying is only permitted in limited situations and under strict conditions of use, which help control the risks to human health and the environment. EU Member States may apply stricter legal restrictions than foreseen in the Directive but are not permitted to fall short of the standards it imposes.

Based on the risk-prevention rationale of Directive 2009/128/EC and its general ban on aerial spraying, the aerial spraying program to eradicate coca crops in Colombia would not be authorized in the EU.

2 About the Authors

This report was prepared by Dr. Reinhard Joas (Dipl.-Ing., Dipl.-Ök.) with the assistance of Dr. Alexandra Polcher, of the consulting company BiPRO (Beratungsgesellschaft für integrierte Problemlösungen).

Dr. Joas is the founder and Managing Director of BiPRO. He has served as consultant and policy adviser for more than a decade to national regulatory authorities, European institutions, including the European Commission and the European Parliament, and industry, focusing on issues related to pesticides, chemicals management, and risk prevention.

Dr. Joas has also served as an international expert for the United Nations Industrial Development Organisation (UNIDO) on chemicals, pesticides and cleaner production for more than 7 years, and is a member of the UNIDO advisory board for Latin America. Dr. Joas' work on behalf of UNIDO has included a project on the use of Plant Protection Products in Sri Lanka and another project on the use of Plant Protection Products in Serbia, both of which involved advising on the risks associated with pesticide use. Dr. Joas has also been retained as an international expert for the United Nations Environmental Programme (UNEP) on the responsible production and prevention of accidents. He is an active member of the international UNIDO-UNEP network on resource efficiency and cleaner production.

Beginning in 2003, Dr. Joas served as a consultant to the European Commission to evaluate policy options for regulating pesticide use generally and aerial spraying in particular. Dr. Joas led the project team that conducted an extended impact assessment for the European Commission to evaluate proposed policies related to the use of pesticides, including the general ban on aerial spraying. The assessment examined various policy options with regard to their economic, social and environmental impacts in order to provide EU institutions with a basis on which to make an informed decision. The final report, "Assessing economic impacts of the specific measures to be part of the Thematic Strategy on the Sustainable Use of Pesticides," issued in October 2004, contributed significantly to the European Commission's development of Directive 2009/128/EC on the sustainable use of pesticides.

On behalf of the European Commission, Dr. Joas helped to conduct an Expert Meeting on Aerial Spraying held in March 2004, which included more than 80 stakeholders ranging from regulatory authorities from Member States, to applicators and pilots, farmers, industry and NGOs. The Expert Meeting further contributed to the evaluation of various policy options and the development of provisions that were included in Article 9 of Directive 2009/128/EC.

Dr. Joas also participated in the Inter-Service consultation regarding the proposed policies, which involved the EU Directorates General for Environment, Health and Consumers, Agriculture, and Enterprise and Industry. The impact assessment that resulted from the Inter-Service consultation represented a key step towards the Commission's legislative proposal that was ultimately adopted by the European Parliament and the European Council on 13 January 2009 and 24 September 2009, respectively. Dr. Joas' curriculum vitae is provided in Appendix 1.

3 EU Directive 2009/128/EC and the Ban on Aerial Spraying

In 2009, the European Union adopted a general ban on aerial spraying that applies to all EU Member States. More specifically, Article 9 of Directive 2009/128/EC states that "*Member States shall ensure that aerial spraying is prohibited"* (Art. 9(1)). Derogations are allowed only in exceptional circumstances when certain conditions are met. This policy is part of a broader, legally binding Directive to strengthen the regulation of pesticide use in the EU.

This section discusses the origin and purpose of the Directive and the ban on aerial spraying, which are intended to reduce the health and environmental risks associated with the use of pesticides. It then addresses the character and legally binding nature of the Directive under EU law, and describes the development of the ban on aerial spraying, which included extensive public consultation, expert review, and input from both the administrative and legislative branches of the European Union. The section concludes with a summary of the Directive's provisions regarding aerial spraying.

3.1 Origin and Purpose of the Directive and the Ban on Aerial Spraying

The central objective of Directive 2009/128/EC is the minimisation of risk for human health and the environment. The general ban on aerial spraying was seen as a necessary measure in this context.

The overall purpose of the Directive is reflected by its Article 1:

> *"The Directive aims at achieving a sustainable use of pesticides by reducing the risks and impacts of pesticide use on human health and the environment and promoting the use of integrated pest management and of alternative approaches or techniques such as non-chemical alternatives to pesticides."*

With respect to aerial spraying, the Directive states that:

> *"Aerial Spraying of pesticides has the potential to cause significant adverse impacts on human health and the environment, in particular from spray drift. Therefore, aerial spraying should generally be prohibited with derogations possible where it represents clear advantages in terms of reduced impacts on human health and the environment in comparison to other spraying methods, or where there are no viable alternatives, provided that the best available technology to reduce drift is used."* (Directive 2009/128/EC, Recital 14).

Thus, the overarching objective of both the Directive as a whole and its general ban on aerial spraying is to reduce the risks and impacts of pesticide use on human health and the environment. The European Commission's "Impact Assessment of the Thematic Strategy on the Sustainable Use of Pesticides" explains the concerns behind the Directive in greater detail:

- Pesticides have an adverse impact on human health when the degree of exposure exceeds the level considered to be safe. Both direct exposure (workers and operators) and indirect exposure (consumers, residents, and bystanders) are of concern in this respect. Indirect risks, via spray drift or otherwise, can be amplified for vulnerable population groups such as children, the elderly, immunologically compromised people, and agricultural workers who receive more intensive exposure.

- Pesticides, which may enter the environment through direct application, leaching, run-off or spray drift, have adverse impacts by contaminating water, air and soil, damaging plants and wildlife, and causing a loss of biodiversity.[1]

A study mandated by the Commission and relating to future EU policy on pesticides (called "plant protection products (PPP)" under EU legislation) identified the following "Top Ten" concerns in connection with pesticide use in the Member States:

- Contamination of water resources used for human consumption
- Possible adverse effects on the ecology, e.g., non-target species
- Risks to consumers from food via residues
- Effects of exposure to residues in water, soil and air
- Contamination of surface water or marine environments
- Risks to users of agricultural chemicals
- Misuse of PPP due to lack of knowledge among the users
- Specific concern about adverse effects on an ecosystem element
- Dependence of agriculture on chemicals for pest control
- Frequent and large-scale use of PPP[2]

In order to avoid these risks, the starting point for the discussion of policy options during the development of the Directive was the proposal that use of pesticides must be well-directed to the intended target, and off-target effects of pesticides should be avoided in order to protect water, air and soil, plants and wildlife, and biodiversity.[3] With respect to aerial spraying, the policy discussions considered that:

- spray drift is a side effect which is inherent to aerial spraying;
- spray drift *always* has some effect on non-target organisms, which is considered an undesirable consequence;
- thus, a general ban on aerial spraying minimises risks to human health and the environment.

In particular, the Commission's Impact Assessment explained that aerial spraying "is suspected to have been at the origin of a majority of cases where dosages were exceeded and where the environment, in particular, watercourses, and residents and bystanders were endangered."[4] The Commission also noted that among the national policy initiatives that have been used to address the risks of pesticides to human health and the environment was the "[p]rohibition of aerial spraying for targeted protection of sensitive species and habitats, and protection of waters in general."[5]

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[1] (SEC (2006) 894), p. 6, *available at* http://ec.europa.eu/environment/ppps/pdf/sec_2006_0894.pdf, p. 24; *see also* Communication, Towards a Thematic Strategy, p. 12-13, *available at* http://eur-lex.europa.eu/LexUriServ/site/en/com/2002/com2002_0349en01.pdf.

[2] Oppenheimer, Wolf and Donnelly, 1998. Possibilities for future EU environmental policy on plant protection products, Synthesis report of six sub-reports in PES-A/phase 2, referenced in COM(2002) 349 final, p. 21.

[3] Document SEC (2006) 894), p. 24.

[4] Document SEC (2006) 894, p. 39.

[5] COM (2002) 349 final, p. 22.

Following the course already taken by a number of Member States, the European Union determined that the risks posed by aerial spraying were unacceptable and that, as a result, aerial spraying should not be permitted. Only in rare, exceptional cases could derogations from the ban be authorized, and in such cases, specific measures must be taken to reduce the impacts and risks from aerial spraying.

3.2 Character and Legal Effect of the Directive

In the European Union, environmental policies such Directive 2009/128/EC represent the agreement of the European Parliament and the European Council on a proposal by the European Commission, as amended during readings before the legislative bodies. Like most EU Directives, the Pesticides Directive reflects the result of expert statements, stakeholder consultation, inter-services consultation among the relevant EU agencies, and compromises between the institutions and various involved actors.

Legally, an EU Directive requires Member States to directly implement the provisions adopted by the competent EU institutions. Directives are implemented through national legislation that makes the policy binding on citizens and private legal entities. The precise form and method of implementation is left to national authorities (see Article 249 of Treaty Establishing the European Community (TEC) and Article 288 of Treaty on the Functioning of the European Union (TFEU)[6]).

With respect to the development of Directive 2009/128/EC, the European Commission determined that additional guidance and/or recommendations would be inadequate. In that regard, the legislative proposal of the European Commission explains the choice of a binding framework directive as the appropriate instrument by observing that "simple recommendations would not be efficient to achieve the envisaged objectives as these could not be enforced."[7] A binding directive was therefore recommended because if a Member State fails to implement a Directive, the European Commission has the authority to launch an infringement procedure and to bring the respective Member State to the European Court of Justice (Article 228 TEC / Article 260 TFEU).

Importantly, an EU Directive represents a minimum standard and the national legislation of Member States may be stricter than the minimum requirements in the Directive itself.[8] In the case of Directive 2009/128/EC, some Member States have in place a total ban on aerial spraying with no possibility for derogation, which goes beyond the requirements of the Directive.

3.3 Development of the Directive

Directive 2009/128/EC was the result of an extended consultation process amongst stakeholders and policymakers at the European and national levels. During this process, various policy options were evaluated based on their economic, social, health, and environmental impacts. The European

[6] Directive 2009/128/EC was adopted under the framework of the TEC which was repealed and replaced effective 1 December 2009 by the TFEU as the Treaties of Lisbon entered into force. In this document, references are made to both the TEC and the TFEU; deviations by the new framework are indicated.

[7] Proposal for a Directive of the European Parliament and of the Council establishing a framework for Community action to achieve a sustainable use of pesticides, presented by the Commission (COM(2006) 373 final), p. 12, available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2006:0373:FIN:EN:PDF

[8] For the case of legal acts based on the competence on the environment, see Article 176 TEC / Article 193 TFEU.

Commission received significant feedback from interested parties, including industry, NGOs, and Member States. Different geographical conditions and agricultural histories were represented.

The purpose of Directive 2009/128/EC was to minimize the health and environmental risks associated with the use of pesticides and to fill a legislative gap at the EU Level regarding the use phase of pesticide regulation. While the EU had previously established consistent standards for the authorisation of pesticides and requirements governing certain other issues, such as maximum residue levels on food and feedstuffs, water protection, and the proper disposal of pesticides, the use phase had not been not regulated at the EU level. Rather, the regulation of pesticide use prior to the Directive had been largely left to the Member States. As a result, there were different approaches and different levels of protection throughout the EU. With respect to aerial spraying, the approach of the Member States varied. A total ban (e.g. Estonia, Slovenia) could be observed as well as a ban with exceptions (e.g. Italy) or regulatory schemes controlling how aerial spraying may be carried out (e.g. Spain). In 10 of the EU Member States, no aerial spraying took place, partly on the basis of a national legal ban.[9]

During the course of the consultation process, the rationale behind the Directive – namely that minimising risks for health and the environment arising from pesticides use should be tackled at the Community level to ensure a high level of protection across Europe – was never seriously questioned.

3.3.1 The 6th Environmental Action Programme

Efforts at the EU level to address the risks associated with the use of pesticides started in 2002 with the adoption of the 6th Environment Action Programme (6th EAP)[10] by the European Parliament and the European Council. The Decision adopting the 6th EAP recognised that the impact of pesticides on human health and the environment must be reduced and stated that "there is no equal level of protection of human health and the environment throughout the Community and pesticide use shows diverging trends between Member States."[11] The 6th EAP proposed the development of a Thematic Strategy on the Sustainable Use of Pesticides with the following specific objectives:

1. to minimise the hazards and risks to health and the environment from the use of pesticides;
2. to improve controls on the use and distribution of pesticides;
3. to reduce the levels of harmful active substances, including through substituting the most dangerous ones with safer (including non-chemical) alternatives;
4. to encourage the use of low-input or pesticide-free crop farming, in particular by raising users' awareness and by promoting codes of good practices; and
5. to establish a transparent system for reporting and monitoring the progress made in the achievement of the objectives of the strategy, including the development of suitable indicators.[12]

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[9] Document SEC (2006) 894, p. 99-100.

[10] Decision n° 1600/2002/EC of the European Parliament and of the Council of 22 July 2002 laying down the Sixth Community Environment Action Programme – OJ L 242, 10.9.2002, p.1

[11] COM(2006) 373 final, p. 8

[12] The concept of thematic strategies was introduced in the 6th EAP and should be seen as a complement to the full implementation and review of the effectiveness of the existing legal framework.

Pursuant to the 6th EAP, the European Commission adopted in 2002 a Communication entitled "Towards a Thematic Strategy on the Sustainable Use of Pesticides."[13] In particular, the Communication identified aerial spraying as an area where action was needed to minimize hazards and risks to health and environment from the use of pesticides. The Commission proposed a general ban on aerial spraying with specific derogations authorized by the national authorities of the Member States only if aerial spraying presents clear advantages and environmental benefits compared to other methods.[14] The Communication was primarily based on the results of a two-phase study programme conducted in co-operation with the Dutch authorities since 1992.

3.3.2 Public Consultation and Technical Meetings

The Thematic Strategy was the basis for a public consultation process that began in July 2002. Enterprises, associations, and other concerned stakeholders, including private persons, were invited to comment on the document. More than 150 responses were received between July and November 2002. Subsequently, a stakeholder conference[15] on "Discussing the communication and establishing a priority-list to develop the Thematic Strategy," was held. The conference was attended, among others, by farmers and growers, NGOs, industry, social partners, the EU Commission, and representatives of public authorities in Member States, as well as by other interested parties.

Additional public consultation regarding the key elements of the new legislative framework was conducted over the internet from 17 March 2005 to 12 May 2005. The Commission received nearly 1,800 responses. Nearly half of the responses submitted highlighted the need for minimum requirements to ensure that aerial spraying is done with great care, the need for risk assessments by national authorities, and the importance of training and certification of pilots.

Further, between March 2003 and June 2004, a number of technical meetings were held, including meetings on aerial spraying. During these discussions, it was emphasized by numerous stakeholders that minimum requirements at the EU level should be established and that training and certification of applicators was a critical element for regulating the effects of aerial spraying.[16]

3.3.3 Expert Analysis

In parallel to the public comment process and the technical meetings, the possible impacts of the different policy options were assessed in a study carried out by Dr. Reinhard Joas on behalf of the European Commission.[17] For each of the policies under consideration, three to five options ranging from voluntary to mandatory measures were examined with regard to their economic, social, and environmental impacts. In addition, a no-action scenario was considered as a reference against which to appraise the costs and benefits anticipated from the measures proposed. This report was also subject to public comment, and a broad range of feedback was received from stakeholders.

With respect to the analysis of policy options to regulate aerial spraying, the study found that while

[13] COM (2002) 349
[14] COM (2002) 349, p. 30.
[15] http://ec.europa.eu/environment/ppps/1st_step_conf.htm
[16] See minutes of technical meeting of 31 March 2004, available at http://ec.europa.eu/environment/ppps/pdf/minutes_aerialspray.pdf
[17] Assessing economic impacts of the specific measures to be part of the Thematic Strategy on the Sustainable Use of Pesticides, ENV.C.4/ETU/2003/0094R, p. 103, October 2004, http://ec.europa.eu/environment/ppps/pdf/bipro_ppp_final_report.pdf.

the situation varies between the Member States, all Member States (except Malta) regulated aerial spraying.[18] The study also found that while strict minimum requirements or a legally binding ban on aerial spraying would bring major benefits to the environment and to the health of operators and bystanders, financial instruments were not favoured because they could not guarantee the necessary controls and ensure a clear shift away from improper aerial spraying practices.

3.3.4 Inter-Service Group Impact Assessment

On the basis of the analyses developed in the Commission's Communication "Towards a Thematic Strategy on the Sustainable Use of Pesticides"[19] and in the outcome of the consultation process, an Inter-Service Group consisting of experts from the EU Directorates General for Environment, Health and Consumers, Agriculture and Enterprise and Industry, conducted an extended assessment of the economic, social, and environmental impacts of the policies under consideration.[20] Among the most important measures considered were training and certification of pesticide users, certification and technical checks of spraying equipment, enhanced protection of water, and a general ban on aerial spraying.

3.3.5 Legislative Process

In July 2006, following the extended public consultation process, expert review, and impact assessment, the European Commission adopted the final "Thematic Strategy on the Sustainable Use of Pesticides"[21] and prepared a legislative proposal for revising the European Union's legal framework on pesticides. This legislative proposal included a framework Directive on the Sustainable Use of Pesticides, which included a general ban on aerial spraying.[22] Taking into consideration the outcome of the consultation process, the Commission explained the rationale for the proposed ban on aerial spraying as follows:

> *"Article 9 obliges Member States to prohibit Aerial Spraying but allows for derogations. Aerial Spraying should be prohibited because of its high potential to cause adverse effects on human health and the environment from spray drift. Derogations could be granted where Aerial Spraying has clear advantages and environmental benefits compared to other spraying methods or where there are no viable alternatives. Detailed requirements for derogation will be adopted at the level of the Member States, on which they shall report to the Commission."*[23]

Unlike other pieces of environmental legislation at the EU level, Directive 2009/128/EC moved relatively swiftly through the legislative process. Notably, both the European Parliament and the European Council endorsed the Commission's proposed general ban on aerial spraying and the

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[18] Assessing economic impacts of the specific measures to be part of the Thematic Strategy on the Sustainable Use of Pesticides, ENV.C.4/ETU/2003/0094R, p. 97-98, October 2004..

[19] Document COM(2002) 349 final, available at http://eur-lex.europa.eu/LexUriServ/site/en/com/2002/com2002_0349en01.pdf

[20] Document SEC (2006) 894.

[21] COM (2006) 372 final

[22] COM (2006) 373 final. Directive 2009/128/EC is part of a "package" of EU regulation that includes the Regulation 1107/2009 on the collection on statistics on plant protection products on the market (COM (2006) 778 final, revising Directive 91/414/EEC) and Directive 2009/127/EC which regulates the placement of pesticide application equipment on the market (amending Directive 2006/42/EC).

[23] COM (2006) 373 final

amendments offered served to strengthen the policy. In the first reading of the European Parliament in September 2007, Article 9 on aerial spraying was strengthened by introducing measures to absolutely prohibit aerial spraying in close proximity to public or residential areas. In the exceptional cases where aerial spraying would be allowed, the European Parliament added measures to require that warnings be given to nearby residents and bystanders and to further require the use of best available technology to reduce spray drift.[24] The European Council further strengthened the policy by adding a provision providing that where aerial spraying is allowed, the pesticides used must be explicitly approved following a risk assessment addressing the affects from aerial spraying and a separate provision mandating that enterprises conducting aerial spraying be certified.[25]

Following two readings by the European Parliament and the European Council, the two legislative bodies reached agreement on the text. The Directive was passed by a majority vote of the European Parliament on 13 January 2009 and confirmed by a majority vote of the Council on 24 September 2009.

3.3.6 Entry into Force and Implementation

Directive 2009/128/EC entered into force on 25 November 2009. Member States must implement the provisions of the Directive into national legislation by 14 December 2011. (see Directive 2009/128/EC Articles 23, 24). Whereas some Member States already have a compliant regime in place (e.g. Slovenia, with a total ban on aerial spraying), other Member States will be required to adjust their national legislation in order to comply with the requirements set out by the Directive.

3.4 Summary of Provisions Related to Aerial Spraying

Article 9 of Directive 2009/128/EC states that *"Member States shall ensure that aerial spraying is prohibited"* (Art. 9(1)). Derogations are allowed only in exceptional circumstances when certain conditions are met. Among other things, there must be no viable alternatives, or there must be clear advantages in terms of reduced impacts on human health and the environment as compared with land-based application of pesticides; the pesticides used must be explicitly approved for aerial spraying by the Member State following a specific assessment addressing risks from aerial spraying; and best available technology must be used to reduce spray drift (Art. 9(2)). The operator proposing to carry out the application must be certified by a program that includes training on a range of subjects, including relevant legislation, preparation and maintenance of equipment, the risks of pesticides to human health, non-target plants, beneficial insects, wildlife, biodiversity and the environment in general, and special care for sensitive areas (Art. 9(2)(c), Art. 5, Annex 1). In addition, if the area to be sprayed is in close proximity to areas open to the public, specific risk management measures must be put into place to ensure that there are no adverse effects on the health of bystanders. Aerial spraying is expressly prohibited "in close proximity to residential areas" (Art. 9(2)(e)). By imposing these numerous and strict requirements, the Directive recognized that all risk minimization measures must be complied with in order to ensure proper risk prevention and to make aerial spraying acceptable in the limited circumstances where it may be allowed.

[24] Documentation of proposed amendments available at
http://www.europarl.europa.eu/sides/getDoc.do?type=TA&language=EN&reference=P6-TA-2007-0444

[25] Documentation of proposed amendments available at
http://register.consilium.europa.eu/pdf/en/08/st06/st06124.en08.pdf

In those exceptional cases, operators do not have an automatic right to execute an aerial spraying operation if they believe they fulfil the requirements set forth in Article 9. Rather, the operator must demonstrate that the envisaged operation fully complies with the numerous and strict provisions of Article 9(2) and (3). Further, the operation must be expressly approved by the competent authority in the relevant Member State (Art. 9(4)). All approvals must specify the measures required for warning nearby residents and bystanders, as well as the specific measures required to protect the environment (Art. 9(3)).

The Directive assigns important functions to Member States. The competent authorities at the national level must implement monitoring programs to ensure that the strict conditions imposed by Article 9(2) and 9(3) are implemented (Art. 9(5). In addition, Member States must make available to the public relevant information contained in any approvals for aerial spraying, including the area to be sprayed, the provisional day and time of the spraying, and the type of pesticide that will be used (Art. 9(6)).

The full text of the Directive is included in Appendix 2.

4 Colombia's Aerial Spraying Program and the EU Directive

4.1 Factual basis

This Section evaluates whether the aerial spraying program to eradicate coca crops in Colombia, executed under similar conditions, would be permissible under EU Directive 2009/128/EC. It also describes the environmental assessment and planning that would be required for an aerial spraying program of this size, scope, and intensity.

The authors of this report have reviewed the following materials, which describe Colombia's aerial spraying program:

a. Colombia Counter-Memorial, Chapter 4;

b. Colombia Counter-Memorial Annex 67 (Report by the Anti-Narcotics Direction of the Colombian National Police, 8 Feb. 2010);

c. Republic of Colombia, Environmental Management Plan for the Illicit Crop Eradication Program Using Aerial Spraying with the Herbicide Glyphosate (2003), available at http://www.state.gov/p/inl/rls/rpt/aeicc/27399.htm;

d. U.S. Department of State, Chemicals Used for the Aerial Eradication of Illicit Coca in Colombia and Conditions of Application (2002), available at http://www.state.gov/p/inl/rls/rpt/aeicc/13234.htm;

e. U.S. Department of State, Updated Report on Chemicals Used in the Colombian Aerial Eradication Program (2003), available at http://www.state.gov/p/inl/rls/rpt/aeicc/26581.htm;

f. Solomon, K.R. et al. 2005, *Environmental and Human Health Assessment of the Aerial Spray Program for Coca and Poppy Control in Colombia*;

g. Solomon, K.R. et al. 2009, *Human Health and Environmental Risks from the Use of Glyphosate Formulations to Control the Production of Coca in Colombia*, Journal of Toxicology and Environmental Health, Part A, 72: 961-965; and

h. Hewitt, A.J. et al. 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.

4.2 Application of the Standards of Directive 2009/128/EC to Colombia's Aerial Spraying Program

As discussed in Section 3, the EU Directive creates a general ban on aerial spraying. In the case of an exceptional derogation from the ban, the Directive sets out a number of risk reduction requirements at the EU level that must be met. It is unlikely that Colombia's aerial spraying program would be considered one of these exceptional cases because the size, scope and intensity of the program significantly increase the risks to human health and the environment, particularly in the form of off-target damage caused by spray drift. These are precisely the types of risks that the EU Directive seeks to prevent. Further, Colombia's aerial spraying program does not meet many of the specific requirements necessary to allow a derogation from the general ban on aerial spraying.

- **Risk assessment and pesticide used**

In cases where aerial spraying is allowed under the EU Directive, "the pesticide used must be explicitly approved for aerial spraying by the respective Member State following a specific assessment addressing risks from aerial spraying." Art. 9(2)(b). Colombia has presented several studies evaluating the environmental risks associated with the aerial spraying operations, including Solomon et al. 2005 and Solomon et al. 2009. However, these studies do not involve field-based testing of important factors, such as pesticide spray drift, nor do they address the actual conditions of application in Colombia. In addition, there have been changes to the pesticides used during the course of Colombia's aerial spraying program and it is not clear whether a specific assessment of risks from aerial spraying was conducted for each combination of chemicals.

Independent of the formal question of whether a "specific assessment addressing the risks of aerial spraying" has been conducted or not, the manner in which Colombia aerially sprays an indiscriminate, broad spectrum herbicide contradicts the underlying rationale of the EU Directive to reduce risks from spray drift to non-target organisms.

- **Risk minimisation measures regarding sensitive areas**

The Directive requires that "if the area to be sprayed is in close proximity to areas open to the public, specific risk management measures to ensure that there are no adverse effects on the health of bystanders have to be included in the approval." In addition, "the area to be sprayed must not be in close proximity to residential areas." Art. 9(2)(e). Colombia's Environmental Management Plan and other procedures are unlikely to ensure "no adverse effects" on the health of bystanders. In particular, the fact that aerial spraying is allowed within 100 meters of human settlements increases the risk of human health effects and would most likely be considered to be "in close proximity to residential areas", particularly under the conditions of application in Colombia.

Further, Member States must specify the means to announce the operation and give adequate warnings to residents. The authors are not aware of specific risk management measures of this type that are in place in Colombia. The operations conducted near the international border are not announced in advance, so no warnings are given to people in Ecuador.

- **Best available technology**

The Directive requires the use of "best available technology to reduce spray drift." Art. 9(f). While the authors of this study do not have the information available to evaluate all of the technologies employed by Colombia's aerial spraying program, we note that the use of OV-10 aircraft, which were not designed for aerial spraying, would not be considered "best available technology." In addition, the study by Hewitt et al. (2009) indicates that the spray nozzles used are not optimal in terms of reducing spray drift.

- **Emergency situations**

Article 9(4) of the EU Directive addresses emergency situations where expedited procedures may be allowed to authorize aerial spraying. Nevertheless, the requirements of Articles 9(2) and 9(3), including the risk assessment and risk minimization measures described above, must be fulfilled. In other words, addressing risks and impacts and providing adequate information to bystanders is considered more important than the possible benefits from quickly implementing aerial spraying. Colombia's aerial spraying program, which has been conducted for more than 10 years, would not likely be considered an emergency situation subject to expedited procedures. Even if it were justified as an emergency situation, the requirements of the Directive would still have to be met, and the program as currently conducted would be prohibited.

- **Environmental Impact Assessment**

Assuming for the sake of argument that Colombia's aerial spraying could be undertaken in the EU, an aerial spraying program of the size and scope of Colombia's coca eradication program would not only have to comply with Directive 2009/128/EC, it would also require an in-depth environmental impact assessment (EIA) prior to authorization. The EIA requirement is not unique to the EU; it would also be required in all of the other jurisdictions that the authors of this report are familiar with.

In the EU, the environmental impact assessment of an aerial spraying program of the scope of Colombia's would need to identify, at the very least, the direct and indirect effects of the project on the following factors: human health, fauna, flora, soil, water, air, climate, landscape, material assets and cultural heritage, and the interaction between these various elements. Based on our review of Colombia's aerial spraying program, however, there is no indication that a prior EIA was designed or carried out that would satisfy the requirements of the EU or any other jurisdiction with which we are familiar.

Colombia has presented an Environmental Management Plan (EMP). This can be considered as a supportive tool for an EIA, but it cannot replace an environmental impact assessment. An EMP, which is a plan for mitigating risks, must be based on an EIA, which identifies the risks in the first place and evaluates options to address them. For example, Colombia would need to analyze the risks associated with various operational parameters before setting such parameters. As another example, Colombia would need to evaluate impacts to non-target organisms before designing a plan to protect such organisms.

The EMP should be designed to ensure an adequate margin of safety to avoid risks to human health and the environment. Such margins of safety can be derived, for example, from chemicals risk assessment (see Regulation (EC) No 1907/2006 "REACH" and corresponding guidance on chemicals safety, where a NOAEL (No Observed Adverse Effect Level) of a chemical is measured and a safety is applied to derive acceptable exposure limits for humans). In the case of Colombia's aerial spraying program, the margin of safety should take into account, at a minimum: the scale of the project, the variability of environmental conditions and unpredictable events (e.g. weather patterns, hostile fire, etc), the number of operational parameters that must be controlled for, and the sensitivity of the receiving environment (vulnerable human population and highly diverse and sensitive ecology). Colombia, however, has not done this.

In sum, Colombia's aerial spraying program presents risks to off-target people and environmental resources that are not in line with the guiding principles of EU legislation. The operations would not be acceptable under the Directive and would not be permitted by any EU Member State.

5 Conclusion

EU Directive 2009/128/EC sets standards for the sustainable use of pesticides throughout the EU. One of the measures introduced by the Directive is a general ban on aerial spraying of pesticides, with the possibility for derogation in exceptional circumstances when certain conditions are met. This provision was included in the Directive following extensive discussions by EU institutions, Member States' representatives, and numerous stakeholders. It expresses the consensus at the EU level that the risks related to aerial spraying – the most important being adverse effects to non-target areas caused by spray drift – are unacceptable. Thus, aerial spraying is only allowed in very limited cases and under strict conditions of use, which help control the risks to human health and the environment. Based on the information provided by Colombia, its aerial spraying program does not fulfil several of the conditions required to obtain an exceptional permit under the EU Directive. In light of the risk-prevention rationale of Directive 2009/128/EC and its general ban on aerial spraying, the aerial spraying program to eradicate coca crops in Colombia would not be authorized in the EU.

6 Annexes

Annex 1 – Curriculum vitae of Reinhard Joas

Annex 2 – Copy of Directive 2009/128/EC

Contact details:

BiPRO GmbH
Grauertstr. 12
81545 Munich, Germany
Phone: +49-89-18979050
Fax: +49-89-18979052
URL: http://www.bipro.de

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APPENDIX 1

Curriculum Vitae of Reinhard Joas, Ph.D.

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Europass Curriculum Vitae

Personal information

First name(s) / Surname(s)	**Reinhard Joas**
Address(es)	BiPRO GmbH, Grauertstr. 12, 81545 Munich, Germany
Telephone(s)	+49 89 18 97 90 50
Fax(es)	+49 89 18 97 90 52
E-mail	Reinhard.joas@bipro.de
Nationality	German
Date of birth	21 November 1961
Gender	male

Work experience

Dates	Since 1999
Occupation or position held	Managing Director
Main activities and responsibilities	**Environmental technologies and industrial processes** • Key expert on process optimization, environmental technologies and risk prevention • Project leader for diverse projects for public authorities and industry on sustainable use of chemicals **Innovative business models regarding the sustainable use of chemicals** • International key expert for chemicals management, chemical leasing and cleaner production • Project leader for implementation projects for innovative sustainable business models related to various processes and industry branches **Occupational Health & Safety** • Responsibilities in studies on health and safety at work place **Environment and Health** • Project coordinator for several projects in the field of human biomonitoring **REACH and chemicals policy** • Key expert for REACH • Project leader for elaboration of REACH dossiers and REACh related services
Name and address of employer	BiPRO GmbH, Munich, Germany
Type of business or sector	Consultancy
Dates	1990 - 1999
Occupation or position held	Director, project leader
Main activities and responsibilities	Project leader for various consulting tasks for ministries and companies regarding technical, economical, ecological problems
Name and address of employer	ECOTEC, Munich, Germany
Type of business or sector	Consultancy
Dates	1989 – 1990

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Occupation or position held	Expert, project leader
Main activities and responsibilities	• Risk assessment for industrial risks in all branches as an expert for the world wide business of technical insurance • Strategy development for business implementation in emerging markets in South East Asia
Name and address of employer	Allianz AG, Germany
Type of business or sector	Technical Insurance

Education and training

Dates	1989-1990
Title of qualification awarded	Doctor of Economic Science (Dr. rer. pol.)
Principal subjects/occupational skills covered	Scientific work on environmental, technical and economic improvement of chlorine chemistry
Name and type of organisation providing education and training	Universität Bremen, Germany
Level in national or international classification	Level 6
Dates	1983-1987
Title of qualification awarded	Economist (Dipl. Ök.)
Principal subjects/occupational skills covered	Scientific work on decision making theories; micro- and macro economy education
Name and type of organisation providing education and training	Fernuniversität Hagen, Germany
Level in national or international classification	Level 5
Dates	1982-1988
Title of qualification awarded	Engineer (Dipl. -Ing.)
Principal subjects/occupational skills covered	Chemical and mechanical engineering, processing
Name and type of organisation providing education and training	Technical University of Munich, Germany
Level in national or international classification	Level 5

Personal skills and competences

Mother tongue(s) German

Other language(s)

Self-assessment	**Understanding**				**Speaking**				**Writing**	
European level	Listening		Reading		Spoken interaction		Spoken production			
English	C2	Proficient user	C2	Proficient user	C2	Proficient user	C2	Proficient user	C2	Proficient user
Spanish	B2	Independent user	B2	Independent user	B2	Independent user	B2	Independent user	B2	Independent user

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Organisational skills and competences	• Company leader with all related organisational competences • Organisation, moderation and post-processing of international meetings, conferences and negotiations • Chair of working groups for health, safety and environmental topics of several associations • Advisor to UNIDO and UNEP • Advisor to the European Commission and national governments
Technical skills and competences	• Policy options assessment and policy support on decision making process • Drafting of documents and guidance for European governments • Stakeholder consultation • Execution of impact assessments • Execution of risk assessments and risk quantifications (for various branches)
Computer skills and competences	• Proficient user of Microsoft Office application
Additional information	• Founding Member of the international network on Resource Efficiency and Cleaner Production (RECP) of UNIDO/UNEP • Member of the UNIDO Advisory Committee for Latin America • Member of International working group on Chemical Leasing

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APPENDIX 2

European Union Pesticides Directive

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DIRECTIVES

DIRECTIVE 2009/128/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 21 October 2009

establishing a framework for Community action to achieve the sustainable use of pesticides

(Text with EEA relevance)

THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION,

Having regard to the Treaty establishing the European Community, and in particular Article 175(1) thereof,

Having regard to the proposal from the Commission,

Having regard to the opinion of the European Economic and Social Committee [1],

Having regard to the opinion of the Committee of the Regions [2],

Acting in accordance with the procedure laid down in Article 251 of the Treaty [3],

Whereas:

(1) In line with Articles 2 and 7 of Decision No 1600/2002/EC of the European Parliament and of the Council of 22 July 2002 laying down the Sixth Community Environment Action Programme [4], a common legal framework for achieving a sustainable use of pesticides should be established, taking account of precautionary and preventive approaches.

(2) At present, this Directive should apply to pesticides which are plant protection products. However, it is anticipated that the scope of this Directive will be extended to cover biocidal products.

(3) The measures provided for in this Directive should be complementary to, and not affect, measures laid down in other related Community legislation, in particular Council Directive 79/409/EEC of 2 April 1979 on the conservation of wild birds [5], Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora [6], Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy [7], Regulation (EC) No 396/2005 of the European Parliament and of the Council of 23 February 2005 on maximum residue levels of pesticides in or on food and feed of plant and animal origin [8] and Regulation (EC) No 1107/2009 of the European Parliament and of the Council of 21 October 2009 on the placing of plant protection products on the market [9]. These measures should also not prejudice voluntary measures in the context of Regulations for Structural Funds or of Council Regulation (EC) No 1698/2005 of 20 September 2005 on support for rural development by the European Agricultural Fund for Rural Development (EAFRD) [10].

(4) Economic instruments can play a crucial role in the achievement of objectives relating to the sustainable use of pesticides. The use of such instruments at the appropriate level should therefore be encouraged while stressing that individual Member States can decide on their use without prejudice to the applicability of the State aid rules.

(5) National Action Plans aimed at setting quantitative objectives, targets, measures, timetables and indicators to reduce risks and impacts of pesticide use on human health and the environment and at encouraging the development and introduction of integrated pest management and of alternative approaches or techniques in order to reduce dependency on the use of pesticides should be used by Member States in order to facilitate the implementation of this Directive. Member States should monitor the use of plant protection products containing active substances of particular concern and

(1) OJ C 161, 13.7.2007, p. 48.
(2) OJ C 146, 30.6.2007, p. 48.
(3) Opinion of the European Parliament of 23 October 2007 (OJ C 263 E, 16.10.2008, p. 158), Council Common Position of 19 May 2008 (OJ C 254 E, 7.10.2008, p. 1) and Position of the European Parliament of 13 January 2009 (not yet published in the Official Journal). Council Decision of 24 September 2009.
(4) OJ L 242, 10.9.2002, p. 1.
(5) OJ L 103, 25.4.1979, p. 1.
(6) OJ L 206, 22.7.1992, p. 7.
(7) OJ L 327, 22.12.2000, p. 1.
(8) OJ L 70, 16.3.2005, p. 1.
(9) See page 1 of this Official Journal.
(10) OJ L 277, 21.10.2005, p. 1.

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establish timetables and targets for the reduction of their use, in particular when it is an appropriate means to achieve risk reduction targets. National Action Plans should be coordinated with implementation plans under other relevant Community legislation and could be used for grouping together objectives to be achieved under other Community legislation related to pesticides.

(6) The exchange of information on the objectives and actions Member States lay down in their National Action Plans is a very important element for achieving the objectives of this Directive. Therefore, it is appropriate to request Member States to report regularly to the Commission and to the other Member States, in particular on the implementation and results of their National Action Plans and on their experiences. On the basis of information transmitted by the Member States, the Commission should submit relevant reports to the European Parliament and to the Council, accompanied, if necessary, by appropriate legislative proposals.

(7) For the preparation and modification of National Action Plans, it is appropriate to provide for the application of Directive 2003/35/EC of the European Parliament and of the Council of 26 May 2003 providing for public participation in respect of the drawing up of certain plans and programmes relating to the environment [1].

(8) It is essential that Member States set up systems of both initial and additional training for distributors, advisors and professional users of pesticides and certification systems to record such training so that those who use or will use pesticides are fully aware of the potential risks to human health and the environment and of the appropriate measures to reduce those risks as much as possible. Training activities for professional users may be coordinated with those organised in the framework of Regulation (EC) No 1698/2005.

(9) Sales of pesticides, including Internet sales, are an important element in the distribution chain, where specific advice on safety instructions for human health and the environment should be given to the end user at the time of sale, in particular to professional users. For non-professional users who in general do not have the same level of education and training, recommendations should be given, in particular on safe handling and storage of pesticides as well as on disposal of the packaging.

(10) Considering the possible risks from the use of pesticides, the general public should be better informed of the overall impacts of the use of pesticides through awareness-raising campaigns, information passed on through retailers and other appropriate measures.

(11) Research programmes aimed at determining the impacts of pesticide use on human health and the environment, including studies on high-risk groups, should be promoted at European and national level.

(12) To the extent that the handling and application of pesticides require the setting of minimum health and safety requirements at the workplace, covering the risks arising from exposure of workers to such products, as well as general and specific preventive measures to reduce those risks, those measures are covered by Council Directive 98/24/EC of 7 April 1998 on the protection of the health and safety of workers from the risks related to chemical agents at work [2] and Directive 2004/37/EC of the European Parliament and of the Council of 29 April 2004 on the protection of workers from the risks related to their exposure to carcinogens or mutagens at work [3].

(13) Since Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery [4] will provide for rules on the placing on the market of pesticide application equipment ensuring that environmental requirements are met, it is appropriate, in order to minimise the adverse impacts of pesticides on human health and the environment caused by such equipment, to provide for systems for regular technical inspection of pesticide application equipment already in use. Member States should describe in their National Action Plans how they will ensure the implementation of those requirements.

(14) Aerial spraying of pesticides has the potential to cause significant adverse impacts on human health and the environment, in particular from spray drift. Therefore, aerial spraying should generally be prohibited with derogations possible where it represents clear advantages in terms of reduced impacts on human health and the environment in comparison with other spraying methods, or where there are no viable alternatives, provided that the best available technology to reduce drift is used.

(15) The aquatic environment is especially sensitive to pesticides. It is therefore necessary for particular attention to be paid to avoiding pollution of surface water and groundwater by taking appropriate measures, such as the establishment of buffer and safeguard zones or planting hedges along surface waters to reduce exposure of water bodies to spray drift, drain flow and run-off. The dimensions of buffer zones should depend in particular on soil characteristics and pesticide properties, as well as agricultural characteristics of the areas concerned. Use of pesticides in areas for the abstraction of drinking water, on or along transport

(1) OJ L 156, 25.6.2003, p. 17.

(2) OJ L 131, 5.5.1998, p. 11.
(3) OJ L 158, 30.4.2004, p. 50.
(4) OJ L 157, 9.6.2006, p. 24.

routes, such as railway lines, or on sealed or very permeable surfaces can lead to higher risks of pollution of the aquatic environment. In such areas the pesticide use should, therefore, be reduced as far as possible, or eliminated, if appropriate.

(16) Use of pesticides can be particularly dangerous in very sensitive areas, such as Natura 2000 sites protected in accordance with Directives 79/409/EEC and 92/43/EEC. In other places such as public parks and gardens, sports and recreation grounds, school grounds and children's playgrounds, and in the close vicinity of healthcare facilities, the risks from exposure to pesticides are high. In these areas, the use of pesticides should be minimised or prohibited. When pesticides are used, appropriate risk management measures should be established and low-risk pesticides as well as biological control measures should be considered in the first place.

(17) Handling of pesticides, including storage, diluting and mixing the pesticides and cleaning of pesticide application equipment after use, and recovery and disposal of tank mixtures, empty packaging and remnants of pesticides are particularly prone to unwanted exposure of humans and the environment. Therefore, it is appropriate to provide for specific measures addressing those activities as a complement to the measures provided for under Directive 2006/12/EC of the European Parliament and of the Council of 5 April 2006 on waste [1], and Council Directive 91/689/EEC of 12 December 1991 on hazardous waste [2]. Measures should also encompass non-professional users, since inappropriate handling is very likely to occur in this group of users due to their lack of knowledge.

(18) The application of general principles and crop and sector-specific guidelines with respect to integrated pest management by all farmers would result in a better targeted use of all available pest control measures, including pesticides. Therefore, it would contribute to a further reduction of the risks to human health and the environment and the dependency on the use of pesticides. Member States should promote low pesticide-input pest management, in particular integrated pest management, and establish the necessary conditions and measures for its implementation.

(19) On the basis of Regulation (EC) No 1107/2009 and of this Directive, implementation of the principles of integrated pest management is obligatory and the subsidiarity principle applies to the way the principles for integrated pest management are implemented. Member States should describe in their National Action Plan how they ensure the implementation of the principles of integrated pest management, with priority given wherever possible to non-chemical methods of plant protection and pest and crop management.

(20) It is necessary to measure the progress achieved in the reduction of risks and adverse impacts from pesticide use for human health and the environment. Appropriate means are harmonised risk indicators that will be established at Community level. Member States should use those indicators for risk management at national level and for reporting purposes, while the Commission should calculate indicators to evaluate progress at Community level. Statistical data collected in accordance with the Community legislation concerning statistics on plant protection products should be used. Member States should be entitled to use, in addition to harmonised common indicators, their national indicators.

(21) Member States should determine penalties applicable to infringements of national provisions adopted pursuant to this Directive and ensure that they are implemented. The penalties should be effective, proportionate and dissuasive.

(22) Since the objective of this Directive, namely to protect human health and the environment from possible risks associated with the use of pesticides, cannot be sufficiently achieved by the Member States and can therefore be better achieved at Community level, the Community may adopt measures, in accordance with the principle of subsidiarity as set out in Article 5 of the Treaty. In accordance with the principle of proportionality, as set out in that Article, this Directive does not go beyond what is necessary in order to achieve that objective.

(23) This Directive respects the fundamental rights and observes the principles recognised notably by the Charter of Fundamental Rights of the European Union. In particular, this Directive seeks to promote the integration into Community policies of a high level of environmental protection in accordance with the principle of sustainable development as laid down in Article 37 of that Charter.

(24) The measures necessary for the implementation of this Directive should be adopted in accordance with Council Decision 1999/468/EC of 28 June 1999 laying down the procedures for the exercise of implementing powers conferred on the Commission [3].

(25) In particular, the Commission should be empowered to establish and update the Annexes to this Directive. Since those measures are of general scope and are designed to amend non-essential elements of this Directive, inter alia, by supplementing it with new non-essential elements, they must be adopted in accordance with the regulatory procedure with scrutiny provided for in Article 5a of Decision 1999/468/EC.

(1) OJ L 114, 27.4.2006, p. 9.
(2) OJ L 377, 31.12.1991, p. 20.
(3) OJ L 184, 17.7.1999, p. 23.

Annex 7

(26) In accordance with point 34 of the Interinstitutional agreement on better law-making ([1]), Member States are encouraged to draw up, for themselves and in the interests of the Community, their own tables illustrating, as far as possible, the correlation between this Directive and the transposition measures, and to make them public,

HAVE ADOPTED THIS DIRECTIVE:

CHAPTER I

GENERAL PROVISIONS

Article 1

Subject matter

This Directive establishes a framework to achieve a sustainable use of pesticides by reducing the risks and impacts of pesticide use on human health and the environment and promoting the use of integrated pest management and of alternative approaches or techniques such as non-chemical alternatives to pesticides.

Article 2

Scope

1. This Directive shall apply to pesticides that are plant protection products as defined in point 10(a) of Article 3.

2. This Directive shall apply without prejudice to any other relevant Community legislation.

3. The provisions of this Directive shall not prevent Member States from applying the precautionary principle in restricting or prohibiting the use of pesticides in specific circumstances or areas.

Article 3

Definitions

For the purposes of this Directive, the following definitions shall apply:

1. 'professional user' means any person who uses pesticides in the course of their professional activities, including operators, technicians, employers and self-employed people, both in the farming and other sectors;

2. 'distributor' means any natural or legal person who makes a pesticide available on the market, including wholesalers, retailers, vendors and suppliers;

([1]) OJ C 321, 31.12.2003, p. 1.

3. 'advisor' means any person who has acquired adequate knowledge and advises on pest management and the safe use of pesticides, in the context of a professional capacity or commercial service, including private self-employed and public advisory services, commercial agents, food producers and retailers where applicable;

4. 'pesticide application equipment' means any apparatus specifically intended for the application of pesticides, including accessories that are essential for the effective operation of such equipment, such as nozzles, manometers, filters, strainers and cleaning devices for tanks;

5. 'aerial spraying' means application of pesticides from an aircraft (plane or helicopter);

6. 'integrated pest management' means careful consideration of all available plant protection methods and subsequent integration of appropriate measures that discourage the development of populations of harmful organisms and keep the use of plant protection products and other forms of intervention to levels that are economically and ecologically justified and reduce or minimise risks to human health and the environment. 'Integrated pest management' emphasises the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms;

7. 'risk indicator' means the result of a method of calculation that is used to evaluate risks of pesticides on human health and/or the environment;

8. 'non-chemical methods' means alternative methods to chemical pesticides for plant protection and pest management, based on agronomic techniques such as those referred to in point 1 of Annex III, or physical, mechanical or biological pest control methods;

9. the terms 'surface water' and 'groundwater' have the same meaning as in Directive 2000/60/EC;

10. 'pesticide' means:

(a) a plant protection product as defined in Regulation (EC) No 1107/2009;

(b) a biocidal product as defined in Directive 98/8/EC of the European Parliament and of the Council of 16 February 1998 concerning the placing on the market of biocidal products ([2]).

([2]) OJ L 123, 24.4.1998, p. 1.

Article 4

National Action Plans

1. Member States shall adopt National Action Plans to set up their quantitative objectives, targets, measures and timetables to reduce risks and impacts of pesticide use on human health and the environment and to encourage the development and introduction of integrated pest management and of alternative approaches or techniques in order to reduce dependency on the use of pesticides. These targets may cover different areas of concern, for example worker protection, protection of the environment, residues, use of specific techniques or use in specific crops.

The National Action Plans shall also include indicators to monitor the use of plant protection products containing active substances of particular concern, especially if alternatives are available. Member States shall give particular attention to the plant protection products containing active substances approved in accordance with Council Directive 91/414/EEC of 15 July 1991 concerning the placing of plant products on the market ([1]) which, when subject to renewal of approval under Regulation (EC) No 1107/2009 will not fulfil the criteria relevant for approval laid down in Annex II, points 3.6 to 3.8 of that Regulation.

On the basis of such indicators and taking into account where applicable the risk or use reduction targets achieved already prior to the application of this Directive, timetables and targets for the reduction of use shall also be established, in particular if the reduction of use constitutes an appropriate means to achieve risk reduction with regard to priority items identified under Article 15(2)(c). These targets may be intermediate or final. Member States shall use all necessary means designed to achieve these targets.

When drawing up and revising their National Action Plans, Member States shall take account of the health, social, economic and environmental impacts of the measures envisaged, of specific national, regional and local conditions and all relevant stakeholder groups. Member States shall describe in their National Action Plans how they will implement measures pursuant to Articles 5 to 15 in order to achieve the objectives referred to in the first subparagraph of this paragraph.

The National Action Plans shall take into account plans under other Community legislation on the use of pesticides, such as planned measures under Directive 2000/60/EC.

2. By 14 December 2012, Member States shall communicate their National Action Plans to the Commission and to other Member States.

([1]) OJ L 230, 19.8.1991, p. 1.

National Action Plans shall be reviewed at least every five years and any substantial changes to National Action Plans shall be reported to the Commission without undue delay.

3. By 14 December 2014, the Commission shall submit to the European Parliament and to the Council a report on the information communicated by the Member States in relation to the National Action Plans. The report shall contain methods used and the implications concerning the establishment of different types of targets to reduce the risks and use of pesticides.

By 14 December 2018, the Commission shall submit to the European Parliament and to the Council a report on the experience gained by Member States on the implementation of national targets established in accordance with paragraph 1 in order to achieve the objectives of this Directive. It may be accompanied, if necessary, by appropriate legislative proposals.

4. The Commission shall make information communicated in accordance with paragraph 2 available to the public on a website.

5. The provisions on public participation laid down in Article 2 of Directive 2003/35/EC shall apply to the preparation and the modification of the National Action Plans.

CHAPTER II

TRAINING, SALES OF PESTICIDES, INFORMATION AND AWARENESS-RAISING

Article 5

Training

1. Member States shall ensure that all professional users, distributors and advisors have access to appropriate training by bodies designated by the competent authorities. This shall consist of both initial and additional training to acquire and update knowledge as appropriate.

The training shall be designed to ensure that such users, distributors and advisors acquire sufficient knowledge regarding the subjects listed in Annex I, taking account of their different roles and responsibilities.

2. By 14 December 2013, Member States shall establish certification systems and designate the competent authorities responsible for their implementation. These certificates shall, as a minimum, provide evidence of sufficient knowledge of the subjects listed in Annex I acquired by professional users, distributors and advisors either by undergoing training or by other means.

Certification systems shall include requirements and procedures for the granting, renewal and withdrawal of certificates.

3. Measures designed to amend non-essential elements of this Directive relating to amending Annex I in order to take account of scientific and technical progress shall be adopted in accordance with the regulatory procedure with scrutiny referred to in Article 21(2).

Article 6

Requirements for sales of pesticides

1. Member States shall ensure that distributors have sufficient staff in their employment holding a certificate referred to in Article 5(2). Such persons shall be available at the time of sale to provide adequate information to customers as regards pesticide use, health and environmental risks and safety instructions to manage those risks for the products in question. Micro distributors selling only products for non-professional use may be exempted if they do not offer for sale pesticide formulations classified as toxic, very toxic, carcinogenic, mutagenic or toxic for reproduction pursuant to Directive 1999/45/EC of the European Parliament and of the Council of 31 May 1999 concerning the approximation of the laws, regulations and administrative provisions of the Member States relating to the classification, packaging and labelling of dangerous preparations [1].

2. Member States shall take necessary measures to restrict sales of pesticides authorised for professional use to persons holding a certificate referred to in Article 5(2).

3. Member States shall require distributors selling pesticides to non-professional users to provide general information regarding the risks for human health and the environment of pesticide use, in particular on hazards, exposure, proper storage, handling, application and safe disposal in accordance with Community legislation on waste, as well as regarding low-risk alternatives. Member States may require pesticide producers to provide such information.

4. The measures provided for in paragraphs 1 and 2 shall be established by 14 December 2015.

Article 7

Information and awareness-raising

1. Member States shall take measures to inform the general public and to promote and facilitate information and awareness-raising programmes and the availability of accurate and balanced information relating to pesticides for the general public, in particular regarding the risks and the potential acute and chronic effects for human health, non-target organisms and the environment arising from their use, and the use of non-chemical alternatives.

2. Member States shall put in place systems for gathering information on pesticide acute poisoning incidents, as well as chronic poisoning developments where available, among groups that may be exposed regularly to pesticides such as operators, agricultural workers or persons living close to pesticide application areas.

3. To enhance the comparability of information, the Commission, in cooperation with the Member States, shall develop by 14 December 2012 a strategic guidance document on monitoring and surveying of impacts of pesticide use on human health and the environment.

CHAPTER III

PESTICIDE APPLICATION EQUIPMENT

Article 8

Inspection of equipment in use

1. Member States shall ensure that pesticide application equipment in professional use shall be subject to inspections at regular intervals. The interval between inspections shall not exceed five years until 2020 and shall not exceed three years thereafter.

2. By 14 December 2016, Member States shall ensure that pesticide application equipment has been inspected at least once. After this date only pesticide application equipment having successfully passed inspection shall be in professional use.

New equipment shall be inspected at least once within a period of five years after purchase.

3. By way of derogation from paragraphs 1 and 2 and, following a risk assessment for human health and the environment including an assessment of the scale of the use of the equipment, Member States may:

(a) apply different timetables and inspection intervals to pesticide application equipment not used for spraying pesticides, to handheld pesticide application equipment or knapsack sprayers and to additional pesticide application equipment that represent a very low scale of use, which shall be listed in the National Action Plans provided for in Article 4.

The following additional pesticide application equipment shall never be considered as constituting a very low scale of use:

(i) spraying equipment mounted on trains or aircraft;

[1] OJ L 200, 30.7.1999, p. 1.

(ii) boom sprayers larger than 3 m, including boom sprayers that are mounted on sowing equipment;

(b) exempt from inspection handheld pesticide application equipment or knapsack sprayers. In this case the Member States shall ensure that operators have been informed of the need to change regularly the accessories, of the specific risks linked to that equipment, and that operators are trained for the proper use of that application equipment in accordance with Article 5.

4. The inspections shall verify that pesticide application equipment satisfies the relevant requirements listed in Annex II, in order to achieve a high level of protection for human health and the environment.

Pesticide application equipment complying with harmonised standards developed in accordance with Article 20(1) shall be presumed to comply with the essential health and safety and environmental requirements.

5. Professional users shall conduct regular calibrations and technical checks of the pesticide application equipment in accordance with the appropriate training received as provided for in Article 5.

6. Member States shall designate bodies responsible for implementing the inspection systems and inform the Commission thereof.

Each Member State shall establish certificate systems designed to allow the verification of inspections and recognise the certificates granted in other Member States following the requirements referred to in paragraph 4 and where the time period since the last inspection carried out in another Member State is equal to or shorter than the time period of the inspection interval applicable in its own territory.

Member States shall endeavour to recognise the certificates issued in other Member States provided that the inspection intervals referred to in paragraph 1 are complied with.

7. Measures designed to amend non-essential elements of this Directive relating to amending Annex II in order to take account of scientific and technical progress shall be adopted in accordance with the regulatory procedure with scrutiny referred to in Article 21(2).

CHAPTER IV

SPECIFIC PRACTICES AND USES

Article 9

Aerial spraying

1. Member States shall ensure that aerial spraying is prohibited.

2. By way of derogation from paragraph 1 aerial spraying may only be allowed in special cases provided the following conditions are met:

(a) there must be no viable alternatives, or there must be clear advantages in terms of reduced impacts on human health and the environment as compared with land-based application of pesticides;

(b) the pesticides used must be explicitly approved for aerial spraying by the Member State following a specific assessment addressing risks from aerial spraying;

(c) the operator carrying out the aerial spraying must hold a certificate as referred to in Article 5(2). During the transitional period where certification systems are not yet in place, Member States may accept other evidence of sufficient knowledge;

(d) the enterprise responsible for providing aerial spray applications shall be certified by a competent authority for authorising equipment and aircraft for aerial application of pesticides;

(e) if the area to be sprayed is in close proximity to areas open to the public, specific risk management measures to ensure that there are no adverse effects on the health of bystanders shall be included in the approval. The area to be sprayed shall not be in close proximity to residential areas;

(f) as from 2013, the aircraft shall be equipped with accessories that constitute the best available technology to reduce spray drift.

3. Member States shall designate the authorities competent for establishing the specific conditions by which aerial spraying may be carried out, for examining requests pursuant to paragraph 4 and for making public information on crops, areas, circumstances and particular requirements for application including weather conditions where aerial spraying may be allowed.

Annex 7

In the approval the competent authorities shall specify the measures necessary for warning residents and bystanders in due time and to protect the environment in the vicinity of the area sprayed.

4. A professional user wishing to apply pesticides by aerial spraying shall submit a request for approval of an application plan to the competent authority accompanied by evidence to show that the conditions referred to in paragraphs 2 and 3 are fulfilled. The request for application of aerial spraying in accordance with the approved application plan shall be submitted in due time to the competent authority. It shall contain information about the provisional time of spraying and the amounts and the type of pesticides applied.

Member States may provide that requests for applications of aerial spraying in accordance with an approved application plan, for which no answer was received on the decision taken within the time period laid down by the competent authorities, shall be deemed to be approved.

In particular circumstances such as emergency or specific difficult situations, single requests for application of aerial spraying may also be submitted for approval. Where justified, competent authorities shall have a possibility to apply an accelerated procedure in order to verify that the conditions referred to in paragraphs 2 and 3 are fulfilled before the application of aerial spraying.

5. Member States shall ensure that the conditions referred to in paragraphs 2 and 3 are met by conducting appropriate monitoring.

6. The competent authorities shall keep records of the requests and approvals as referred to in paragraph 4 and shall make available to the public the relevant information contained therein such as the area to be sprayed, the provisional day and time of the spraying and the type of pesticide, in accordance with the applicable national or Community law.

Article 10

Information to the public

Member States may include in their National Action Plans provisions on informing persons who could be exposed to the spray drift.

Article 11

Specific measures to protect the aquatic environment and drinking water

1. Member States shall ensure that appropriate measures to protect the aquatic environment and drinking water supplies from the impact of pesticides are adopted. Those measures shall support and be compatible with relevant provisions of Directive 2000/60/EC and Regulation (EC) No 1107/2009.

2. The measures provided in paragraph 1 shall include:

(a) giving preference to pesticides that are not classified as dangerous for the aquatic environment pursuant to Directive 1999/45/EC nor containing priority hazardous substances as set out in Article 16(3) of Directive 2000/60/EC;

(b) giving preference to the most efficient application techniques such as the use of low-drift pesticide application equipment especially in vertical crops such as hops and those found in orchards and vineyards;

(c) use of mitigation measures which minimise the risk of off-site pollution caused by spray drift, drain-flow and run-off. These shall include the establishment of appropriately-sized buffer zones for the protection of non-target aquatic organisms and safeguard zones for surface and groundwater used for the abstraction of drinking water, where pesticides must not be used or stored;

(d) reducing as far as possible or eliminating applications on or along roads, railway lines, very permeable surfaces or other infrastructure close to surface water or groundwater or on sealed surfaces with a high risk of run-off into surface water or sewage systems.

Article 12

Reduction of pesticide use or risks in specific areas

Member States shall, having due regard for the necessary hygiene and public health requirements and biodiversity, or the results of relevant risk assessments, ensure that the use of pesticides is minimised or prohibited in certain specific areas. Appropriate risk management measures shall be taken and the use of low-risk plant protection products as defined in Regulation (EC) No 1107/2009 and biological control measures shall be considered in the first place. The specific areas in question are:

(a) areas used by the general public or by vulnerable groups as defined in Article 3 of Regulation (EC) No 1107/2009, such as public parks and gardens, sports and recreation grounds, school grounds and children's playgrounds and in the close vicinity of healthcare facilities;

(b) protected areas as defined in Directive 2000/60/EC or other areas identified for the purposes of establishing the necessary conservation measures in accordance with the provisions of Directives 79/409/EEC and 92/43/EEC;

(c) recently treated areas used by or accessible to agricultural workers.

Article 13

Handling and storage of pesticides and treatment of their packaging and remnants

1. Member States shall adopt the necessary measures to ensure that the following operations by professional users and where applicable by distributors do not endanger human health or the environment:

(a) storage, handling, dilution and mixing of pesticides before application;

(b) handling of packaging and remnants of pesticides;

(c) disposal of tank mixtures remaining after application;

(d) cleaning of the equipment used after application;

(e) recovery or disposal of pesticide remnants and their packaging in accordance with Community legislation on waste.

2. Member States shall take all necessary measures regarding pesticides authorised for non-professional users to avoid dangerous handling operations. These measures may include use of pesticides of low toxicity, ready to use formulations and limits on sizes of containers or packaging.

3. Member States shall ensure that storage areas for pesticides for professional use are constructed in such a way as to prevent unwanted releases. Particular attention shall be paid to location, size and construction materials.

Article 14

Integrated pest management

1. Member States shall take all necessary measures to promote low pesticide-input pest management, giving wherever possible priority to non-chemical methods, so that professional users of pesticides switch to practices and products with the lowest risk to human health and the environment among those available for the same pest problem. Low pesticide-input pest management includes integrated pest management as well as organic farming according to Council Regulation (EC) No 834/2007 of 28 June 2007 on organic production and labelling of organic products [1].

2. Member States shall establish or support the establishment of necessary conditions for the implementation of integrated pest management. In particular, they shall ensure that professional users have at their disposal information and tools for pest monitoring and decision making, as well as advisory services on integrated pest management.

3. By 30 June 2013, Member States shall report to the Commission on the implementation of paragraphs 1 and 2 and, in particular, whether the necessary conditions for implementation of integrated pest management are in place.

4. Member States shall describe in their National Action Plans how they ensure that the general principles of integrated pest management as set out in Annex III are implemented by all professional users by 1 January 2014.

Measures designed to amend non-essential elements of this Directive relating to amending Annex III in order to take account of scientific and technical progress shall be adopted in accordance with the regulatory procedure with scrutiny referred to in Article 21(2).

5. Member States shall establish appropriate incentives to encourage professional users to implement crop or sector-specific guidelines for integrated pest management on a voluntary basis. Public authorities and/or organisations representing particular professional users may draw up such guidelines. Member States shall refer to those guidelines that they consider relevant and appropriate in their National Action Plans.

CHAPTER V

INDICATORS, REPORTING AND INFORMATION EXCHANGE

Article 15

Indicators

1. Harmonised risk indicators as referred to in Annex IV shall be established. However, Member States may continue to use existing national indicators or adopt other appropriate indicators in addition to the harmonised ones.

Measures designed to amend non-essential elements of this Directive relating to amending Annex IV in order to take account of scientific and technical progress shall be adopted in accordance with the regulatory procedure with scrutiny referred to in Article 21(2).

[1] OJ L 189, 20.7.2007, p. 1.

Annex 7

2. Member States shall:

(a) calculate harmonised risk indicators as referred to in paragraph 1 by using statistical data collected in accordance with the Community legislation concerning statistics on plant protection products together with other relevant data;

(b) identify trends in the use of certain active substances;

(c) identify priority items, such as active substances, crops, regions or practices, that require particular attention or good practices that can be used as examples in order to achieve the objectives of this Directive to reduce the risks and impacts of pesticide use on human health and the environment and to encourage the development and introduction of integrated pest management and of alternative approaches or techniques in order to reduce dependency on the use of pesticides.

3. Member States shall communicate the results of the evaluations carried out pursuant to paragraph 2 to the Commission and to other Member States and shall make this information available to the public.

4. The Commission shall calculate risk indicators at Community level by using statistical data collected in accordance with the Community legislation concerning statistics on plant protection products and other relevant data, in order to estimate trends in risks from pesticide use.

The Commission shall also use these data and this information to assess progress in achieving the objectives of other Community policies aimed at reducing the impact of pesticides on human health and on the environment.

The results shall be made available to the public on the website referred to in Article 4(4).

Article 16

Reporting

The Commission shall regularly submit to the European Parliament and to the Council a report on progress in the implementation of this Directive, accompanied where appropriate by proposals for amendments.

CHAPTER VI

FINAL PROVISIONS

Article 17

Penalties

Member States shall determine penalties applicable to infringements of the national provisions adopted pursuant to this Directive and shall take all measures necessary to ensure that they are implemented. The penalties provided for shall be effective, proportionate and dissuasive.

Member States shall notify those provisions to the Commission by 14 December 2012 and shall notify it without delay of any subsequent amendment.

Article 18

Exchange of information and best practice

The Commission shall put forward as a priority for discussion in the expert group on the thematic strategy on the sustainable use of pesticides the exchange of information and best practice in the field of sustainable use of pesticides and integrated pest management.

Article 19

Fees and charges

1. Member States may recover the costs associated with any work pursuant to obligations under this Directive by means of a fee or charge.

2. Member States shall ensure that the fee or charge referred to in paragraph 1 is established in a transparent manner and corresponds to the actual cost of the work involved.

Article 20

Standardisation

1. The standards referred to in Article 8(4) of this Directive shall be established in accordance with the procedure provided for in Article 6(3) of Directive 98/34/EC of the European Parliament and of the Council of 22 June 1998 laying down a procedure for the provision of information in the field of technical standards and regulations and of rules on Information Society services [1].

The request for developing these standards may be established in consultation with the Committee referred to in Article 21(1).

2. The Commission shall publish the references of the standards in the *Official Journal of the European Union*.

(1) OJ L 204, 21.7.1998, p. 37.

3. When a Member State or the Commission considers that a harmonised standard does not entirely satisfy the requirements which it covers and which are set out in Annex II, the Commission or the Member State concerned shall bring the matter before the Committee set up by Article 5 of Directive 98/34/EC, giving its arguments. The Committee shall, having consulted the relevant European standardisation bodies, deliver its opinion without delay.

In the light of the Committee's opinion, the Commission shall decide to publish, not to publish, to publish with restriction, to maintain, to maintain with restriction or to withdraw the references to the harmonised standard concerned in or from the *Official Journal of the European Union*.

The Commission shall inform the European standardisation body concerned and, if necessary, request the revision of the harmonised standards concerned.

Article 21

Committee procedure

1. The Commission shall be assisted by the Standing Committee on the Food Chain and Animal Health established by Article 58 of Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety ([1]).

2. Where reference is made to this paragraph, Article 5a(1) to (4) and Article 7 of Decision 1999/468/EC shall apply, having regard to the provisions of Article 8 thereof.

Article 22

Expenditure

In order to support the establishment of a harmonised policy and systems in the field of sustainable use of pesticides, the Commission may finance:

(a) the development of a harmonised system including an appropriate database to gather and store all information relating to pesticide risk indicators, and to make such information available to the competent authorities, other interested parties and the general public;

(b) the performance of studies necessary for the preparation and development of legislation, including the adaptation of the Annexes to this Directive to technical progress;

(c) the development of guidance and best practices to facilitate the implementation of this Directive.

Article 23

Transposition

1. Member States shall bring into force the laws, regulations and administrative provisions necessary to comply with this Directive by 14 December 2011.

When Member States adopt these measures, they shall contain a reference to this Directive or be accompanied by such a reference on the occasion of their official publication. The method of making such reference shall be laid down by Member States.

2. Member States shall communicate to the Commission the text of the main provisions of national law which they adopt in the field covered by this Directive.

Article 24

Entry into force

This Directive shall enter into force on the day following its publication in the *Official Journal of the European Union*.

Article 25

Addressees

This Directive is addressed to the Member States.

Done at Strasbourg, 21 October 2009.

For the European Parliament	*For the Council*
The President	*The President*
J. BUZEK	C. MALMSTRÖM

([1]) OJ L 31, 1.2.2002, p. 1.

Annex 7

ANNEX I

Training subjects referred to in Article 5

1. All relevant legislation regarding pesticides and their use.

2. The existence and risks of illegal (counterfeit) plant protection products, and the methods to identify such products.

3. The hazards and risks associated with pesticides, and how to identify and control them, in particular:

   (a) risks to humans (operators, residents, bystanders, people entering treated areas and those handling or eating treated items) and how factors such as smoking exacerbate these risks;

   (b) symptoms of pesticide poisoning and first aid measures;

   (c) risks to non-target plants, beneficial insects, wildlife, biodiversity and the environment in general.

4. Notions on integrated pest management strategies and techniques, integrated crop management strategies and techniques, organic farming principles, biological pest control methods, information on the general principles and crop or sector-specific guidelines for integrated pest management.

5. Initiation to comparative assessment at user level to help professional users make the most appropriate choices on pesticides with the least side effects on human health, non-target organisms and the environment among all authorised products for a given pest problem, in a given situation.

6. Measures to minimise risks to humans, non-target organisms and the environment: safe working practices for storing, handling and mixing pesticides, and disposing of empty packaging, other contaminated materials and surplus pesticides (including tank mixes), whether in concentrate or dilute form; recommended way to control operator exposure (personal protection equipment).

7. Risk-based approaches which take into account the local water extraction variables such as climate, soil and crop types, and relieves.

8. Procedures for preparing pesticide application equipment for work, including its calibration, and for its operation with minimum risks to the user, other humans, non-target animal and plant species, biodiversity and the environment, including water resources.

9. Use of pesticide application equipment and its maintenance, and specific spraying techniques (e.g. low-volume spraying and low-drift nozzles), as well as the objectives of the technical check of sprayers in use and ways to improve spray quality. Specific risks linked to use of handheld pesticide application equipment or knapsack sprayers and the relevant risk management measures.

10. Emergency action to protect human health, the environment including water resources in case of accidental spillage and contamination and extreme weather events that would result in pesticide leaching risks.

11. Special care in protection areas established under Articles 6 and 7 of Directive 2000/60/EC.

12. Health monitoring and access facilities to report on any incidents or suspected incidents.

13. Record keeping of any use of pesticides, in accordance with the relevant legislation.

ANNEX II

Health and safety and environmental requirements relating to the inspection of pesticide application equipment

The inspection of pesticide application equipment shall cover all aspects important to achieve a high level of safety and protection of human health and the environment. Full effectiveness of the application operation should be ensured by proper performance of devices and functions of the equipment to guarantee the following objectives are met.

The pesticide application equipment must function reliably and be used properly for its intended purpose ensuring that pesticides can be accurately dosed and distributed. The equipment must be in such a condition as to be filled and emptied safely, easily and completely and prevent leakage of pesticides. It must permit easy and thorough cleaning. It must also ensure safe operations, and be controlled and capable of being immediately stopped from the operator's seat. Where necessary, adjustments must be simple, accurate and capable of being reproduced.

Particular attention should be paid to:

1. Power transmission parts

   The power take-off driveshaft guard and the guard of the power input connection shall be fitted and in good condition and the protective devices and any moving or rotating power transmission parts shall not be affected in their function so as to ensure protection of the operator.

2. Pump

   The pump capacity shall be suited to the needs of the equipment and the pump must function properly in order to ensure a stable and reliable application rate. There shall be no leakages from the pump.

3. Agitation

   Agitation devices must ensure a proper recirculation in order to achieve an even concentration of the whole volume of the liquid spray mixture in the tank.

4. Spray liquid tank

   Spray tanks including indicator of tank content, filling devices, strainers and filters, emptying and rinsing systems, and mixing devices shall operate in such a way as to minimise accidental spillage, uneven concentration distribution, operator exposure and residual content.

5. Measuring systems, control and regulation systems

   All devices for measuring, switching on and off and adjusting pressure and/or flow rate shall be properly calibrated and work correctly and there shall be no leakages. Control of pressure and operation of pressure adjustment devices shall be easily possible during application. Pressure adjustment devices shall maintain a constant working pressure at constant revolutions of the pump, in order to ensure that a stable volume application rate is applied.

6. Pipes and hoses

   Pipes and hoses shall be in proper condition to avoid disturbance of liquid flow or accidental spillage in case of failure. There shall be no leakages from pipes or hoses when run with the maximum obtainable pressure for the system.

7. Filtering

   In order to avoid turbulence and heterogeneity in spray patterns, filters shall be in good condition and the mesh size of the filters shall correspond to the size of nozzles fitted on the sprayer. Where applicable the filter blockage indication system shall operate correctly.

8. Spray boom (for equipment spraying pesticides by means of a horizontally positioned boom, located close to the crop or the material to be treated).

   The spray boom must be in good condition and stable in all directions. The fixation and adjustment systems and the devices for damping unintended movements and slope compensation must work correctly.

9. Nozzles

   Nozzles must work properly to control dripping when spraying stops. To ensure homogeneity of the spray pattern, the flow rate of each individual nozzle shall not deviate significantly from the data of the flow rate tables provided by the manufacturer.

Annex 7

10. Distribution

The transverse and vertical (in case of applications in vertical crops) distribution of the spray mixture in the target area must be even, where relevant.

11. Blower (for equipment distributing pesticides by air assistance)

The blower must be in good condition and must ensure a stable and reliable air stream.

24.11.2009 EN Official Journal of the European Union L 309/85

ANNEX III

General principles of integrated pest management

1. The prevention and/or suppression of harmful organisms should be achieved or supported among other options especially by:

   — crop rotation,

   — use of adequate cultivation techniques (e.g. stale seedbed technique, sowing dates and densities, under-sowing, conservation tillage, pruning and direct sowing),

   — use, where appropriate, of resistant/tolerant cultivars and standard/certified seed and planting material,

   — use of balanced fertilisation, liming and irrigation/drainage practices,

   — preventing the spreading of harmful organisms by hygiene measures (e.g. by regular cleansing of machinery and equipment),

   — protection and enhancement of important beneficial organisms, e.g. by adequate plant protection measures or the utilisation of ecological infrastructures inside and outside production sites.

2. Harmful organisms must be monitored by adequate methods and tools, where available. Such adequate tools should include observations in the field as well as scientifically sound warning, forecasting and early diagnosis systems, where feasible, as well as the use of advice from professionally qualified advisors.

3. Based on the results of the monitoring the professional user has to decide whether and when to apply plant protection measures. Robust and scientifically sound threshold values are essential components for decision making. For harmful organisms threshold levels defined for the region, specific areas, crops and particular climatic conditions must be taken into account before treatments, where feasible.

4. Sustainable biological, physical and other non-chemical methods must be preferred to chemical methods if they provide satisfactory pest control.

5. The pesticides applied shall be as specific as possible for the target and shall have the least side effects on human health, non-target organisms and the environment.

6. The professional user should keep the use of pesticides and other forms of intervention to levels that are necessary, e.g. by reduced doses, reduced application frequency or partial applications, considering that the level of risk in vegetation is acceptable and they do not increase the risk for development of resistance in populations of harmful organisms.

7. Where the risk of resistance against a plant protection measure is known and where the level of harmful organisms requires repeated application of pesticides to the crops, available anti-resistance strategies should be applied to maintain the effectiveness of the products. This may include the use of multiple pesticides with different modes of action.

8. Based on the records on the use of pesticides and on the monitoring of harmful organisms the professional user should check the success of the applied plant protection measures.

Annex 7

ANNEX IV

Harmonised risk indicators

Annex 8

Claudia Rojas Quiñonez, Esq., *The Aerial Spray Program and Violations of Colombia's Domestic Laws Regarding the Environment and the Rights of Indigenous Peoples* (Jan. 2011)

Annex 8

The Aerial Spray Program and Violations of Colombia's Domestic Laws Regarding the Environment and the Rights of Indigenous Peoples

Report Prepared by

Claudia Rojas Quiñonez, Esq.

January 2011

Introduction

1. This report focuses on the State's failure to comply with internal Colombian law in the areas of Environmental Impact Assessments, the use of pesticides, and indigenous rights in connection with its program to spray illicit crops with herbicides. It includes a brief introduction to Colombian environmental law, and then a review of Colombian legislation and regulations regarding Environmental Impact Assessments and their application in practice. Next, in order to evaluate the level of compliance by the State with its domestic legal obligations, it includes an analysis of the development and application of the regulations on Environmental Licensing and Environmental Impact Assessments (in Section III), an evaluation of the standards regarding pesticide use (in Section IV), and a study of indigenous rights law (in Section V).

2. 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.

About the Author

3. Claudia Rojas is a Colombian lawyer and a Lecturer at the Universidad Externado de Colombia, where she specializes in Colombian environmental law and international environmental law. She holds a Law degree from the Universidad Externado de Colombia (1994), a Masters degree in International Studies from the Universidad de Barcelona (1996), and is a Ph.D. candidate in International Law at the University of St. Gallen. Mrs. Rojas previously served as a Legal Adviser to the Colombian Administrative Department of State Security (Departamento Administrativo de Seguridad del Estado, "DAS"), and as a Lecturer in Public International Law at the University of Barcelona. She is the author of the treatise,

The Evolution of the Characteristics and Principles of International Environmental Law and its Application in Colombia (*Evolución de las Características y los Principios del Derecho Internacional Ambiental y su Aplicación en Colombia*) (2004). Her other publications include: "The International Protection of the Human Right to the Environment," in Sindico *et al.* (Eds.), *International Environmental Law: An Ibero-american Perspective* ("La protección internacional del derecho humano al medio ambiente" en *Derecho Internacional del Medio Ambiente: Una Visión desde Iberoamérica*), CMP Publishing (2010); and "The Jurisprudence of the International Court of Justice: From *Gabcikovo-Nagymaros* to *Argentina-Uruguay*" ("Die Rechtsprechung des internationalen Gerichtshofs auf dem Gebiet internationaler Wasserläufe. Von *Gabcikovo-Nagymaros* bis *Argentinien-Uruguay*"), *Jusletter*, (June 2007). Mrs. Rojas's curriculum vitae is provided in Appendix 1.

Section I. Environmental protection in the Colombian legal system

A. Constitutional Law and basic legislation related to the environment in Colombia

4. The Colombian State has distinguished itself for having pioneering legislation in the area of environmental protection. In this sense, it should be noted that already in the 1970s, under the influence of the principles established in the Stockholm Declaration of 1972, Colombia issued Decree 2811 of 1974, or the National Code of Renewable Natural Resources and Environmental Protection (known as the CNRNR for its initials in Spanish). This was the first framework law in this field enacted in Latin America and the Caribbean.

5. Based on the CNRNR, Colombia began to address the environment as an issue in its own right and in a coherent and unified fashion -- thereby overcoming the previous system which operated based on the fragmented and isolated regulation of natural resources -- primarily focused on those resources which were of special importance to the national economy.

6. The issuance of the CNRNR therefore represents the consideration of the environment as a legal asset in and of itself, worthy of legal protection as a whole and as the heritage of all Colombians. From this perspective, the CNRNR is based on a series of rules, of which we can highlight: the placing of environmental policy management in the hands of the national government, the express introduction of the right of all people to enjoy a healthy environment, the joint duty of the State and of individuals to preserve the environment, and the civil liability of the State and of individuals for damage caused as a result of activities that generate pollution or environmental degradation.

7. In addition to the regulatory decrees issued in the development of the CNRNR, many environmental regulations were adopted from this point on. However, despite the apparent interest in the issue of the environment beginning in the 1970s, the Colombian Political Constitution at that time did not make any reference to the environment, and therefore any Constitutional backing in this field had to be sought in article 16 of the Constitution, according to which the authorities of the Republic were instructed to protect the life, integrity, and property of all persons residing in Colombia.

8. The lack of constitutional provisions in the area of the environment was overcome with the passage of the Political Constitution of 4 July 1991, which included the commitment to environmental protection in an intentional and comprehensive manner throughout its articles.

9. In general terms, the Constitution of 1991 orders that natural resources are a birthright of all Colombians; it incorporates in the chapter dedicated to collective rights the right of all people to enjoy a healthy environment, and establishes the responsibility of the State and of individuals and institutions to preserve and properly manage the environment, guided by the goal of sustainable development.

10. Under this perspective, and particularly from the point of view of the content of the regulations regarding environmental protection, it can be affirmed that the 1991 Constitution considered the most cutting-edge criteria that had been developed at the time at the international level, including those put forth by the United Nations Commission for Environment and Development.

11. Despite the fact that the Constitution was issued before the United Nations Conference on Environment and Development in 1992 (the Rio "Earth Summit") took place, it is important to recognize that the guidelines of the constitutional text coincide with the principles developed during that conference. The Constitution, in addition to including the concept of sustainable development throughout its text, considers the linkage between environmental protection and human rights, and institutes the principles of prevention, liability for environmental damages, citizen participation, and international cooperation (article 80).

12. In order to develop these constitutional precepts, and those inspired by the Rio Conference, Law 99 of 1993 was enacted, *"by which the Ministry of the Environment is created, the public agencies in charge of the management and conservation of the environment and renewable natural resources are reorganized, the National Environmental System (SINA) is established, and other provisions are issued."*

13. Article 1 of Law 99, corresponding to Title I on "Foundations of Colombian Environmental Policy," refers to general environmental principles, of which the following are of note: sustainable development as a goal; respect for the human right to the environment; attention to the principles of precaution, polluter pays, prevention, the repair of environmental damage and participation; and the need to conduct Environmental Impact Assessments.

14. These principles acquired great importance by being incorporated into this framework Law, which is hierarchically superior and regulates environmental protection and management in Colombia. Of particular importance for this study are the principles of precaution, prevention, and the need for Environmental Impact Assessments. In this regard, the following provisions are of particular importance:

- Article 1.6 on precaution: *"The formulation of environmental policies shall take into account the results of the process of scientific investigation. Nevertheless, environmental authorities and individuals shall apply the precautionary principle, according to which, when there exists the risk of grave and irreversible damage, the lack of absolute scientific certainty shall not be used as a reason to delay the adoption of effective measures to prevent the degradation of the environment."*
- Article 1.7 on prevention and the polluter pays principle: *"The State shall promote the integration of economical instruments for the prevention, correction, and restoration of environmental deterioration, and for the conservation of renewable natural resources."*
- Article 1.11 on Environmental Impact Assessments: *"Environmental impact assessments shall be the basic instrument for decision-making with respect to construction projects and activities which significantly affect the natural or artificial environment."*

15. In the same way it should be noted that one of the central aspects of Law 99 is the creation of the Ministry of the Environment, as the governing entity of national environmental policy. Article 5 of Law 99 defines the functions of this Ministry. Within the functions related to regulatory and oversight authority, the following are particularly relevant to the subject of this study:

- *"5) To establish environmental criteria that must be incorporated into the formulation of sectoral policies and in the planning processes of the other Ministries and entities, upon consultation with those bodies";*
- *"10) To determine the minimum environmental rules and regulations to be observed by urban centers and human settlements and mining and industrial activities, transportation*

and in general any service of activity that can directly or indirectly generate environmental damages";

- *"15) To evaluate environmental studies and issue, deny or suspend the corresponding environmental license, in those cases indicated in title VIII of this law";*[1]

- *"17) To contract, when necessary for the performance of its duties, research studies and the monitoring of ecological and environmental processes and the evaluation of Environmental Impact Assessments";*

- *"To issue environmental regulations on the distribution and use of chemical or biological substances used in agricultural activities."*

16. In addition, according to article 6 of Law 99, the Ministry of the Environment (since 2002, the Ministry of the Environment, Housing, and Territorial Development) enjoys a general authority clause, by which: *"in addition to the other functions assigned by law or regulations, the MINISTRY OF THE ENVIRONMENT will exercise in relation to the environment and renewable natural resources those functions which have not been expressly attributed by law to any other authority."*

17. The Ministry of the Environment also possesses sanctioning powers. According to article 83 of Law 99 of 1993, this Ministry is vested with: "*(...) police functions to impose and execute police-like measures, fines and penalties established by law, that are applicable to the case*".[2] In this regard, article 85 of this law states that the Ministry of the Environment will impose various types of sanctions and injunctions on anyone who violates environmental protection regulations or regulations on the management and use of renewable natural resources. Here we can highlight the Ministry's authority to order the "*performance within a fixed term of the studies and evaluations required to establish the nature and characteristics of the damages, effects and impacts caused by the infraction, as well as the measures*

[1] Chapter VIII of the Law refers to the Environmental License.
[2] Title XII (articles 83 to 86) of Law 99 of 1993 refers to "Sanctions and Police Measures."

necessary to mitigate them or compensate for them."[3] In other words, the Ministry of Environment has authority to create, implement and enforce laws concerning environmental protection. In so doing, it can direct other government agencies, including the National Narcotics Directorate (DNE), and enforce compliance through orders and sanctions when necessary.[4]

B. Incorporation of international environmental law in internal Colombian law

18. Colombia has ratified most of the international treaties related to environmental protection.[5] By ratifying them, the State has assumed the obligations contained therein, which means that it is internationally accountable for any failures to comply with them. In this sense, by way of example, the Colombian State is bound by the commitments it assumed in the 1992 Rio Convention on Biological Diversity, which among other things includes provisions on the need to carry out Environmental Impact Assessments (article 14).

19. In addition, as mentioned above, the vast majority of the principles established in the large international conferences on development and the environment, and especially in the Rio Declaration of 1992, were incorporated into the Constitution of 1991 and Law 99 of 1993 (Const. arts. 80 and Law 99 art. 1). Therefore, those general principles of international environmental law, which in addition to being consolidated as binding legal rules by the effect

[3] Law 99 of 1993, Art. 85(2)(d).
[4] Law 1333 of 2009, which establishes the Environental Sanction Procedure along with other provisions, subrograted articles 83 and 86 of Law 99 of 1993 (regarding Sanctions and Police Measures). Law 1333 established, in a detailed manner, the procedure for imposing preventive and punitive measures in environmental issues. It also granted the relevant powers to the Ministry of Environment, the Regional Autonomous Corporations, the urban Environmental Units, and the Special Administrative Unit of the National Parks System.
[5] Convention on Wetlands of International Importance Especially as Waterfowl Habitat, Ramsar, reprinted in 11 ILM 963 (1972); Convention on International Trade in Endangered Species of Wild Fauna and Flora, 993 U.N.T.S. 243 reprinted in 12 I.L.M. 1085 (1973); The Amazon Cooperation Treaty (1978); International Tropical Timber Agreement (1994); Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, 1673 U.N.T.S. 125, reprinted in l28 I.L.M. 657 (1989); Convention for the Protection of the Ozone Layer, 1513 UNTS 323 reprinted in 26 ILM 1529 (1987); United Nations Convention to Combat Desertification in Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa, 1954 UNTS 3 reprinted in 33 ILM 1328 (1994); United Nations Framework Convention on Climate Change, U.N. Doc. A/AC.237/18 (Part II)/Add.1 (1992), reprinted in 31 I.L.M. 849 (1992); Convention on Biological Diversity, 1760 UNTS 79, reprinted in 31 I.L.M. 818 (1992); Cartagena Biosafety Protocol to the Convention on Biological Diversity, reprinted in 39 I.L.M. 1027 (1983).

of custom -- as are, for example, the principles of prevention (Law 99, art. 1.7; Const. art. 80) and of international cooperation (Law 99, art. 5.22, Const. art. 80) -- have been expressly incorporated into the Colombian legal order not only through legislation but also in the Constitution.

Section II. Environmental Licensing and Environmental Impact Assessments in Colombia: law and practice

20. Studying the regime of Environmental Impact Assessments (EIA) in Colombia requires beginning with an analysis of the broader context, that is, Environmental Licensing regulation.

21. 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.

22. The issue of Environmental Licenses in Colombia began in earnest in the 1970s. The Constitutional Court itself has called attention to the importance of this instrument for environmental protection in its ruling C-328 of 1995, which finds that *"the duty to prevent and control environmental deterioration is exercised, among other ways, through the granting, denial or cancellation of environmental licenses by the State"*.[6] To this, the Court adds that *"only the prior permission of the relevant authorities makes it legally viable to execute construction works or activities that can have potential effects on the ecosystem (...)"*.[7] The Court goes on to maintain that "*the reason for the existence of environmental licenses is to protect individual and collective rights. It is the responsibility of public*

[6] Constitution Court, Sentence C-328 of 1995, Judge: Eduardo Cifuentes Muñoz, para. 16.
[7] Ibid.

authorities to ensure these rights, particularly when the risk of them being violated increases due to the performance of hazardous activities."[8]

23. In this way, Colombia's highest jurisdictional body makes it clear in a harmonious interpretation of the relevant constitutional mandate, that the ultimate end of Environmental Licenses and their correlates, among them Environmental Impact Assessments, is to prevent the possible negative effects of a project or activity, and with this, to ultimately guarantee respect for individual rights, like the right to health (Const. art. 49) or to life (Const. art. 11), and for collective rights, like the right to the environment (Const. art. 79).

A. The Environmental License before Law 99 of 1993

24. The institutionalization of environmental management in the country began with the CNRNR in 1974, as discussed above.

25. 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.

26. It is useful here to reproduce the content of the relevant provisions of the CNRNR in the area of environmental impact assessments, specifically articles 27, 28 and 29:[9]

[8] Constitution Court, Sentence C-328 of 1995, Judge: Eduardo Cifuentes Muñoz, para. 11.

- *Article 27* of the CNRNR orders that *"any individual or entity, public or private which plans to carry out or is carrying out any work or activity that could produce environmental damage, is obligated to declare the presumed danger that is a consequence of the work or activity."*

- *Article 28* of the CNRNR states that *"in order to build works, establish industries or carry out any other activity which due to its nature could produce serious deterioration to renewable natural resources or the environment or introduce considerable or notable modifications to the landscape, a prior ecological and environmental study will be necessary, and a license must be obtained."*

- *Article 29,* which is especially relevant to activities that could have repercussions outside of the national territory, states that *"when the abovementioned works or activities could have effects of an international nature on natural resources and other environmental elements, the opinion of the Ministry of Foreign Relations must be sought."* This provision reflects the Colombian State's commitment, at that time, to avoid damaging the environment and natural resources of other States.

27. It must be clarified that originally the first two abovementioned provisions were intended to regulate different situations. Based on Article 27, it was the responsibility of the people executing the respective projects or works to classify their activity as environmentally risky or not. Before the first event, the person would acquire the obligation of declaring the danger that their project or activity involved. This Declaration is known as the Declaration of Environmental Effect (DEE). Based on the DEE, the State would issue its decision. The difficulty in enforcing this provision lay in the lack of regulations to indicate what kind of projects could involve danger to the environment.

28. Article 28 focused its attention not on a presumed situation of danger, but on a series of characteristics of the work that made it possible to predict that it would produce grave danger to the environment, in which case it was obligatory to submit an Ecological and Environmental Study (EES) to the State, in addition to requesting a license.

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[9] Article 118 of Law 99 of 1993 repealed, among others, these three provisions.

29. Essentially, the purpose of these rules was related to the duty to disclose and the principle of prevention, which is of enormous significance for environmental preservation and protection. In fact, this goal is confirmed in the attitude adopted by the authorities in charge of environmental issues during this period of time, which consisted of assuming that all construction projects were required to present a DEE, and if the environmental authority considered it necessary, an EES was required as well.

B. The Environmental License after Law 99 of 1993

30. The inconsistencies of the rules discussed above were resolved with the enactment of Law 99 of 1993. The Political Constitution of 1991 had already incorporated in its text the main environmental principles, developed at the international level, among them sustainable development and prevention, which in turn demanded from the State a more proactive attitude in relation to the control and management of natural resources, and assigned the State the ultimate responsibility to determine the effects of a project and to adopt the appropriate measures.

31. Nevertheless, one aspect that Law 99 of 1993, unlike the CNRNR (article 29), did not consider within its provisions on Environmental Licensing was the potential cross-border environmental effects of the projects carried out in Colombian territory. In fact, Law 99 has a significant legal vacuum on this issue, to the extent that the provisions that define the content of the EIA do not make any reference to the consideration of the possible consequences of activities, projects or construction works that go beyond national borders. In any case, bearing in mind the functions and powers of the Ministry of the Environment, defined in Law 99, it is understood that it is left to the Ministry, when establishing the terms of reference for the EIA and EMP, [10] to set the necessary parameters to consider cross-border environmental

[10] Articles 5 and 57 of Law 99 of 1993.

impacts that could potentially be caused by the project to be carried out on Colombian territory.

32. Title VIII of Law 99 defines the concept of the Environmental License (art. 50), and establishes that it is obligatory and must be obtained prior to the development of any projects that require it (art. 49). In addition, the law regulates the process of granting the license (art. 58) and defines the responsibilities of the environmental authorities in this area (art. 51).

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

33. Before proceeding, it is important to highlight the difference between an Environmental License (EL), an Environmental Impact Assessment (EIA) and an Environmental Management Plan (EMP), under Colombian law.

34. According to article 49 of Law 99 of 1993, "*The execution of works, the establishment of industries or the performance of any activity which according to the law and regulations could produce serious damage to renewable natural resources or to the environment or introduce significant or notable modifications to the landscape will require an environmental license.*"

35. The Environmental License (EL) consists, therefore, of the authorization granted by the competent environmental authority with respect to the execution of a construction project or activity, which commits its beneficiary to comply with the requirements established therein with regard to the prevention, mitigation, correction, compensation and management of the environmental effects of the authorized project or activity, as described in article 50 of Law 99 of 1993.

36. The EIA, for its part, is the fundamental instrument based on which the environmental authorities adopt decisions on whether or not to grant a license to projects or activities that could significantly affect the environment prior to their implementation, as determined by article 1, paragraph 11 of Law 99 of 1993. More specifically, article 57 of Law 99 defines the EIA as the set of information that anyone requesting an environmental license must submit to the relevant environmental authority. This assessment must contain, according to article 57: "*information regarding the location of the project and the abiotic, biotic and socioeconomic elements of the environment that could suffer damage due to the project or activity, for whose execution the license is requested, as well as the evaluation of impacts that could occur. In addition, it shall include the design of plans for the prevention, mitigation, correction and compensation of impacts and the environmental management plan for the project or activity*."

37. Under these terms, the EIA is intended to predict, identify, value and correct the environmental consequences or effects that certain actions could cause to the quality of the natural and artificial surroundings. To do this, the assessment must appropriately identify, describe and value the notable, foreseeable effects that the implementation of the project will have on the different environmental aspects.

38. This content, in practice and according to relevant current regulations, is contained in: an executive summary; a delimitation of the direct and indirect area of influence of the project; a project description, including: location, stages, dimensions, estimated costs, execution timetable, processes, basic identification and estimate of inputs, products, wastes, emissions, effluent and risks inherent to the technology to be used, its sources and control systems; the determination of the natural renewable resources that are planned to be used, processed or affected in the development of the project; the description, classification and analysis of the biotic, abiotic, socio-economic and cultural context in which the project is to

be carried out; the identification and evaluation of the environmental impacts that the project could cause, including what can be prevented, mitigated or compensated for.

39. The EMP, meanwhile, according to Colombian law, is one of the documents that the applicant for the license must attach to the EIA when submitting the application for a license to the corresponding environmental authority. The EMP is intended for the monitoring and oversight phase of the respective authorized project. That is, it is a part of the EIA that describes how the environmental monitoring of the project in question will be carried out. The EMP establishes in a detailed fashion, after an environmental assessment, the actions that will be taken to mitigate, correct or compensate for the negative environmental impacts identified by the EIA, and includes the follow-up, monitoring, emergency and abandonment plans depending on the nature of the project.

40. In procedural terms, article 57 orders that the environmental authority that is competent to grant the environmental license will establish the terms of reference for the EIA within a term that cannot exceed sixty (60) working days, counting from the date of the application submitted by the interested party.

41. Thus, according to Colombian environmental legislation, the EL is the authorization issued by the relevant environmental authority to be able to begin a project, work or activity that has the potential to be harmful to the environment. The environmental authority's decision to grant or not grant the EL is based on information provided by the applicant, primarily through the EIA, which in turn is comprised of the set of information related to both the phase prior to the initiation of the corresponding activity (in line with the prevention principle), as well as to the phase after the startup of the activity which is described in the EMP.

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

42. Title VIII of Law 99 of 1993 on Environmental Licensing constitutes the overall regulatory framework for the subject. Through the years this issue has been the subject of various additions and modifications.

43. The regulation of this general framework begins with Decree 1753 of 1994, which developed in detail the notion of Environmental Licensing, and the nature, types, effects, content, procedures, requirements and authority for granting licenses.

44. 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). In addition, paragraph 9 referred to projects that affect the National System of National Parks. Article 25 of the Decree dealt with the concrete content of the EIA. Article 26 provided that the Ministry of the Environment, in consultation with the Technical Advisory Council for Environmental Policy and Legislation, would establish the terms of reference for each sector, with their respective instructions.[11]

45. It should be mentioned that, in 1995, Decree 2150 was issued, which among other things, was intended to simplify the process of granting an Environmental License and other types of permits. At the same time, it introduced the possibility of allowing an exemption from the requirement of the Environmental Assessment of Alternatives (art. 133), the Environmental Impact Assessment (art. 134) and abolished the normal Environmental License. Article 133 stated that "*The National Government shall regulate those cases in*

[11] Decree 1753 was in force until it was replaced by Decree 1728 of 2002, which in turn was repealed by Decree 1180 of 2003. This latter decree was overturned by Decree 1220 of 2005, which is the regulatory instrument currently in force, and was partially modified by Decree 500 in 2006.

which the environmental authority may refrain from requiring the Environmental Assessment of Alternatives." This provision was declared unenforceable by the Constitutional Court in Ruling C-433 of 1996. For its part, article 134, which was also declared unenforceable in the same ruling, ordered that "*The National Government will determine those cases in which the submission of an environmental management plan is sufficient to begin activities*."

46. All of the above-mentioned regulations (whether repealed or currently in force) in the area of Environmental Licensing contain precise provisions intended to concretely define the content of the EIA.[12]

47. 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, article 14 of which, in discussing the impact assessment and the reduction of any adverse impact to a minimum, states: *"1. Each Contracting Party, as far as possible and as appropriate, shall: (a) Introduce appropriate procedures requiring environmental impact assessment of its proposed projects that are likely to have significant adverse effects on biological diversity with a view to avoiding or minimizing such (...)."*

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

48. This section is dedicated to the evaluation of the Colombian government's compliance with the obligations established in its internal legislation with regard to

[12] In summary, the content of the EIA has been regulated by Chapter V of Decree 1753 of 1994, Article 17 of Decree 1728 of 2002, Article 16 of Decree 1180 of 2003 and Article 20 of Decree 1220 of 2005.

Environmental Impact Assessments, specifically in relation to the government activities to eradicate illicit crops through the aerial spraying of chemical herbicides.

49. In order to carry out this analysis, this Section will first examine the Colombian legal-regulatory framework in the area of illicit crop eradication. It will then evaluate the Colombian government's compliance with the regulations on Environmental Licenses with regard to its aerial spraying activities.

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

50. This section provides a brief overview of the various stages of Colombian legislation and regulations regarding the aerial eradication of illicit crops.

51. The first relevant phase of government activity in relation to aerial eradication of illicit crops lasted from 1974 to 1992. This phase was characterized by the adoption and execution of decisions without the backing of a resolution, and by the experimental nature of the respective programs.

52. It was only in 1994 that the decision was made to spray illegal crops pursuant to an official resolution. Resolution 001 of 1994 authorized -- on an "experimental basis" -- aerial spraying using chemical herbicides of coca and poppy crops, and established the obligation to conduct constant monitoring and evaluation by an environmental auditor, as well as to initiate the Epidemiological Surveillance Plan that had been proposed by the Ministry of Health in 1984.

53. In support of this Resolution, the government invoked communications dated October 8 and 11, 1993, signed by the General Manager of INDERENA and the Minister of Health, respectively, which considered the CNE (Spanish initials for the National Council of Narcotics) strategy for eradicating poppy, coca, and marihuana crops under the conditions that

the parameters recommended by these institutions were strictly applied. These communications did not include any supporting documentation in the form of technical studies, much less studies on potential environmental impacts.

54. 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.

55. In accordance with Resolution 005 of 2000, the Anti-Narcotics Police, in order to determine possible risks, had to request information from various public and private entities (paragraph 2, article 2). The information collected was to be evaluated by the Anti-Narcotics Police themselves in order to determine the potential risks with regard to human health, the environment and agricultural activities. This dilutes the essence of the prevention principle, one of whose corollaries is focused on the need to evaluate the possible negative impact of a project or activity on the environment, as a prerequisite prior to its authorization by an environmental authority. In this case, the Anti-Narcotics Police did not have the independence or expertise to evaluate the environmental impacts of a program that it was going to execute itself.

56. The result of the sprayings was such that citizen discontentment with spraying operations significantly grew. This discontentment was reflected in an increase in the number of complaints, to the point that the government, through the CNE, issued a Resolution in order to regulate the procedure to attend to complaints resulting from the alleged damages caused

by the aerial spraying within the Illicit Crops Eradication Program: DNE Resolution 0017, dated October 4, 2001.[13]

57. In 2003, the CNE issued Resolution 0013, which adopted a "new Procedure" for the PECIG[14] and revoked CNE Resolutions 001 of 1994 and 005 of 2000. The new Resolution authorized spraying in any part of the national territory where illegal crops are present, including National Parks, and reduced the buffer zones around urban centers, aqueducts, *paramos* (high-altitude Andean plateaus), bodies of water and areas of socio-economic, ethnic and environmental interest, leaving them practically unprotected from spray drift.[15]

58. 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.

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[13] Modified by Resolution 0008 of 2007.
[14] Program of Eradication of Illicit Crops using Aerial Spraying with Glyphosate (Spanish initials).
[15] Spray drift refers to the fact that the herbicide is not only dispersed on the place that is intended to be sprayed, but also falls in unplanned areas due to the wind, and even more so when these fumigations are done by airplane. The buffer zones or spaces where spraying should not be done, to avoid the effects of fumigation in special areas, had been defined in Order 558 of 13 August 1996 by the Ministry of the Environment, which established the Terms of Reference for the DNE (National Narcotics Directorate) to produce the EMP for the aerial spray program and were later confirmed precisely in Resolution 1065 of 2001 "Whereby a management plan is established and other decisions are made."

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

59. This section analyzes whether the various stages of the government's aerial spraying program complied with existing Environmental Licensing regulations.

60. This analysis must begin by considering, on the one hand, the type of activity – widespread and intensive aerial sprayings – and on the other, the biological wealth that the country possesses, particularly in its National Natural Parks, where said sprayings have been carried out.

61. 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.

62. However, due to their different nature, characteristics, objectives, scope, procedures, and potential environmental impacts, a distinction must be made between the different programs that the Colombian state has carried out, in order to identify the laws and regulations that applied to each of them at the corresponding point in time.

63. 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. [16] 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 de 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.[17] This demand was not met.

64. Similarly, the spraying operations to eliminate marihuana crops pursuant to the order from the Ministry of Justice in 1984, were also done while the CNRNR was in force, and therefore the above analysis applies to this case as well. That is to say, these spraying activities were performed without regard for the provisions in articles 27 and 28 of the CNRNR on the Environmental Declaration and the Ecological and Environmental Study, respectively,[18] such that during these aerial sprayings we can also see the Colombian government's failure to comply with the requirement to conduct an environmental study and obtain an environmental license, as can be observed in INDERENA's pronouncements made in August 1984, calling for the execution of an EES of the spray program.[19]

65. In addition, when the Colombian Government decided to implement the program for the aerial eradication of illicit crops in 1984, the Group of Scientific Experts that had been called together by the National Institute of Health recommended the creation of a committee,

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[16] As analyzed previously in the section entitled "Environmental Licensing before Law 99 of 1993".
[17] Report of the INDERENA visit to Sierra Nevada de Santa Marta, 1978, Official communication 05821 of July 19, 1978.
[18] See the content of these articles in section "Environmental Licensing before Law 99 of 1993," above.
[19] INDERENA, Official communication number 08885 of August 8, 1984. Attached to this communication INDERENA provided the terms of reference that the DNE should have considered to produce an Ecological and Environmental Study, which was never done.

composed of epidemiologists and toxicologists, who would be in charge of the design and execution of a toxic surveillance program to monitor people exposed to the sprayings because of the aerial eradication program. The Group also emphasized the need for the country to develop its own technology to analyze the herbicides that were being sprayed in environmental and biological samples, in order to develop appropriate programs of toxicological surveillance and monitoring. Neither of these recommendations were followed.

66. In light of the fact that no studies on the effect of the sprayings had been initiated by the CNE, officials from INDERENA were commissioned to fly over the sprayed areas. As a result of this commission, which found very worrying evidence of environmental deterioration, INDERENA developed a proposal called *"Studies for the environmental management of areas of the Sierra Nevada de Santa Marta National Park and buffer zones affected by marihuana crops and their destruction by aerial spraying with glyphosate*."[20] This proposal for environmental studies was sent by the management of INDERENA for the consideration of the National Council of Narcotics (CNE) in official communication number 07364 dated July 31, 1986.

67. The new and expanded wave of *spraying* operations that were announced in a press release to the public in 1992 referred to the elimination of the poppy crop and were of an "experimental" nature.[21] These operations were carried out during the time when the CNRNR was still in effect. In this regard, while the aerial spraying order expressly mentions the participation of the Ministry of Health and INDERENA in the poppy crop reconnaissance and identification phase, in reality the initiation of these spraying operations did not rely on the opinion or authorization of said entities, which constituted a clear failure to comply with

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[20] See Report from the Commission of INDERENA officials held from December 12-16, 1986 in: Documentation Center, Pro-Sierra Nevada Foundation of Santa Marta.
[21] Communiqué of the National Narcotics Council of Colombia to public opinion on the eradication illicit poppy crops, 31 January 1992.

existing environmental law, particularly in relation to the requirement of conducting an environmental study and requesting a license, as indicated by the CNRNR.

68. In this respect, one should note proposition No. 56 of the Plenary Minutes of the ordinary session of the Senate on February 5, 1992, which states: "*The Senate of the Republic recommends to the National Government that it review the decision made by the National Council of Narcotics on January 31, in which it approves the use of Glyphosate via aerial application to eradicate illegal crops in our country. A decision of this nature cannot be made without the corresponding study on the environmental impact and the effects on human health, flora and fauna. That is what this body recommended in its proposition approved unanimously on December 19, 1991. If that decision was approved by the null vote of the Ministry of Education and the Attorney General and also with the negative vote of the Ministry of Health, it should be studied with greater care, with an analysis of alternatives that do not damage the ecosystem nor affect the social and ecological peace*."

69. 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:

- First, the letter or communication from the Manager of INDERENA was not supported by any environmental or other studies. For environmental matters, the requirement established in article 91(g) of Law 30 of 1986 ("*favorable opinion of the entity in charge* *of ensuring the preservation of the equilibrium of the country's ecosystem*") cannot be understood as a mere formality, but involves a detailed, deep and documented environmental assessment, which makes it possible to decide on the environmental viability of the project or work in question.

- Second, the Resolution was adopted after Law 99 of 1993 had gone into effect, and therefore it was not allowed to ignore the mandates established in that law in the area of Environmental Licensing (Title VIII). Specifically, the above-mentioned mandate of article 49 of Law 99 on the obligatory nature of the Environmental License, interpreted together with the already cited article 91g) of Law 30 of 1986, reinforced even more the obligation to carry out studies on the detailed environmental assessment of the coca, poppy and marihuana spraying operations of 1994. That mandate was clearly disregarded.

70. 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,[22] 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.

71. Later, in an order dated October 26, 1996, reiterating the position adopted on August 15, 1995, the Council of State said, in response to a compliance action, that the authorization of illicit crop eradication in Resolution 001 of February 1994 constituted a continuation of the governmental authorization of 1992 to eradicate poppy crops, and in this sense, because it began before the enactment of Law 99 of 1993, it was under the transitional

[22] Article 1.1, 1.10, 1.11 of Law 99 of 1993; Article 80 of the Political Constitution of Colombia.

regime described in article 38 of Regulatory Decree 1753 of August 1994, so that the activity could continue to be carried out without the need for an Environmental License.

72. 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.

73. In any event, even if one accepts the arguments of the Council of State of 1995, and considers the 1994 operations to be under the transitional regime of Decree 1753 of 1994, that does not completely release the CNE from its environmental obligations, as the Council of State itself acknowledged in saying: "*without prejudice to the fact that the environmental authorities can intervene when they deem necessary to enforce compliance with the laws that regulate the environment in order to maintain it healthy, recover it or restore it as the case may be*".[23] Within the framework of general environmental obligations, the principles of prevention and precaution could not be ignored, as they are guiding principles of legislation.

74. Moreover, in a letter to the Minister of Justice, dated 20 December 1994, the Minister of Environment made clear that even under Law 99 of 1993 and the transitional regime it established, the Ministry of Environment would still require the Government to carry out an Environmental Impact Assessment for the aerial spray program.[24]

75. 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 above. Resolution 005 of

[23] Council of State, Sentence of 27 October 1995, Judge: Dra. Nubia González Cerón.
[24] Letter from Cecilia Lopez Montano, Minister of Environment, Republic of Colombia, to Nestor Humberto Martinez Neira, Minister of Justice and Law, Republic of Colombia of December 20, 1994.

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. Three fundamental changes distinguish the 2000 aerial spray program from the ones that preceded it: the first is the radical increase in the intensity of the sprayings; the second is the new territories exposed to the spray, particularly including Colombia’s southern international border; and the third is the change in the composition and concentration of the herbicide used in the sprayings and the new norms for their application.

- With respect to the first change, it should be noted that beginning in 2000, the number of hectares fumigated was much more than had been fumigated in earlier years. This increase was revealed in figures reported in 2001.[25] In that year, the government fumigated 94,153 hectares of land – compared to the period from 1994 – 1999, when between 3,871 and 66,029 hectares were fumigated each year.[26]

- Regarding the second fundamental change, the Government program had a new orientation, in that it concentrated on the border between Colombia and Ecuador – in the border provinces of Putumayo and Nariño, which are also close to natural parks and reserves, areas long excluded from aerial eradication.

- In terms of the third fundamental change, it must be remembered that after the events that occurred surrounding the so-called Aponte case in 2000,[27] an attempt was made to find an explanation for the unusual injuries suffered by the population after an intense spraying,[28] under the suspicion that the government had begun to use a new chemical product of greater reach, the formula for which was not yet publicly known. In fact, it later was revealed that the chemicals were different than had been used previously.

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

[25] 2003 UNODC Report, p. 51.
[26] 2003 UNODC Report, p. 51.
[27] See more information in Section V of this study on indigenous rights.
[28] Organization of Indigenous Nations of Colombia (ONIC), Black Communities Process (PCN), National United Agricultural Labor Federation (FENSUAGRO-CUT), Evaluation of the Fumigations in Colombia, Destruction of Rural Areas by the Plan Colombia, August 2002, Page 20 ff.

77. 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.

78. 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. As can be observed from the series of events described below, the DNE did not readily meet its obligations:

- In 1998, in official communication No. 11430 of July 30, 1998, the National Directorate of Narcotics (DNE) sent the Ministry of the Environment (MMA) a proposed EMP for the activity of "*Illicit crop eradication through aerial spraying with Glyphosate*," without the chapter corresponding to the "Identification and Assessment of Environmental Impacts." Once the proposed EMP had been evaluated, Technical Opinion No. 419-99 dated December 21, 1999 was issued, in Order No. 599 of December 23, 1999, which required the DNE to complete the Environmental Management Plan, which had been deemed inadequate.
- In a letter dated February 1, 2000, the DNE filed an Appeal for Reversal against Order No. 599 of 23 December 1999, arguing among other things that it did not agree with the

technical opinions issued by the Colombian Institute of Agriculture and Livestock (ICA, for its initials in Spanish) and the technical office of the Ministry of the Environment, nor with the deadline established for the presentation of the complete Environmental Management Plan.

- In Order No. 143 of March 29, 2000, the Ministry of Environment resolved the Appeal for Reversal by confirming the other terms of the first article of Order 599 of 1999, and setting a term of 3 months for the delivery of the information requested, which had not been provided by the DNE.

- In an official communication dated May 10, 2000, the DNE filed an Appeal for Reversal against the Order mentioned above, arguing, among other things, that in order to expand, revise and submit the EMP, it would need the participation of other entities.

- In Order 275 of June 6, 2000, the Ministry of the Environment decided on the appeal for reversal filed against Order No. 143 of March 29, 2000, by denying the appeal and ratifying the order in its entirety.

- The DNE, in a communication dated September 13, 2000, submitted to the Ministry of the Environment the document entitled *"Complement to the Environmental Management Plan for the application of the herbicide Glyphosate in the eradication of illicit crops*,*"* which was supplemented on October 17, 2000. After receiving and studying the additional information complementary to the proposed EMP in question, the Sub-directorate of Licenses, in its technical opinion No. 589, dated December 20, 2000, found that this information provided by the DNE did not comply with the requirements established under Order No. 588A of 1996.

- In response to the above, on December 20, 2000, the Ministry of the Environment invited the DNE to a meeting where the Ministry informed the DNE that the information provided did not satisfy the requirements imposed. At this meeting, the DNE committed to submitting a document providing greater detail in its descriptions and orienting the impact assessment to an analysis of risks, for the Putumayo region, according to what had been requested in the terms of reference for the Environmental Management Plan contained in Order 558A of 1996.

- In compliance with the above, in official communication numbered 3111-1-1627 of January 30, 2001, the DNE delivered a document entitled *"Environmental Management*

Plan based on the assessment of the potential operations risks derived from the eradication of illicit crops by spraying in the Putumayo Department." Through Resolution 341 of May 4, 2001, the Ministry of the Environment decided not to accept the Environmental Management Plan submitted by the DNE.

- The Ministry of the Environment in Order 516 of July 16, 2001, required the DNE to report the steps it had taken to comply with Resolution 341 of 2001.

- In communication number 3110-1-1069 of August 8, 2001, the DNE sent the Ministry of the Environment the first progress report regarding the obligations established in Resolution 341 of 2001. In response to this report, the Ministry, in official communication 2211-2-126 of August 24, 2001, requested clarifications regarding the communications with the Ministry of Health and ICA.

- Through official communication No. 3113-1-14331 dated November 7, 2001, the DNE sent the Ministry a document entitled "*Environmental Management Plan for the Program to Eradicate Illicit Crops with the Aerial Spraying of Glyphosate*," as well as the document related to the Status of Progress of Resolution 341 of 2001.

- Soon thereafter, the Ministry of Environment imposed a revised Environmental Management Plan on the DNE, through Resolution 1065 of 26 November 2001. At the same time, the Ministry of Environment initiated an investigation of the DNE for its failure to comply with Resolution 341 of 2001, through Resolution 1066 of 26 November 2001. The sanctioning procedure brought under Resolution 1066 resulted in the imposition of a fine in the amount of 33,200,00 Pesos, under Resolution 0670 of 2003.

79. For its part, Resolution 1065 of 2001 required the clarification of a series of issues that up to that time the DNE had not verified. Two questions raised in this resolution are particularly relevant: the first question relates to buffer zones and the second question refers to the insistence that the spray program not operate in environmentally sensitive areas like populated areas, parks, nature reserves, aqueducts and bodies of water.

80. 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. Reducing the buffer zones was not within its scope of powers. It is the Ministry of the Environment's duty to establish the parameters of the Environmental Management Plan for the spray program and the dimensions of these zones are part of those parameters. To justify the modifications, the CNE invoked the application of article 87 of Decree 1843 of 1991,[29] according to which the buffer zone for the application of pesticides in rural areas must be at least 10 meters if applied on the ground and 100 meters if by air, from bodies of water, highways, human settlements, herds of animals or any other area requiring special protection. However, it must be stated that legally the definition of buffer safety zones established in Resolution 341 of 2001 and confirmed in Resolution 1065 of 2001 prevail, particularly because the aerial spray program is a special case of widespread and intensive aerial spraying, which requires greater care due to the special circumstances under which the program is executed, and is not a spraying of traditional agricultural crops.[30] The failure to abide by the provisions on buffer zones imposed by the MMA therefore represented a violation by the State of its internal environmental regulations.

81. It must also be pointed out that CNE Resolution 0013 of 2003, *"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,"* is a clear violation of what the Ministry of Environment instructed in Resolution 1065. In fact, the Environmental Management Plan imposed by the Ministry of the Environment in 2001 had established buffer zones of 2000, 1600 and 200 meters, while Resolution 0013 of June 2003 reduced the protection zone to between 10 and 100 meters, by invoking article 87 of CNE Decree 1843 of 1991, as noted above.

[29] Decree No. 1843 of 1991, which partially regulates titles III, V, VI, VII and XI of Law 09 of 1979, on the use and handling of pesticides.
[30] See Resolution No. 108 of January 31, 2002 of the Ministry of the Environment.

82. Additionally, Resolution 0013 of 2003 fails to comply with the terms imposed by the Ministry of Environment in Resolution 1065 in relation to the coverage of the aerial spray program, by ordering that the Program may operate in all areas of the country where there is evidence of the presence of illegal crops, which opens up the possibility of spraying even in National Natural Parks; areas where Resolution 1065 expressly orders only manual eradication (article 3).

83. In other words, by November 2003, there was no EIA, much less an Environmental License, and therefore there was an open violation of Colombian law in this respect.

84. 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.

85. 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*".[31]

- 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.[32]

- The most important law of the juridical hierarchy regarding the environment, Law 99 of 1993, clearly states, in article 52, that projects that affect the National System of Natural Parks are subject to the obtainment of an Environmental License from the Ministry of the Environment, with no exceptions.

86. In light of the foregoing, no other conclusion can be reached than that the Colombian Government failed to comply with its internal environmental laws and regulations in the area of Environmental Licensing and Environmental Impact Assessments.

87. In fact, this non-compliance has been demonstrated by Colombia's jurisprudence. In this regard, we can highlight the decision of the Administrative Court of Cundinamarca of 2003, which relates to a popular legal action filed against the Program of Eradication of Illicit Crops with Glyphosate (PECIG), claiming that the program violated, *inter alia*, the collective rights to enjoy a healthy environment (Const. art. 79) and the State's obligations to ensure the proper management and use of natural resources (Const. art. 80) and public health and safety (Const. art. 78).

88. The Court, in its ruling, ordered the temporary suspension of the aerial spraying of illicit crops with the glyphosate – POEA – Cosmoflux mixture throughout the entire national

[31] Emphasis added.
[32] Decree 2811 of 1974, Law 99 of 1993, Law 599 of 2000 (Penal Code).

territory.[33] This suspension was to remain in place until all of the following conditions were met: 1) That the DNE comply strictly with the measures imposed by the Ministry of the Environment, including both the preventative measures required in Resolution 341 of 2001 (arts. 2, 6, 7 and 8) and those established for the EMP under Resolution 1065 of 2001; 2) That the Ministry of Social Security and Protection (Colombia's Ministry of Health) provide the "*medical-scientific studies that determine the effect of glyphosate, POEA, Cosmo Flux, on the health of Colombians*"; and 3) That the DNE comply with CNE Resolution 0017 of 2001 which was intended to address the damage caused by the application of the aerial spraying program.

89. In 2004, the Council of State overturned this decision and ruled that the suspension of the aerial spraying program should be lifted on the condition that "*the guidelines stated by the environmental authorities should be followed when illicit crops are being sprayed, and not even the slightest deviation from these should be permitted, which means that it is therefore necessary for permanent controls to be undertaken, with continuous evaluations, of any effects which might begin to appear*".[34]

90. As can be seen, although the Council of State revoked the decision of the Administrative Court of Cundinamarca of 2003, it demonstrated a concern for the root of the problem, and at the same time established clear obligations for the State, in Numerals 2 and 3 of the Court's decision, which are:

- The Ministry of the Environment, Housing and Territorial Development must continue with *"its work of verification in order to assure strict compliance with the **Environmental Management Plan** imposed by Resolution No. 1065 of 2001, as well as the obligations*

[33] State Council of Colombia, *Claudia Sampedro and Others*, Judgment on Appeal From the Administrative Tribunal of Cundinamarca (19 Oct. 2004).
[34] State Council of Colombia, *Claudia Sampedro and Others*, Judgment on Appeal From the Administrative Tribunal of Cundinamarca (19 Oct. 2004), p. 10.

contained in Articles 2, 6, 7, and 8 of Resolution No. 341 of 2001, both Resolutions issued by that same Ministry."

- The Ministry of Social Protection *"must carry out studies which include groups exposed to* ***glyphosate****, plus* ***POEA****, plus* ***cosmoflux****, and with a control group that has not been exposed over time. These studies should include records of mortality and morbidity in order to determine the impact of the referenced chemicals on the health and life of the Colombian people living in the sprayed areas, especially in the area of influence of the Sierra Nevada de Santa Marta, but also other areas which have been subjected to spraying. The study areas are to be chosen by the Ministry of Social Security, and must include areas sprayed during different periods."*

91. These obligations have not been properly fulfilled by the corresponding State entities. On one hand, as mentioned previously, the terms of reference established in Resolutions 341 and 1065 of 2001, issued by the Ministry of the Environment, have never been properly followed by the DNE, and in addition, there is no evidence that the Ministry of Social Protection has carried out the study ordered by the Council of State in its ruling.

92. In addition, it is important to note the decision of the Contentious-Administrative Court of Nariño in response to a Popular Action interposed in 2001 by the a representative of the municipality of Barbacoas against the Nation, the Ministry of Defense, the National Police and the Government of Nariño.[35] This Action requested the preventative suspension of the spraying in that province, and the continuation of manual eradication, in order to protect the collective rights of the inhabitants of Barbacoas, Roberto Payan and Magui.

93. The Court ruled that the DNE, by initiating the spraying program without having an EMP approved by the environmental authorities had violated the collective right to a healthy environment. Additionally, it ruled that the DNE and the DIRAN *"may not carry out indiscriminate Glyphosate spraying without being subject to the corresponding regulations."*

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[35] By request of the Prosecutor's Office the Ministry of the Environment, the National Drug Council and the Autonomous Regional Corporation of Nariño – CORPONARIÑO, were joined in the case.

The ruling states that a "lack of foresight" by those entities had caused damage to property and protected resources, particularly those located in exclusion areas and along safety zones.

94. Because the actor did not continue the case, there was no accompanying proof of damage, and the petition to suspend the Eradication Program was not heeded. Nonetheless, based on what had been presented, the Court ordered the Nation, the Ministry of Justice, the DNE, the Ministry of Defense, and DIRAN to abstain from continuing sprayings in the mentioned municipal areas, "*unless they are in compliance with the stipulations of the Ministry of Environment imposed in the Environmental Management Plan"*.[36]

95. This decision was upheld by the Contentious Administrative Court, Second Section, Subsection "B" of the Council of State.[37]

96. 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. The EMP is only one part of the EIA, which must be presented in order to obtain an Environmental License before initiating any activity involving projects that could potentially cause serious damage to the environment, such as the case of the government program of aerial spraying.

[36] Contentious-Administrative Court of Nariño; Popular Action No. 2 -1172 of June 14, 2002.
[37] Council of State, Statement No. 5200123310002000117201 of October 10, 2002.

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

97. In Colombia there are regulations addressing the use, production, storage, sale, importation, aerial application and, in general, any activities related to the management of pesticides. Pesticides are broadly defined to include fungicides, insecticides, and herbicides.

98. This topic has been the subject of policies and regulations due to growing awareness of the large number of chemical formulations that have effects on the environment and human health. As evidenced in official reports, there are currently more than 1000 types of pesticides used in Colombia, marketed as approximately 40,000 products.[38]

99. The objective of this Section is to analyze Colombian pesticide regulations particularly in the context of aerial spraying of illicit crops with herbicides. The main regulatory standards on the subject of pesticides in Colombia are the Renewable Natural Resource Code, Law 9 of 1979, and Decree 1843 of 1991 issued by the Ministry of Health. The analysis of pesticide regulations in this Section focuses on the following: the emphasis on prevention in Colombian pesticide regulations; the distribution of authority in matters of pesticide regulation and control; and, the regulation of pesticide use, with emphasis on aerial application methods.

A. General framework and emphasis on prevention

100. Colombian law on the subject emphasizes prevention, which generally implies meeting all requirements necessary to protect the environment and human health prior to importation, production, commercialization, storage, use, handling, or disposal of pesticides.

101. The regulation of pesticides began in Colombia with Decree 2811 of 1974, or the Renewable Natural Resources Code (CNRNR). Article 300 of that Code establishes a

[38] The Auditor General of the Republic, Office of Analysis and Oversight of the use and handling of pesticides in Colombia, Bogotá D.C.; March, 2004, page 13

core principle, according to which, *"The importation, production, commercialization, transportation, storage and application of products destined for use on animals or vegetation will be controlled, and require permission."* This requirement is still in effect at the present time.

102. Later, Law 9 of 1979 outlined health measures and established certain standards and principles, including an emphasis on prevention. It stipulates in its Article 142, that: *"In the application of pesticides, all appropriate measures must be adopted in order to avoid health risks to the people employed in this activity, and the occupants of the treated areas, as well as to avoid contamination of products destined for human consumption, and risks to the environment in general, in accordance with the regulations issued by the Ministry of Health".*[39]

103. These stipulations set out the general standards, which required a more detailed set of regulations in order to be applied. Those regulations were established in 1990, by Decree 775, which was replaced by Decree 1843 of August 26, 1991. Decree 1843 establishes a regulatory regime for control of the use and application of pesticides.[40] These regulations contain an equal emphasis on prevention of risks to human health and to the environment. Particularly notable is Article 86, regarding "Prevention of Environmental Risks," which requires that application of pesticides near populated areas, places that cultivate fish, bees, birds, or other animals, water sources or streams, and areas that are managed for

[39] Other evidence of the emphasis on prevention of risk to human health and the environment in Colombian pesticide law can be found, for example, in Law 9 of 1979, whose Article 137, regarding prior registration of pesticides, requires that: "*For importation, manufacture and commerce (...). This registration may only be issued by the appropriate authority when in the judgment of the Ministry of Health the pesticide in question does not represent a serious risk to human health or the environment, and it would not be possible to adequately substitute less risky products."* Also, Article 140 of this regulation, regarding storage, states that *"in any activity involving handling of pesticides, any situation that would allow a pesticide to come in contact with or have close proximity to food, drugs, medicines or any other substances, or objects whose use would pose a risk to human health if contaminated, is prohibited."*

[40] Decree 1843 of 1991, was partially revised on several occasions by: Decree 1840 of 1994, which modified Numeral 3 of Article 195 regarding the functions of the ICA over pesticides; Decree 3213 of 2003, which modified Articles 11 and 12 regarding the composition and functions of the Intra-sectional Pesticide Council; Decree 4368 of 2006, which modified Article 98 regarding location of runways and tanking sites; and Decree 3830 of 2008, which modified Article 8 regarding the formation of the Sectional Pesticide Council.

the protection of natural resources, must utilize protective techniques appropriate to the risks inherent in that activity.

104. Other evidence of the emphasis on prevention in Colombian pesticide regulation is seen in the requirements regarding the labeling of pesticides and the emphasis on strict compliance with those label requirements. Specifically, Chapter XI of Decree 1843 is dedicated to regulating the manner and content of labeling on containers and packages containing pesticides. Among other requirements, Article 149 of Decree 1843 states that pesticide labels must include the following inscriptions: *"Warnings or information about precautions that should be taken to minimize risks to human health and the environment, highlighting in technical language any risk specific to that product. For example: 'Flammable. Keep out of reach of children and away from animals and food.'"* In addition, those responsible for any activities related to use and handling of pesticides are obligated to comply with the pesticide label. Decree 1843 provides that *"Anyone involved in the use and handling of pesticides must comply with and enforce the regulations applicable to that activity, as outlined in this ruling"*.[41] These regulations include *"Handling products in accordance with the instructions on the label or as indicated by the technical advisor of the company"*.[42] Failure to comply with this obligation may result in safety measures and sanctions on the part of the health authorities.[43]

B. Jurisdiction over regulation and control of the use of pesticides

105. Decree 1843 establishes a distribution of authority among three agencies, in order to ensure comprehensive prevention of environmental and health risks. The Colombian

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[41] Decree 1843 of 1991, Article 180.
[42] Decree 1843 of 1991, Article 181(h).
[43] Article 196 and following, of Decree 1843 of 1991. It is worth noting that ICA Resolution No. 03759 of December 16, 2003, states in its Article 26 that it is necessary to comply with Section 3 of the Technical Manual of the Andean Countries regarding labeling. Civil or criminal penalties may apply in cases of non-compliance. ICA Resolution No. 03759, Article 33. Also, ICA Resolution No. 002713 of October 10, 2006, Article 11.8 establishes that the labeling must comply with the FAO International Code of Conduct for the Distribution and Use of Pesticides.

Agricultural Institute (ICA), which is under the Ministry of Agriculture is responsible for analyzing the agricultural effectiveness of a pesticide and granting permission for its commercialization, after receiving approval from the Ministry of Health. The ICA is also responsible for approving pesticide product labels. The Ministry of Health, in turn, is in charge of issuing toxicity statements. There are also certain areas of authority belonging to the Ministry of the Environment, including the evaluation and prevention of environmental risks which are inherent to pesticide use. In addition, issues regarding aerial application of pesticides require the involvement of authorities such as the Civil Aeronautics Administration.[44]

106. Regarding the application of pesticides it is important to note that Article 27 of the cited Resolution 3079 of 1995[45] established that any individual or entity involved in the commercial application of the products referred to in that Resolution, whether by air or by land, must comply with the procedures and obligations established by the ICA through the Division of Agricultural Supplies, as outlined in the corresponding technical manual.[46] This is in addition to the regulations of the Ministry of Health, the Ministry of the Environment, and the Civil Aeronautics Administration (Aerocivil).

107. In addition, in order to coordinate the application of pesticide regulations, Decree 1843 of 1991 creates a National Pesticide Council. This Council includes delegates from the Ministry of Agriculture, the Ministry of Rural Development, the Ministry of Social Protection, industry, and pesticide users. The purpose of the Council is the study and planning of solutions regarding pesticides issues in Colombia. Through this Council, the

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[44] Article 195 of Decree 1843. Following the issuance of Decree 1843 of 1991, pesticides use has been regulated based on various Resolutions issued by the Ministry of Health (Resolution 010834 of 1992), the Ministry of the Environment (Resolution 0189 of July 15, 1994) and by the ICA (Resolutions Number 3079 of 1995 and 1068 of 1996). Nevertheless, Decree 1843 of 1991 remains in effect.

[45] This Resolution, issued by the ICA, regulated functions of this Institute which are directed toward having technical control over agricultural supplies commercialized within the country; authorizing exportation of pesticides; and maintaining a registry of importers, quality-control laboratories, and sales records. This Resolution, 3079 of 1995, was replaced by ICA Resolution 2713 of 2006.

[46] In Resolution 1068 of 1996, the ICA adopts the Technical Manual for Application of Agricultural Supplies.

Ministry of Health (now the Ministry of Social Protection) and the Ministry of Agriculture coordinate the public and private entities involved in use, handling and disposal of pesticides. The objective is to ensure the health of the community and the preservation of agricultural, livestock, and natural resources.

108. Article 7 of Decree 1843 of 1991 of the Ministry of Health gave the National Pesticide Council important functions in the areas of control and oversight of pesticide use in Colombia, including control and oversight of both aerial application and land application. Considering the importance of these functions to prevent and control the risks related to the government program of aerial spraying of illicit crops, it is surprising to note that, although there is no evident reason or legal impediment, this Council has only met one time since its creation.

109. In addition, it is worth noting the statements made by the General Auditor of the Republic in 2004, in his report on the use of pesticides in Colombia:

> *"12.7. In accordance with the information requested of the Department of Public Health of the Ministry, we were able to verify that the National Pesticide Council had a meeting, after 6 years of inactivity, on October 16, 2001. Since that date they have not had any other sessions, even though they are required to do so every six (6) months, according to Article 6 of Decree 1843 of 1991. Consequently, they have not complied with one of their main functions, which is to formulate and adopt an annual plan of basic activities for the oversight and control of the use and handling of pesticides, during the last quarter of each year, for the following year".*[47]

C. Regulation of the use, handling and application of pesticides

110. One of the central questions to be analyzed for purposes of this study is the regulation of use, handling and application of pesticides. In that regard, two basic questions need to be considered: first, how pesticides are registered, and second, the measures and procedures stipulated by law for the use of pesticides.

[47] General Auditor of the Republic, Analytical Auditor for the use and handling of pesticides in Colombia, Bogotá D.C. March, 2004

111. In general any activity related to use and handling of pesticides[48] requires a registration. For that purpose, Article 13 of Decree 1843 requires that each product receive a toxicity classification and a permit for use in Colombia. Article 13 states that: *"any individual or entity who imports or manufactures pesticide products for application within the country, regardless of the quantity to be imported or commercialized, must first obtain the toxicity classification and permit for use in the country from the Ministry of Health or its delegated authority, in compliance with the stipulations of Chapter X of this Decree"*.[49]

112. Classification of pesticides based on toxicity levels is established in Article 14 of Decree 1843, in the following toxicity categories:

- CATEGORY I "Extremely toxic"
- CATEGORY II "Highly toxic"
- CATEGORY III "Moderately toxic"
- CATEGORY IV "Slightly toxic"

According to Article 18 of Decree 1843, the Ministry of Health, through its Division of Potentially Toxic Substances, issues the toxicity classification and either permits or denies use of the product in Colombia. The classification process involves a series of tests for acute, sub-acute and chronic toxicity in mammals, generally conducted by the product manufacturer. After reviewing the documentation, the Ministry of Health, through its Division of Potentially Toxic Substances, will issue a toxicity classification and will permit or deny permission for the use of the product within the country.[50]

113. 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. Article

[48] Pursuant to Article 3 of Decree 1843 this includes any activity related to those pesticides, including synthesis, experimentation, importation, exportation, formulation, transport, storage, distribution, supply, application, and final disposal of wastes or remnants of pesticides.
[49] Chapter X of Decree 1843 outlines the procedures for Authorizations, Health Licenses, Registrations, Permits and Approvals.
[50] Decree 1843, Article 18.

29 stipulates that *"Any individual or entity involved in activities related to experimentation with pesticides must have prior permission from the Ministry of Health"*.[51] Activities related to production, processing and formulation of pesticides are regulated in Chapter V (Articles 44 to 51) of Decree 1843. Article 44 stipulates that *"Any individual or entity involved in the production, processing or formulation of pesticides, whether they perform all the chemical and physical steps necessary, or only one or some of them, must have a Health License issued by the Ministry of Health, which will be valid for five (5) years, renewable for equal periods."* Chapter VI of Decree 1843 (Articles 52 to 57) refers to the activity of pesticide storage, and Article 52 stipulates that *"Any individual or entity involved in the storage of pesticides to be commercialized must obtain a Health License to Operate, issued by the appropriate Sectional Health Office, which will be valid for five (5) years, renewable for equal periods."* The activity of supply and distribution of pesticides is regulated in Chapter VII of Decree 1843 (Articles 58 to 64) and its Article 58 stipulates that *"Any individual or entity involved in the distribution or supply of pesticides must obtain a Health License to Operate, issued by the appropriate Sectional Health Office."* Chapter VIII of Decree 1843 (Articles 65 to 81) regulates the activity of transportation of pesticides, and its Article 65 establishes that *"Any individual or entity involved in the transportation of pesticides by land, air, sea, or rivers, must obtain a transportation license for a term of five (5) years, renewable for equal periods, issued by the Sectional Health Office, in accordance with the stipulations of this Decree."*

114. It should be clarified that Andean Decision 436 of 1998, which became effective in 2002,[52] 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

[51] Title IV of Decree 1843 (Articles 29 to 43) regulates experimentation with pesticides

[52] Article 70 of Ruling 436 deferred the effective date, making it subject to approval of the Andean Technical Manual, which was only issued in 2002, by Resolution 630 of June 25, by the Secretary General of the Andean Community of Nations.

conditions authorized, and facilitating their commercialization in the region. Therefore, Decision 436 describes procedures for obtaining national and sub-regional registration of pesticides as well as procedures for three special permits (investigation, experimentation, and phytosanitary emergencies). However, it should be noted that the Andean regulations do not deal with specific topics, such as the aerial application of pesticides. 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.

115. 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."*

116. The application or use of pesticides is regulated under Chapter IX of Decree 1843.[53] Article 82 clarifies that the idea of application includes both aerial and terrestrial methods, and mandates that this must be done in compliance with the regulations established by the Ministry of Health, the Colombian Agricultural Institute, the National Institute for Renewable Natural Resources and the Environment, and other State organizations in their respective field of expertise.

[53] In accordance with the definitions of Article 3 of the Decree, application consists of *"Any action by any appropriate person, whether connected to a company or not, involved with the control or elimination of pests using officially registered and authorized chemical or biological substances, using techniques, equipment, and tools approved by the health authorities and the Colombian Agricultural Institute."*

117. Within the framework of the Section concerning the application of pesticides, we must remember that, in addition to respect for the safety zones,[54] the abovementioned Article 86, along with Article 89, stipulate special attention to avoiding risks to environment or human health.[55]

118. Furthermore, Article 93 of Decree 1843 defines the obligations of those responsible for the prescription and application of pesticides, emphasizing in general that *"Any individuals or entities responsible for the prescription and/or application of pesticides must comply with all the pertinent requirements of the preceding Chapters of this Decree."* In addition, the regulation establishes, among other obligations, that pesticide applicators must be registered in the corresponding Sectional or Regional Health Office of the Colombian Agricultural Institute, depending on the type of activity. It also establishes the obligation for the responsible parties to demonstrate that they have complied with all preventative measures and safety measures in the area, buildings, vehicles, or product to be treated, as well as in the surrounding areas.[56]

119. Therefore, according to the current regulations on the matter, the ICA has the sole authority for performing registration of pesticides. However, there is also some involvement of both the Ministry of Environment, as the entity that issues the Technical Environmental Rulings, and the Ministry of Social Protection, which issues the Toxicity Evaluation. Activities related to the use and management of pesticides, including pesticide application, are regulated primarily under Decree 1843 of 1991.

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[54] Analyzed in Section III of this study.
[55] Article 89 of Decree 1843: "Pesticides must be applied within a determined area, respecting the safety zones, to avoid damage to the health of the population and the environment."
[56] Decree 1843, Article 93.

D. Regulation of the aerial application of pesticides

120. The activity of aerial application of pesticides is specifically addressed in Decree 1843, Articles 95 through 102. Among other requirements, any individual or entity who applies pesticides using airplanes, based on Article 95, must:

- Obtain an operating permit for each of their runways, issued by the Civil Aeronautics Administration (DAAC);
- Obtain a health license issued by the respective Sectional Health Office;
- Comply with and enforce the pertinent current regulations established by the Ministry of Health, the Ministry of Agriculture, and any other State organizations.

121. The health license required by Article 95 is necessary for every individual or entity that applies pesticides using aircraft. The requirements for obtaining a health license are described in Articles 131 and 132 of Decree 1843 1991.

122. Under the pertinent regulations, it should be noted that there is no distinction made between public entities or private companies. Article 3 of Decree 1843, broadly defines an APPLICATOR, as *"Any individual or entity involved in the application of pesticides."* That means that the DNE, as the entity responsible for the aerial spraying of illicit crops, was subject to the legal requirement to obtain a Health License and Permit from the DAAC.

123. Article 102 establishes the obligations of the pilots that carry out aerial spraying operations. In general, these requirements refer to compliance with the pertinent regulations established in Decree 1843 of 1991. In particular, pilots must comply with the following requirements, among others:

> *"a) To take into account wind speed, temperature, relative humidity, flight speed and altitude, in accordance with the stipulations of the respective agricultural and civil aviation authorities;*
>
> *b) To make applications within a fixed-width area;*

c) Not to fly over populated areas, water supplies, schools, or other locations that would present a risk to the health or safety of humans, animals, or vegetation;

d) Not to apply pesticides over housing located within the treatment area, areas of protection for bodies of water, natural parks, reserved or restricted areas."

124. These obligations are also referenced in Item No. 1 of the Environmental Management Plan, adopted in Resolution 1054 of 2003. Resolution 1054 states that, in order to avoid the adverse consequences of the drift effect: *"Article 102 of Decree 1843 of 1991 which refers to pilots' obligations must be strictly obeyed; likewise, any other articles that may be applicable to the program must also be taken into account."*

125. The complaints received from the civil population after the aerial sprayings with glyphosate,[57] are just one piece of evidence of non-compliance with these requirements. As discussed above, it is not only the non-compliance by the pilots that is relevant, as described in Decree 1843 (Article 102); the responsible agency must also verify that all personnel involved in the operation comply with the preventive measures and safety measures that apply to aerial spraying.[58]

126. Decree 1843 was in effect at the moment when Resolution 001 of 1994 was issued by the DNE, authorizing the aerial spraying of coca and poppy plantations with herbicides, and also when it was modified by Resolution 005 of 2000. Therefore, pursuant to the requirements just described, the DNE was required to obtain an operating permit for the operation of its runways from the Civil Aeronautics Administration and a health license issued by the Sectional Health Office. In addition, the DNE had the obligation to ensure that the pilots carrying out aerial spraying operations complied with the requirements of Decree

[57] Reason for which the DNE had to adopt Resolution 0017 of 2001 regarding the procedure for addressing complaints arising from aerial spraying.
[58] Decree 1843, Article 93.

1843 Article 102. Nevertheless, Colombia has not provided evidence to demonstrate compliance with these requirements.

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

A. Background

127. According to information from the National Statistics Administration (DANE), the indigenous population in the country is currently estimated at approximately 1.3 million inhabitants, occupying 25% of the country's territory. The majority of the indigenous populations are located in the south of the country, along the border areas.

128. In addition to the problems that have historically affected these populations due to poverty, marginalization, and discrimination, in recent years they have also had the problem of aerial spraying over their territories.

129. On many occasions, the activity of aerial spraying over lands which are indigenous reserves has coincided in time with the death of the people's traditional legal crops (yucca, plantain, corn, and potatoes), as well as soil erosion problems, livestock diseases and the appearance of human illnesses such as digestive, respiratory, and skin problems among the indigenous people in the sprayed areas.

130. The problem was at its peak, and became a subject of considerable public attention, during the government of President Pastrana. At that time, the Organization of Indigenous Populations of the Colombian Amazon (OPIAC) filed an action of protection against the President of the Republic, arguing that forced eradication of illicit crops using glyphosate affected their rights to life (Const. art. 11), to community existence (Const. arts. 1, 7, 70), to a healthy environment (Const. art. 79), to due process (Const. art. 29) and the right

of the indigenous populations to participate in decisions affecting their development (Const. art. 330).

131. The Court ruling on this matter did not ultimately order a suspension of the sprayings, but it did partially protect the rights of the indigenous communities. It mandated that the President and the National Narcotics Council were obligated to consult the indigenous and tribal peoples about eradication of illicit crops in their territories, in order to reach agreement on or get their approval for any measures to be adopted in this matter.[59]

132. In 2005, another case raised issues caused by the sprayings over indigenous territories. A short time after intense sprayings in the territory of the Esperara Saipidara tribe, in northeastern Nariño province, three indigenous children died and sixteen more were affected by the aerial sprayings in Bocas de Satinga on March 25, 2005, according to reports by the Provincial Health Department of Nariño.[60] Additionally, according to the census of the Association of Indigenous Esperara Siapidaara Councils of Nariño (Aciesna), 107,337 plants were lost to the sprayings, including plantain, banana, Chinese yams, yucca, sugar cane, chilma, limes, coconut, sapodilla, orange, chontaduro, cocoa and wood-producing plants.

133. Based on this brief description of the situation of the indigenous population in the context of the aerial spray program, this Section focuses on the analysis of the Colombian government's compliance with its own obligations regarding the protection of indigenous peoples' rights in the matter of aerial eradication of illicit crops.

B. Law on the protection of indigenous rights

134. The constitutional reform of 1991 elevated the subject of ethnic groups' rights to the Constitutional level, for the first time in Colombia. Legislative treatment of the issue

[59] Constitutional Court, Protection Ruling of May 13, 2003, File entry T-517583, Presenting Magistrate Álvaro Tafur Galvis.
[60] García, Mario Camilo, Human Rights: Indigenous Children Victims of Fumigation with Glyphosate, Voltairenet.org, June 23, 2005.

was addressed in the following regulations: Law 160 of 1994 regarding the National System of Agrarian Reform;[61] Law 70 of 1993 regarding the rights of black and racial communities; Law 21 of 1991 which approved Convention 169 of the International Labor Organization (OIT, *initials in Spanish*); and Law 99 of 1993 regarding environmental protection and licensing.

135. In compliance with Colombian legal regulations, the indigenous communities and populations were granted the same administrative, fiscal and financial autonomy over their own territories as is granted to the provinces, districts, and municipalities. They were also given a certain level of autonomy in political and legal matters. In addition, they were granted autonomy over other aspects, including issues of language, education and culture (Const. art. 68, para. 5 and art. 70, para. 2). This autonomy was rooted in the general principles of democratic and pluralist participation established in Article 7 of the Constitution.

136. The Constitutional Court, in essence, has stated that justice will only be done, according to Article 7 of the Constitution, once the indigenous communities are granted maximum autonomy, with the aim of assuring their cultural survival.[62] Based on this reflection, the Constitutional Court developed the principal of maximizing autonomy, the corollary of which is limiting interference, as a way to protect the greater good.[63]

137. The principle of maximizing autonomy to benefit indigenous peoples transcends all national legal regulations, such that in practice it must prevail in any case where there is a conflict between other properties and interests. That was the decision of the Constitutional Court in 1992, when construction was suspended on a highway that would have crossed through indigenous lands.[64] On that occasion, the Court determined that

[61] Chapter XIV of the Law makes reference to Indigenous Reserves.
[62] Constitutional Court, Rulings SU-510/98, T-349/96, T-523/97, T-266/99.
[63] Constitutional Court, Rulings T-349/96, T-523/97, SU-383/03.
[64] Constitutional Court, Ruling T-428/92.

indigenous peoples' rights to autonomy are not merely private interests. Rather, they are general interests arising from the principle embodied in Article 7 of the Constitution. Similarly, in the previously-cited OPIAC ruling of 2003, the Court clarified that an overall reference to peaceful coexistence and public order as legal goods of a higher order was not sufficient to merit the limitation of constitutional rights.[65]

138. As a consequence of autonomy, and beginning with the regulations included in the Constitution and in Law 21 of 1991, which make reference to the participation of indigenous peoples, the Constitutional Court developed and established the content of the mechanism of the *prior consultation,* at the time that it granted the protection now enjoyed by those basic rights.[66] In principle, this consists of the State's duty to consult indigenous people when legislative or administrative measures are adopted that would directly affect them. This prior consultation is not an end in itself, but has the objective of assuring the effectiveness and enforcement of the basic rights to cultural, social, and economic integrity of the indigenous community and its survival as a social group. In the end, it is the process that puts the concept of maximizing indigenous autonomy into practice.[67]

139. In addition to the rights recognized for the indigenous communities by Law 21 of 1991 and Law 99 of 1993, these regulations have in common that they establish the obligation of the State to consult indigenous communities when they plan to adopt any measures that would affect them.

140. 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:

[65] Constitutional Court, Ruling SU 383/03.
[66] Constitutional Court, Ruling T-652/98.
[67] Constitutional Court, Ruling SU 383/03.

> *"a) consult the population involved, using appropriate procedures – specifically, through their representative institutions – any time legislative or administrative measures are being considered that could directly affect them;*
>
> *… 2. The consults carried out under this Agreement must be done in good faith and in a manner appropriate to the circumstances, with the objective of reaching an agreement upon or obtaining consent for the proposed measures."*

The objective of the law, therefore, is to protect these communities which are often affected by State intervention or private entities, in their own territories, without being considered and without being able to express their opinion regarding the measures to be implemented in their lands.

141. 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."*

142. The preceding finds additional support in Article 330 of the National Constitution, which establishes that *"…The exploitation of natural resources in indigenous territories must be done without negatively affecting the cultural, social, or economic integrity of the indigenous communities. In the decisions made regarding such exploitation, the Government must enlist the participation of the representatives of the respective communities."*

143. Along with the jurisprudence of the Colombian Constitutional Court, the ILO Conventions ratified by Colombia constitute one of the main sources of their internal body of law.[68] Therefore, this high court ruled that, in accordance with Section 4 of Article 53 of the National Constitution, *"generally, any conventions ratified by Colombia take on the character of obligatory legal regulations in internal law by the simple fact of their ratification, without*

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[68] Constitutional Court, Ruling C-401 of April 14, 2005.

any need for new laws to be issued in order to incorporate their specific content into the legal system of the country".[69] In addition, the Court confirmed that *"conventions ratified by Colombia that protect and promote human rights are the source that prevails in the internal legal system, forming part of the framework of constitutionality"*,[70] in light of Article 93 of the National Constitution, which places them in a higher position within the hierarchy of internal law.[71]

144. Therefore, the ratification of ILO Convention 169 by Colombia signifies that its terms are incorporated into internal legal regulation. Consequently, any obligations acquired as a result of the Convention, related to recognized indigenous rights and particularly in relation to prior consultation, constitute regulations that are directly applicable and whose compliance may be demanded by the citizens.

145. In addition to the rights recognized by the Constitution, such as the right to life, health, and healthy environment, which are generally enjoyed by everyone in Colombia, indigenous peoples also enjoy the specific protection of their right to autonomy, particularly the right to be consulted regarding matters that would affect them.

C. The Colombian government's non-compliance with internal regulations regarding indigenous rights

146. The spray operations that the Colombian government has carried out under the aerial spray program since 2000 over indigenous territories, and with special intensity in the communities in the south of the country, have been done without the obligatory prior consultation established in the Constitution and the law, as demonstrated in the preceding discussion.

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[69] Constitutional Court, Ruling C-401 of April 14, 2005, Paragraph 17.
[70] Constitutional Court, Ruling C-401 of April 14, 2005, Paragraph 20.
[71] For an analysis of the jurisprudence of the Constitutional Court on this matter, see : *Alzate Vargas*, Beatriz E., Ruling C-401/05 Constitutional Court, The OIT Conventions as a primary source of internal order, in: School Documents, N° 54, Escuela Nacional Sindical, Editors; Medellín, 2005.

147. 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. The Court maintains that, in order to assure the survival and integrity of the indigenous communities as a people and as a culture, as ordered by the Constitution and the law, *"when dealing with the exploitation of natural resources in indigenous territories, it is absolutely necessary to include the participation of the community in decisions made about authorizing exploitation. In this way, the fundamental right of the community to preserve their integrity is guaranteed, and enforced through the exercise of another right, which is also considered to be fundamental in nature, in terms of Article 40, Numeral 2 of the Constitution, which is the right to participation of the community in adopting those decisions"*.[72] Additionally, pursuant to the Court's decision, and based on various constitutional standards, there are several modalities of citizen participation (Const. Preamble, arts. 1, 2, 40, 79, 103, and others). Political participation is not the only form. For that reason, in regard to the indigenous communities, the mechanism of prior consultation is one of the main ways to facilitate self-determination as well as participation. As stated by the Court: *"the participation of the indigenous communities in decisions that could affect them in relation to the exploitation of natural resources offers the particular fact or circumstance that this participation, through the mechanism of consultation, takes on the connotation of a basic right, because it is established as part of an instrument which is fundamental for the preservation of the ethnic, social, economic and cultural integrity of the indigenous communities and to assure, ultimately, their survival as a social group*".[73] Therefore, the

[72] Constitutional Court, Ruling SU-039 of February 3, 1997
[73] Constitutional Court, Ruling SU-039 of February 3, 1997. This position has been strongly supported by the Court on various occasions, such as, for example, Ruling C-418 of 2002, which decided the unconstitutionality suit against Article 122 (partial) of the Mining Code approved by Law 685 of 2001.

spraying that was done without fulfilling the legal requirement for prior consultation constitutes a clear violation of Laws 21 of 1991 and Law 99 of 1993.[74]

148. Subsequently, in 2001 the National Ombudsman reported this violation, maintaining that the aerial sprayings had destroyed development programs in Putumayo, which had included crop substitution projects supported by international cooperation. According to the National Ombudsman, the most critical case at that time occurred in December of 2000 when 45 hectares of forest in areas belonging to the indigenous people of Putumayo were fumigated. Those forests were part of a substitution project sponsored by the United Nations. On that occasion, according to the Colombian Ombudsman's Resolution of 2001, the chemical spray had affected chicken pens and fields that were used for livestock. As a result, the National Ombudsman's Office asked the government to suspend the sprayings, and Plan Colombia, and to compensate for the damages caused to the communities involved in the crop substitution program.[75]

149. It is interesting that after signing several treaties for voluntary eradication and substitution of crops with the indigenous communities under the National Plan for Alternative Development, the aerial eradication programs were carried out, regardless, at the end of 2000 and beginning of 2001, and again at the end of 2001 and beginning of 2002, which, as indicated in various reports from the Ombudsman's Office, affected many indigenous families.[76]

150. In 2001, various Colombian organizations initiated legal actions demanding respect for the rights of the populations located within the spray zones. The most significant action was the case initiated by the Organization of Indigenous Peoples of the Colombian

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[74] Ombudsman's Office "Amicus Curiæ; The Fumigations and Human Rights", Bogotá, April of 2002.
[75] Ombudsman's Resolution N° 4 of 2001 and their Reports - No. 1: "Fumigations and Alternative Development Projects in Putumayo" of February 9, 2001 and No. 2: "Follow-up to the Ombudsman's Resolution No. 4, of February 12, 2001" dated April 16, 2001.
[76] National Ombudsman's Resolution No. 026 Human Rights and International Humanitarian Law in the context of armed conflict an fumigations of coca crops in the Province of Putumayo, Bogotá, D.C., October 9, 2002.

Amazon (OPIAC), which requested the *"interim protection of the rights to life, health, and free development of personality, cultural integrity, participation, due process, and a healthy environment"*.[77]

151. In that case, the Court ultimately decided against the request for suspension of sprayings and did not make any statement regarding the protection of the rights to life, health and a healthy environment. However, the Court did agree with the protection of the right of the indigenous communities to their cultural integrity, thus ordering the responsible authorities to proceed with a prior consultation before aerially spraying over indigenous lands.

152. To support its decision the Court invoked several anthropological studies describing and demonstrating the special relationship between the indigenous people and their natural environment. These studies highlighted the spiritual nature of the ancestral lands, which is very different from the way they are perceived in Western cultures. This way of seeing the world on the part of the indigenous cultures has allowed them to accumulate certain knowledge over the centuries about ways of conserving the environment, and has put these populations in a position of being the guardians of the ecosystem and its balance.

153. The Court gave priority to the right to prior consultation over arguments about social interest – in this case, combating drug trafficking – without ignoring its importance. The Court stated that *"the indigenous and tribal people have managed to link the Colombian Government to ILO Convention 169, and also managed to have the Constitutional Assembly of 1991 recognize their right to diversity. The Judges at that time were not able to hide the mechanism of prior consultation, and even less so by arguing that reasons of general interest would impede it. Nor did they succeed in giving the impression that the populations demanding it had lost that right by being involved in the offense of cultivating the illegal*

[77] Upon admitting the case, the court ordered the suspension of the aerial fumigations, as a provisional measure, on 23 July 2001. The suspension was terminated on 6 August 2001.

plantations which the State is obligated to suppress. Even if that were the case, consults would still be required, in order to respect the mechanisms that allow preservation of their customs and institutions".[78]

154. The Court insisted that in accordance with Article 13 of ILO Convention 169 (Law 21 of 1991, art. 13), by applying the mandates of the international treaty, governments must respect the special importance of indigenous peoples' relationship with their land, the cultures and the spiritual values of the people involved, and the collective aspects of that relationship.

155. The Court also mentioned one aspect that took on special significance -- that prior consultation is not an objective in itself. Rather, in addition to enforcing the right to self-determination and participation, prior consultation addresses the problem of population displacement. In the Court's words, observing the requirement for prior consultation *"is a concern for the international community, because the effects of mining and other large, non-consulted projects that were carried out in indigenous territories ... threaten to displace or have already displaced hundreds of thousands of indigenous people and tribes ... from their habitat,"* citing the study "An International Agenda" by Julian Burger, the person responsible for the program for indigenous populations at the United Nations Center for Human Rights.[79]

156. Beginning on 28 July 2002, as described in the National Ombudsman's Resolution No. 026 of 2002, the aerial spray campaigns reinitiated in some of the municipalities of Putumayo. Several complaints were presented by the indigenous communities to the Ombudsman's Office for damages caused by the sprayings to various food security initiatives, and to production projects in which state resources had been invested as well as international aid, particularly from Europe. Such was the case, for example, in the

[78] Constitutional Court, Ruling SU 383/03 (OPIAC), 2003
[79] Burger, Julian, An International Agenda, in: "The State of the (World's Indigenous) People" Cultural Survival (1993), Bellaterra Editor, Barcelona, 2000

report publicly issued by the Indigenous Organization of Putumayo (OZIP), the associations of Indigenous Councils, and the Indigenous Councils of Putumayo, regarding spraying in the "Nasa Chamb" community of Puerto Asís, where it was stated that *"there has never been any coca"*.[80]

157. In addition, relating to the matter of prior consultation, the opinion of the U.N. Special Rapporteur on the situation of human rights and fundamental freedoms of indigenous peoples, Mr. Rodolfo Stavenhagen, should be noted. Stavenhagen stated: *"82. The spread of narcotics cultivation and trafficking, and efforts to combat that spread, notably by spraying fields from the air, have had an adverse effect on indigenous peoples' environment, economy, social life, health and culture (...) 106. Except where expressly requested by an indigenous community which has been fully apprised of the implications, no aerial spraying of illicit crops should take place near indigenous settlements or sources of provisions"*.[81]

158. The Colombian Government has not complied with its constitutional and legal obligations to consult the indigenous communities before carrying out aerial sprayings over indigenous territories, on numerous occasions since 2000, thereby violating the rights of those communities to cultural integrity and self-determination.

159. In addition to this non-compliance, recognized by Colombian courts, one must not neglect the rights granted by Law 21 of 1991, which approved ILO Convention 169 regarding indigenous and tribal people. The following provisions have been affected by the government's aerial spray activities carried out without the required prior consultation:

- Article 4: Special protective measures to safeguard persons, institutions, property, culture, work and the environment;

[80] National Ombudsman's Resolution No. 026 Human Rights and International Humanitarian Law in the context of armed conflict an fumigations of coca crops in the Province of Putumayo, Bogotá, D.C., October 9, 2002.
[81] Stavenhagen, Rodolfo, Special Rapporteur's Report on the situation of human rights and basic liberties of the indigenous people; Human Rights Commission, 61st term of sessions, Topic 15 of the provisional agenda; INDIGENOUS ISSUES Human Rights and indigenous issues, 2003.

- Article 7: The right of indigenous peoples to decide their own priorities in matters of development and the extent to which this affects their life, beliefs, institutions, spiritual well-being, and the lands they inhabit as well as controlling their economic, social and cultural development;
- Article 13: Cultural integrity -- recognition of the special cultural and spiritual relationship with their lands;
- Article 14: Ownership of traditional territories -- recognition of ownership and possession of traditional territories inhabited by indigenous people;
- Article 15: Special protection of natural resources, especially resources existing in indigenous territories;
- Article 16: Territorial seizure -- indigenous people may not be moved away from their territories. In exceptional cases, relocation may be provided; and
- Article 17: Prohibition against seizure of indigenous territories -- government authorities must prevent any outside parties from appropriating lands that belong to indigenous people.

Conclusions

160. It follows from the preceding analysis of Colombian law on the subject of Environmental Licenses and Impact Assessments, pesticides, and indigenous rights in the specific case of the aerial spraying program, that the Colombian Government has failed to comply with its own internal legislation in the cited areas, as is summarized in the following conclusions:

<u>Regarding Environmental Licenses and Environmental Impact Assessments:</u>

161. Since 1974, in the framework of Colombian environmental legislation, there has been an obligation to request an Environmental License and to carry out Environmental Impact Assessments before implementing any activity, project, or work that could have a

serious negative effect on natural resources or the environment. Two periods can be distinguished in that regard:

- The first period (1974 – 1993) was governed by the CNRNR. This was the basis for establishing two instruments for environmental management and control: the Declaration of Environmental Effects (DEE) and the Ecological and Environmental Study (EES), which were the precursors to the Environmental License and the Environmental Impact Assessment. Specifically the EES, under Article 28 of the CNRNR, was needed prior to obtaining a license, and consisted of an ecological and environmental study that had to be carried out before starting any work, establishing any industry or developing any activities that could produce serious environmental degradation. The study also had to contain information about the social and economic environment of the project and its impact on the respective region.

- The second period (1993 - present), governed by Law 99 of 1993, which defines the concept of Environmental License (Article 50), and establishes that this license is obligatory prior to developing any projects that would require it (Article 49). In addition, Article 57 of that law establishes the content and definition of the Environmental Impact Assessment (EIA), as the information that must be presented to the appropriate environmental authority in order to attain an Environmental License. Likewise, the law regulates the process for granting the license (Art. 58) and defines the jurisdiction of various environmental authorities in this area (Art. 51). That law has been modified by a series of regulations since 1994, however, the content and the objective of the obligations regarding Environment Licenses has remained the same.

162. The aerial spraying operations to eradicate illicit crops carried out by the Colombian Government fall within the realm of activities that require an Environmental License and Environmental Impact Assessment, in accordance with the previously cited regulations.

163. Due to the way that the policies on illicit crop eradication by the Colombian government have been developed and executed, it is not possible to refer to one single aerial eradication program. Essentially, considering the differing policies' various objectives,

scopes, areas of operation, types of herbicide, etc., it is more accurate to recognize that in Colombia, since 1978 (the date when the sprayings began) there have been various aerial spraying programs for the elimination of illicit crops, each one governed by the environmental obligations for new projects in effect at that time. Of those, we can clearly distinguish the following:

- The first aerial spraying in 1978, under the label of an "experimental" program, using the herbicide *Paraquat*, was carried out during the time of Decree Law 2811 of 1974 or the National Code of Renewable Natural Resources and Environmental Protection (CNRNR). It required an Environmental and Ecological Study (EES) and an Environmental License, according to the stipulations of Article 28 of that legal document. This requirement was not fulfilled.

- Starting in 1984, spray operations to eliminate marijuana crops were carried out based on an order from the Ministry of Justice. These also took place during the time that the CNRNR was in effect, so the previous analysis applies here as well. In other words, these spray activities were carried out in disregard for the requirements of Article 28 of the CNRNR.

- The aerial spraying operations on illicit crops were opened up to public attention through a press communication in 1992. Its details made reference to the elimination of poppy crops, and said that it was "experimental." These operations were also done under the CNRNR. Again, there is clear evidence of non-compliance with the regulations in effect at the time, specifically regarding the requirement to perform an environmental study and obtain a license, as stipulated in the CNRNR.

- The aerial spraying operations starting in 1994 were authorized under CNE Resolution 001 of February of 1994 and aimed at the elimination of poppy, coca and marijuana crops. Even though the resolution mentions official communications from the environmental authority (IDERENA) and of the Ministry of Health of that time, who gave approval for the spraying operations of poppy corps, these spraying operations did not comply with the legal environmental requirements in effect at the time, established under Law 99 of 1993, since the cited communications were not supported by any environmental study and cannot be considered to be a license. These operations did not have any Environmental

Impact Assessment, nor an Environmental License, and did not fall within the interim regime established by the regulatory standards in Law 99 or Decree 1753 of 1994 (which entered into force after this program's establishment).

- The aerial spraying of illicit crops starting in 2000 were authorized under Resolution 005 of 2000. These sprayings constituted an activity significantly different from the programs designed and carried out in the previous years, as previously cited. This resolution marked the end of the "experimental" phase of the old spraying program. Three principle changes highlighted the difference between this program and the previous ones: First, it involved a sharp increase in the intensity of the sprayings. Second, there was a new focus on sprayings in the areas along the southern border of the country. Third, the composition and concentration of the herbicide used in the sprayings was different. Evidently the government's new aerial spraying program, under Plan Colombia - and strongly focused on the south of the country - did not form part of the operations that fell under the interim regime outlined in Article 38 of the Decree regulating Law 99 of 1993. Rather, they were operations that fell under the normal regulations of Environmental License stipulated in said Law (Title VIII). Therefore, the spraying program of 2000 required an Environmental License that should have been requested from the Ministry of the Environment, and for which it would have consequently been necessary to do an Environmental Impact Assessment, as stipulated in Article 57 of the cited Law. None of the preceding requirements were fulfilled and Colombia was therefore in non-compliance with its own internal environmental regulations.

- In the same way, the sprayings carried out under Resolution 013 of 2003, which approved a "new aerial spraying program" and that were aimed at any part of the territory where there were illicit crops (including National Parks), constituted a disregard for Colombian environmental legislation and regulations. First of all, as it was a new program, clearly distinguishable from other programs, it was subject to the existing Colombian environmental legal obligations. Secondly, this resolution was adopted in violation of Resolution 1065 of 2001 of the Ministry of Environment. And furthermore, the later approval by the Ministry of the Environment of the changes to the EMP made by the DNE allowed a violation of superior environmental laws, like those that protect the National Park System, where any intervention, according to Law 93 of 1993, requires, necessarily and without exception, an Environmental License.

164. Consequently, since 1978, Colombia has been in non-compliance with its own internal standards related to the obligation to solicit an Environmental License and perform an Environmental Impact Assessment for its various programs of aerial eradication of illicit crops with chemical herbicides, and consequently has ignored the basic environmental principle of prevention.

Regarding the pesticides regulations:

165. The standards regarding pesticides in Colombia regulate a broad range of activities related to pesticides, including the use, sale, importation, and in general, any activities involving the handling of pesticides. These regulations take a preventative approach, emphasizing the prevention of risks to the environment and human health.

166. The aerial spraying operations that have been carried out by the Colombian government for eradication of illicit crops clearly fall within the scope of Colombian pesticide regulations, and Decree 1843 of 1991 applies specifically to aerial spraying activities. These standards complement the specific standards issued for this specific case by the Ministry of Environment.

167. In particular, those responsible for any activities related to the use and handling of pesticides are obligated to comply with the pesticide label, and failure to comply with this obligation may result in sanctions.

168. Decree 1843 of 1991 precisely regulates aerial spraying in its Articles 95 to 102. It requires operating permits to be issued by the Civil Aeronautics Administration (D.A.A.C) as well as a health license to be issued by the respective Sectional Health Office before spraying. In addition, the DNE had the responsibility to verify that the pilots operating the spray aircraft complied with the specific requirements of Article 102, including the requirement to *"take into account wind speed, temperature, relative humidity, flight speed*

and altitude, in accordance with the stipulations of the respective agricultural and civil aviation authorities." In this case, such requirements were established by the Environmental Management Plan. In addition, DNE had the responsibility to verify compliance with the obligations of pilots *"[n]ot to fly over populated areas, water supplies, schools, or other locations that would present a risk to the health or safety of humans, animals, or vegetation."* Several sources of evidence, including the demands of the Ministry of the Environment with respect to the Environmental Management Plan, and the establishment of a formal complaint mechanism, indicate a failure to comply with these requirements.

<u>Regarding protection of indigenous rights:</u>

169. Protection of indigenous rights in Colombia is rooted in the Political Constitution of 1991 and in the legal instruments that have been developed to address the issue, such as: Law 160 of 1994 regarding the National Agrarian Reform System; Law 70 of 1993 regarding the rights of black and racial communities; Law 21 of 1991 which approved International Labor Organization (ILO) Convention 169; and Law 99 of 1993 governing environmental protection.

170. Legal recognition of the autonomy of these peoples and communities has special significance within the protection of indigenous rights, and is supported by the principle established by Article 7 of the Political Constitution, which recognizes that Colombia is a pluralistic, democratic and participative State which respects ethnic and cultural diversity.

171. A reflection of the autonomy enjoyed by the indigenous people, based on the Constitution and on Law 21 of 1991, is the mechanism of prior consultation, which the Colombian Constitutional Court has established as a fundamental right.

172. The mechanism of prior consultation consists fundamentally of the duty of the State to consult indigenous peoples when adopting legislative or administrative measures that could directly affect them. It is not an end in itself, but is intended to assure the effectiveness and enforcement of the indigenous peoples' fundamental rights to cultural, social and economic integrity and their survival as social groups. This includes the concept of maximizing indigenous autonomy. This principle is further recognized by the Constitutional Court, which has limited interference as a means to protect broader interests in order to assure the respect for and survival of native cultures.

173. The Colombian government has been openly non-compliant with its own internal standards in the matter of the protection of indigenous rights, and specifically in the requirement of prior consultation regarding the aerial spraying of illicit crops. This has endangered the fundamental indigenous rights affected by such operations, including the right to their own ethnic identity, to their cultural integrity, to their autonomy, and to the integrity of their lands. The State has only carried out the prior consultation process since the order imposed by the Constitutional Court in its OPIAC Ruling of 2003. It should be clarified, however, that even after that time, it has not done so in all of the sprayings performed in indigenous territories. Consequently, it can be firmly concluded that the sprayings carried out by Colombia under the aerial spray program since 2000 in indigenous territories, and with even more intensity in the communities in the south of the country, have been done on the majority of occasions with disregard for Article 40 of the Political Constitution concerning citizen participation, and above all, they have been done without the obligatory prior consultation with indigenous peoples established by the Constitution and Colombian law.

Annex 8

APPENDIX 1

Curriculum Vitae of Claudia Rojas Quiñonez, Esq.

Annex 8

Claudia Rojas Quiñonez

Education

- University of St. Gallen, Ph.D Studies in International Law (2006 – present). Research: *The Protection of Indigenous Languages in International Law*.

- University of Barcelona, Masters Degree in International Studies, with specialization in European Law (1994-1996). Research: *The Freedom of Expression on the Subject of the Environment within the European Union*.

- Universidad Externado de Colombia, Law Degree (1989-1994). Research: *Legal Defence Mechanisms of the Right to the Environment in Colombia*

Professional experience

- 1996 – present Universidad Externado de Colombia, Lecturer on Environmental Law, Bogotá - Colombia

- 2010 Swiss Federal Institute of Technology Zurich (ETH), Guest Lecturer on International Water Law, Zurich - Switzerland

- 2007-2008 University of St. Gallen, Researcher at the Chair of International and European Law, St. Gallen - Switzerland

- 2003 – 2004 Observatori de Drets Ecònomics Socials i Culturals de Catalunya, Barcelona - Spain

- 2002 Federal University of Espiritu Santo, Guest Lecturer on International Cooperation on Environmental Protection in the Amazon Basin, Vitoria - Brasil

- 2002 Office of the High Commissioner for Human Rights, Right to Food, Geneva - Switzerland

- 2001 Ecoburo Consulting, Legal Adviser on Spanish and European Environmental Law, Barcelona - Spain

- 2000 Council of Europe, Right to a Healthy Environment, Strasbourg - France

- 2000 Universtiy of Lérida, Guest Lecturer on The Right to Information on Environmental Subjects in the European Union, Lérida - Spain

- 1998 – 2003 University of Barcelona, Lecturer and Researcher in International and Environmental Law, Barcelona - Spain

- 1994 Departamento Administrativo de Seguridad del Estado - DAS (Department of State Security), Legal Adviser to the General Secretary, Bogotá - Colombia

- 1992 Ministerio Relaciones Exteriores de Colombia, Oficina de Derechos Humanos (Colombian Ministry of Foreign Affairs - Human Rights Office), Bogotá - Colombia

- 1992 – 1994 Universidad Externado de Colombia, Researcher in the Department of Civil Law, Bogotá - Colombia

Languages

Spanish (native), German, English and French

Areas of Expertise

- International, European, and Colombian law
- Environmental law
- Human Rights law
- Indigenous Rights law

Publications

Books

EVOLUCIÓN DE LAS CARACTERÍSTICAS Y LOS PRINCIPIOS DEL DERECHO INTERNACIONAL AMBIENTAL Y SU APLICACIÓN EN COLOMBIA (THE EVOLUTION OF THE CHARACTERISTICS AND PRINCIPLES OF INTERNATIONAL ENVIRONMENTAL LAW AND ITS APPLICATION IN COLOMBIA), Universidad Externado de Colombia, Bogotá (2004)

Articles

- "La protección internacional del derecho humano al medio ambiente" ("The International Protection of the Human Right to the Environment"), in: Francesco Sindico, Rosa Fernandez Egea and Susana Borras Pentinat (Eds.), Derecho Internacional del Medio Ambiente: Una Visión desde Iberoamérica, CMP Publishing, (2010).
- "Los cursos de agua internacionales en la jurisprudencia de la Corte Internacional de Justicia" ("International Watercourses in the Jurisprudence of the International Court of Justice"), in: Derecho de Aguas, Volume IV, Universidad Externado de Colombia, Bogotá, (2010)
- Book review: Turner Stephen J., A Substantive Environmental Right, An Examination of the Legal Obligations of Decision-Makers towards the Environment, Wolters Kluwer, Kluwer International Law, 2009, in: Ambientalia, Revista interdisciplinar de ciencias ambientales, Ambientalia, Vol. 1, (2009)
- "La diversidad lingüística en Colombia – Protección de las lenguas indígenas" ("Linguistic Diversity in Colombia – Protection of Indigenous Languages") in: Revista Pensamiento Jurídico, N° 22, Universidad Nacional de Colombia, (2008)

- "Die Rechtsprechung des internationalen Gerichtshofs auf dem Gebiet internationaler Wasserläufe. Von Gabcikovo-Nagymaros bis Argentinien-Uruguay" ("The Jurisprudence of the International Court of Justice: From *Gabcikovo-Nagymaros* to *Argentina-Uruguay*"), Jusletter, (2007)
- "El nuevo reto de la cooperación internacional en el marco de la Cuenca del Río Amazonas: La gestion integrada" ("The New Challenge of International Cooperation in the Amazon Basin: Integrated Management"), in: Gestión Integrada de Recursos Hídricos , Amaya Navas, Oscar Darío and García, María del Pilar (Eds.), Universidad Externado de Colombia, Bogotá, (2007)
- "Derecho a la vivienda en Africa Subsahariana" ("The Right to Housing in Sub-Saharan Africa"), in: Mundialización y Equidad Social, Observatori de Drets Economics Social i Culturals, Barcelona, (2004)
- "Del desarrollo sostenible al desarrollo humano sostenible" ("From Sustainable Development to Human Sustainable Development"), in: Lecturas sobre Derecho del Medio ambiente IV, Universidad Externado de Colombia, Bogotá, (2003)
- Translation of : Déjeant-Pons, Maguelone, "Les droits de l'homme à l'envirnnement au niveau national, international et europeen" into Spanish : "Los derechos del hombre al medio ambiente en el ámbito nacional, mundial y europeo" ("Man's Rights to the Environment in the National, Global, and European Context"), in: Justicia Ambiental – las Acciones Judiciales para la Defensa del Medio Ambiente, Universidad Externado de Colombia, Bogotá, P. 25-74, (2001)
- "El efecto directo de las directivas comunitarias de medio ambiente" ("The Direct Effect of the European Directives on Environmental Protection"), in: Lecturas sobre Derecho del Medio ambiente I, Universidad Externado de Colombia, Bogotá, (2000)
- "La reparación de los daños ambientales en el marco del Derecho Comunitario Europeo" ("Reparation of Environmental Damages in European Law"), in: La Responsabilidad Ambiental, Universidad Externado de Colombia, Bogotá, (2000)