**The Distributive effects of aerial spraying policy in Colombia: Reduction of coca crops and socio-ecological impacts in vulnerable communities.**

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## Abstract

During the last twenty years, the plantation of coca crops for cocaine has concentrated in three countries: Colombia, Peru and Bolivia. Since 1997, Colombia is the main coca producer, accounting for more than 50% of total world production. Colombia is the only country where authorities have applied aerial spraying to reduce coca plantation. As a result of the anti-drug policy, between 2001 and 2008 coca crops decreased 44%. However, behind this apparent success, there are important negative socio-ecological impacts that are generally not taken into account by the government. This paper studies the socio-ecological impacts (direct and indirect) of the aerial spraying antidrug policy and their inequitable spatial and social distribution, concentrated in high forest extensions where the population is predominantly poor. Our analysis covers Colombia as a whole and an in-depth case study of Nariño, one of the regional departments most affected by aerial spraying. Our data shows that aerial spraying has generated a continuous displacement of coca crops to other regions (so-called "Balloon effect"),

expanding deforestation, and spraying in new zones where coca was not planted previously. Population displacement and impacts in traditional crops and on the health of the locals are the most important impacts. The displacement of coca crops and the expansion of the sprayings have affected mainly the territories where indigenous, afro-Colombian and rural communities prevail. We conclude that while aerial spraying and coca cultivations expand, in a "cat and mouse" pursuit affecting more and more of Colombia's territory, the local population and the forests are the big losers.

## 1. INTRODUCTION

Coca production is the largest illegal agribusiness in the world. The global cocaine retail value is estimated at US$80–$100 billions, equivalent to 0.15% of global GDP, and at the level of the annual GDP of countries such as Iraq or Slovakia (UNODC, 2010). Cocaine, consumed mostly in North America and Europe, is primarily produced in the Andean region. The plantation of coca crops for cocaine has concentrated in three countries: Colombia, Peru and Bolivia. Since 1997, Colombia is the main coca producer, accounting for more than 50% of total world production, with some 81.000 ha of coca cultivated and 450 metric tons of cocaine produced in 2008. Coca production in Colombia accounted for 623 millions of dollars of revenue in 2008, 0.3% of GDP and 3% of agriculture's GDP (UNODC, 2008).

Inevitably, such a grand-scale agricultural activity has great consequences on the people and the territories involved. There is considerable literature under the rubric of "political ecology" concerning the socio-ecological impacts of mining, agriculture and timber exploitation in the "commodity frontiers", or marginal apertures of the global economy (Gerber et al., 2009; Hilson and Yakovleva, 2007; Martinez-Alier, 2001; Martínez-Alier, 2002; Pegg, 2006), including new agribusinesses such as bio-fuel production (Ariza-Montobbio et al., 2010; Hazlewood, 2011) and tree plantations (Gerber et al., 2009). Political ecologists however have paid less attention, however, to the on-the-ground effects of illegal agribusinesses. One expects here different socio-environmental processes compared to that of more legal activities. The typical triad— State – private corporations -local communities - whereby the State and/or the private sector exploit resources for far-away markets and come often in conflict with local communities that

use the same resources for their livelihood (Martinez-Alier, 2001; Martinez-Alier et al., 2010) is not applicable to the cultivation of illegal crops. One finds instead the triad of the State security apparatus, illegal organizations, and, as we will argue in this article, a local population caught in the middle of the crossfire between the two. Rather than national policies of "development" confronted with local livelihoods, one finds national "wars" waged on illegal businesses. A vital step in understanding the on-the-ground complexities that constitute such "geographies of terror" (Oslender, 2008) is a basis of spatialized social and environmental facts. This is the objective of this article, our intention being to complement the rich existing ethnographic analyses of coca's geographies of terror, with a "bird's eye view" of the general tendencies, drivers and consequences of the coca frontier. Indeed, our statistical findings support most of what has been suggested by case-study research and hence strengthen the robustness of existing explanations.

Unlike Peru and Bolivia, who pursue crop eradication with manual eradication techniques, Colombia is the only country in the world that uses aerial fumigation. This fumigation policy began cautiously in the end of the 1970´s in order to fight marijuana plantations, but was extended in 1994 to the expanding cultivations of coca. With the signing of ´Plan Colombia´ in 1999, by Colombia and U.S.A., and the subsequent creation of the ´Program of Eradication of Illicit Crops with Glyphosate" in 2000, aerial fumigation intensified and proliferated. Plan Colombia has been celebrated as a great success in reducing the total area of the country occupied by coca from 144.800 ha in 2001 to 81.000 ha in 2008 ((UNODC, 2010), presumably liberating local populations from the grip of the illegal business and its devastating consequences. The Colombian government has also heralded the environmental benefits of the war on drugs; the coarse

assumption here is that less coca cultivated means less environmental impacts since coca cultivation has negative environmental effects (Álvarez, 2007; Bernal, 2007) Yet, other researchers argue that fumigation goes hand-in-hand with deforestation and environmental degradation (Ávila et al., 2007; Vargas, 2004; Walsh et al., 2008a)

This article highlights new, more spatially refined, data that shows that even if fumigation has reduced the overall extent of coca cultivation and production, it has increased environmental and social impacts, by prompting a diffusion of the activity in the territory. There is less and more widespread coca production, which means more forest is cleared out and more people are being displaced as a result of violence extending to more territories. Section 2 sets the context of our work presenting the particular "ecological economy" of coca in the Colombian territory. By ecological economy we refer to particular ecological features of the crop and its production setting, and their inter-relationship with the economic and social (labour) organization of production. Section 3 presents the methods used and the new data mobilized or constructed for this analysis. Section 4 presents the results of a cross-municipal and ecosystem analysis. Section 5 reports on in-situ field-work at the regional department of Nariño, one of the departments most affected by fumigation policy. Section 6 discusses the socio-environmental failures of the war on drugs, and speculates on why the Colombian government does not change course. Section 7 concludes by insisting that policy makers can no longer look the other way as landcover and livelihoods are left to decay and as glysophate settles into the everyday lives of the humans and non-humans of the forested landscape.

## 2. THE ECOLOGICAL ECONOMY OF COCA

The commodity chain of cocaine begins with the plantation-based production of coca and finishes with the acquisition and consumption of the final product, cocaine. The production stage, which is the principal concern of this section and this article, consists of three main steps: cultivation, harvesting and processing into cocaine (Brain et al., 2005). Coca leaves (*Erythroxilum coca*) are grown in humid to very humid subtropical forests. The optimum altitude is between 1000 and 2000 meters above sea level, where the cocaine content is higher, and the optimal average annual rainfall around 2000 mm. Given these bio-physical requirements, the majority of coca crops are found in humid to very humid areas, such as the tropical zone of Colombia. To initially plant coca, an open field must be cleared. If a forested area is the target cultivation space, the usual practice is to cut most of the larger trees and then burn those parts of the trees that are not a source of wood for construction. Depending on the region, those cultivating the plant will then transplant either coca seeds, germinated for two months in humus-enriched soil seedbeds, or cuttings, obtained from mature bushes. The former mature and are ready for harvest 12-24 months after transplantation, while cuttings can be harvested after 6 months. Although coca is a robust plant that will live for years and produce multiple leaf harvests, when grown in monoculture for maximum yield in a short period of time, for sustained growth and protection, the coca requires nutrients, fertilizers, herbicides, fungicides, and insecticides. Depending on the climate, harvest of the coca leaf can occur between two to six times per year, with one larger harvest that accounts for around half of the total production usually occurring after the rainy season. At harvest, the majority of the leaves are removed from the plant, leaving just a few at the tips of the branches. The leaves are packed into bags for transport to nearby

processing areas. Chemical processing takes place in three major steps: conversion of the coca leaf into coca paste, from paste to cocaine base, and finally, from the base to cocaine hydrochloride (Brain et al., 2005).

The majority of the labour in coca production is allocated to cultivation. Some of those not only cultivate but also process the coca leafs. In addition there is a floating population of day laborers who sell periodically their labour on different parts of the chain depending on seasonal production cycles. Wages are generally higher than wages in the labor market, although the difference is not significant; it is the stability and security of income and employment that coca offers that is most appealing to producers. Leaf collectors are commonly known as "pickers" and their earnings depend on the amount of leaf collection, itself a function of their skills and experience. For removing the paste (cocaine base) the people hired tend to need a degree of specialization. A study by the Integrated Illicit Crops Monitoring System (SIMCI in Spanish) found that 34% of the farmers (representing 25% of the fresh coca leafs) sell the fresh coca leaves without processing. Another 35% of the farmers (comprising of 26% of the production) process them to coca paste and the remaining 31% (49% of production) process the leaves into cocaine base. The marketing of leaf and coca paste is linked to illegal armed groups that assume direct control of the links between the peasant producers and the intermediaries. They set the prices and the payment (cash or in quotas) for the producers as well as the systems of product collection. While in the previous years drug traffickers had control of all phases of the business, more recently primary producers are increasingly involved in the transformation process, as the traffickers are transferring to them the risks and costs involved.

Some 80,000 families were involved in coca production in 2007 and 60,000 in 2008 (UNODC, 2008, 2009) Other than the – highly temporal and precarious – salaries it pays farmers, coca production does not leave any benefit to the production region. Those who are involved in illegal activities do not pay taxes, of course, but instead are implicated in an intricate system of corruption constituted by loans and payments, violence and money laundering through other legal activities (Rocha, 2005). Most of the benefits from the business are appropriated by drug traffickers and illegal armed groups. According to reports (UNODC, 2010a) the cocaine market brings in more than 72,000 millions of dollars, of which 20% remains in cocaine importing countries.

The average earnings in Colombia from coca leaf and derivatives production were some 11,675 dollars in 2007 (10,508 dollars in 2008) per household engaged (UNODC, 2008). The total of 683 millions of dollars paid to farmers in 2007 is negligible for the industry's commodity chain as a whole and the largest incomes come after, in the trafficking phase. Indeed, the majority of farming households involved in production make less than the average indicated above as they only participate in cultivation and collection, not processing. Incentives for engaging with the activity have less to do with earnings (they are not considerably higher than competitive crops), and more with the reduced risk and more guaranteed market demand for coca (Accion Social and UNODC, 2008; Ibañez, 2006). Most of the benefits from the business are appropriated by drug traffickers and illegal armed groups and invested abroad (Morales, 2008), though an undefined portion returns to the country through money laundering..

The illegal nature of the business has as its prerequisites both remoteness and ability to hide the plantations. Tropical forests provide ideal environments for growing coca not

only because of their bio-physical characteristics but also because accessibility is difficult and their remoteness renders them beyond direct central State control, allowing criminal organizations to hide and avoid persecution. It is the same factors of remoteness vis-à-vis the lack of "modern" state-based development that render the same forests both primary biodiversity and conservation hotspots and ideal "habitats" for coca production. Colombia is at the top 12 countries with greatest biodiversity in the world (Myers et al., 2000). With a land area of only a 0.7% of the planet's surface, Colombia hosts about 10% of the fauna and flora of the world. Two of the world's most important biodiversity hotspots are in Colombia: the tropical Andes and the Chocó Humid Forests (Myers et al., 2000).

For those invested in the coca business, the tropical forests serve multiple functions: stock, shelter and territory. Despite distance from urban areas, the abundance and diversity of hydrological resources and flora and fauna can sustain both production and the daily needs of the armed groups that battle for control over territory for coca cultivation. The tremendous surplus generated by the business makes it possible for the criminal organizations to finance and sustain lavish settlements for themselves (and livable for the workers), even if located very distant from markets. Transport and connection are secured by fluvial or aerial transport. (Le Billon, 2001) explains how this peculiar socio-environmental geography of products like coca, which are produced diffusively in the territory (i.e. they are not localized resources, such as mines) and combined with remoteness, go hand-and-glove with "war-lordism", i.e. armed illegal groups controlling production and engaging in war with the far-positioned central government. From a government perspective, he explains, fighting war-lords in remote jungles requires risky ground engagement. Aerial fumigation emerges then as a risk-less

war from control centers in the cities. Yet, as we argue later, this distance comes at considerable human and ecological cost at the ground, which culminates in "a crime against nature and humanity" (Oslender, 2010). The next sections lays out the methodological architecture for supporting this argument.

## 3. DATA SOURCES AND METHODS

The research findings discussed in this article were gathered following a multi-evidentiary strategy consisting of four components. First, an extensive literature review was conducted of all peer-reviewed and government publications concerning antidrug policies and the social, economic, environmental and political aspects of coca plantations in Colombia. This preliminary phase of the research benefited by discussions with experts SIMCI, the National Office of Narcotics (DNE), the Ministry of Defense, and the NGOs Transnational Institute (TNI), the Arcoiris Foundation and Acción Andina, as well as other researchers from Colombian Universities.

Second, and at the heart of the research findings which we are presenting, is a database at the municipal level, the first of its kind, including data for all 1060 municipalities of Colombia with respect to social, economic, environmental and institutional features, as well as information on the extent of coca production and aerial fumigation. Table 1 details the variables used in the database, their definition and the sources of the data. On the basis of this database, we test for the first time in a quantitatively rigorous manner (spatial association and correlation analysis) hypotheses concerning the socio-economic characteristics of the expanding coca frontier (including claims for ethnic discrimination), and the relationships between aerial fumigation, the spatial distribution

of coca production, environmental effects and people displacement. The statistical significance of the correlations was carried out using 10,000 permutations (Anselin, 2005; Anselin et al., 2002). Analysis of spatial information and the statistical tools were done using the software SPSS, Geoda and ArcGis.

Third, we analysed the deforestation and ecosystem impacts of coca cultivations by overlapping information about land coverage from the national map of ecosystems in 2000 in shape format (IDEAM. et al., 2007) with geospatial information about coca cultivations from SIMCI's maps for the 2001-2008 period, in order to determine the share of cultivation of coca within each of the land cover types. We estimated the share of deforested area and ecosystems affected at the municipality level and the results were complemented with data from the United Nations Office on Drugs and Crime and its 2006 and 2008 reports. Where relevant, we also used maps (shape format) of the collective lands belonging to communities of Afro-Colombian descent and indigenous reserves.

Fourth, a rapid assessment was conducted in the department of Nariño (map 1), one of the areas most affected by the expansion of illicit coca crops in the 2000s. During a period of one month of field-work, the first author interviewed a total of 18 people, ten of them representing different scales of affected by or involved in coca production (including indigenous leaders, Interior departmental advisers, members of the health department secretary, members of the national police) and eight people from local communities. Additional information on the impacts of fumigation on the local population was collected through direct conversations with local people, particularly with five peasants from the coca-growing areas of the department of Nariño and leaders

of the indigenous community indigenous Awá that inhabit the southwest of Colombia. The Awá community has been one of the communities most affected by armed conflict in Colombia and the war on drugs (Saavedra, 2009). Finally, our research on impacts at Nariño benefited from a review of governmental documents from the Ombudsman, the local police, the health secretary and the hospitals of Nariño. Ombudsman claims need to be treated with caution as there is both a tendency for over-reporting, since compensation may be granted if losses are verified, as well as under-reporting if the people perceive that the government is not acting on complaints.

Below we report on the key findings of our analysis. The core is based on the municipal statistical research and the ecosystem impact assessment, grounded where relevant with material from secondary literature. In section 5 we offer a more local glimpse of the impacts of the fumigation policy with material from Nariño.

**Table 1. Description of variables included in the analysis**

| Name | Variable Name | Years | Source | Unit | Description |
|---|---|---|---|---|---|
| PRD | Primary road density | 2005 | Road map (shape) by Geographic Institute Agustín Codazzi - Estimation by the authors | M/ha | meters of primary roads per hectare. |
| FDP | Forced displacement of population | 2001 to 2008 | Presidency of the Republic of Colombia - Presidential Agency for Social Action and International Cooperation | Number of displaced people | Number of forced displaced people by violende and conflict. This information is taken from the National System of attention to Displaced People ("Sistema Nacional de Atención Integral a la Población Desplazada") |
| RUBN | Rural Unsatisfied Basic Needs Index | 2005 | National Administrative Department of Statistics - (DANE Spanish acronym for "Departamento Administrativo Nacional de Estadística") | Index from 0 to 100 (From ´no basic need satisfied´ to completely satisfied) | The index is determined through 5 indicators: adequacy of housing, degree of household overcrowding, adequacy of basic household services, degree of economic independence of the household; household with children at school-age which are not attenting scho |
| IMD | Index of municipal development* | 2001 to 2008 | National Planning Department of Colombia (DNP - Spanish acronym for "Departamento Nacional de Planeación") and Direction of territorial sustainable development (DDTS - Spanish acronymun for "Dirección de Desarrollo Territorial Sostenible") | Index from 0 to 100 (where 0 means low municipal development) | Synthetically measuring the performance of municipalities in social and financial indices, including: % of households with water supply,% of households with sewage,% households with energy services,% of people without Unsatisfied Basic Needs in urban area |
| VAIA | Number of violent acts by illegal armed groups | 2001 to 2006 | Los Andes University Bogotá and Ministery of defense Colombia | Number of violent acts | Number of violent acts by Illegal Armed Groups (FARC, AUC, ELN) per Municipality, Including terroristic acts, assaults, attacks, roadblocks, ambushes, harassment, attacks on population. |
| MR | Murder Rate by Illegal armed groups | 2001 to 2008 | Colombian National Police - Estimation by the Authors | Number of homicides | Number of homicides per 100,000 inhabitants committed by illegal armed groups (FARC, AUC, ELN). Homicides committed by common crime are not taken into account. |
| MIAG | Number of murders by Illegal armed groups | 2001 to 2008 | Colombian National Police | Number of homocides by Illegal armed groups | Homicides committed by common crime are not taken into |
| PPF | Percentage of primary forest area | 2000 | Colombia Ecosystem map (shape) - Institute of Hydrology, Meteorology and Environmental Studies of Colombia (IDEAM - Spanish acronymun for "Instituto de Hidrología, Meteorología y Estudios Ambientales de Colombia) - Estimation by the authors | Percentage | Hectares of primary forest as percentage of the total area of the municipality. |
| PCOCA | Percentage of coca area | 2001 to 2008 | Coca maps (shape) - Integrated Illicit Crops Monitoring System (SIMCI: Spanish acronym for "Sistema Integrado de cultivos ilicitos") | Percentage | Hectares of cultivated coca as percentage of the total area of the municipality. |
| NCOMP | Number of complaints to the Ombudsman by citizens concerning aerial spraying | 2001 to 2008 | Local and National Ombudsman's Office | Number of complaints | Number of complaints to the Ombudsman by citizens concerning aerial fumigation |
| AF | Aerial fumigation | 2001 to 2008 | National Direction of Narcotics (DNE - Spanish acronym for "Dirección Nacional de Estupefacientes" | Number of hectares | Number of fumigated hectares per municipality |
| CA | Coca Area | 2001 to 2008 | Coca maps (shape) - Integrated Illicit Crops Monitoring System (SIMCI: Spanish acronym for "Sistema Integrado de cultivos ilicitos") | Number of hectares | Ha of area cultivated with coca in the municipality |
| RPOP | Rural population | 2005 | National Administrative Department of Statistics - DANE, estimation by the authors | Number of persons | Number of persons living in the rural zones of each municipality |
| AF01-08 | Area fumigated between 2001 and 2008 | Total 2001 - 2008 | National Direction of Narcotics (DNE - Spanish acronym for "Dirección Nacional de Estupefacientes" | Number of hectares | Total area fumigated between 2001 and 2008 |
| SDC01-08 | Indicator of variation in coca cultivation | Total 2001 - 2008 | Coca maps (shape) - Integrated Illicit Crops Monitoring System (SIMCI: Spanish acronym for "Sistema Integrado de cultivos ilicitos") | Number of hectares | Starndar Deviation of the area of coca cultivated from the 2001-200 |
| ABC and AIT | Area of the municipality belonging to Indigenous territories and black communities | | Maps of black communities and Indigenous territories (shape) - Geographic Institute Agustín Codazzi | Number of hectares | Number of hectares under legal status of indigenous territory (AIT) or under title of black comminities (ABC) |
| AECO | Area of natural cover and natural ecosystems at municipal level | 2000 | Colombia Ecosystem map (shape) - Institute of Hydrology, Meteorology and Environmental Studies of Colombia (IDEAM - Spanish acronymun for "Instituto de Hidrología, Meteorología y Estudios Ambientales de Colombia) - Estimation by the authors | Number of hectares | Hectares of natural cover of a certain ecosystem type within the municipality |

## 4. FINDINGS

Our data confirms the government's claim of an overall reduction of coca plantations at the national level since the beginning of the fumigation policy. Between 2000 and the commencement of Plan Colombia and 2008, coca cultivations at a national level have been reduced from an area of 163.000 ha to half, i.e. 81.000 ha. This finding is not surprising, since our data is the same official data produced and used by the

government. It is important to note that other sources have challenged this finding (REF). For example CIA's Crime and Narcotics Center (CNC) has reported that unlike what the government claimed, in 2001 and in 2007 the area cultivated with coca has not really declined, but on the contrary it has remained stable at around 170.000 ha. (GAO, 2008) Even so, and despite this dispute about the data, we will show that even with using the official government data that suggest an overall reduction, still the fumigation policy has diffused production to the territory increasing both deforestation and social impacts.

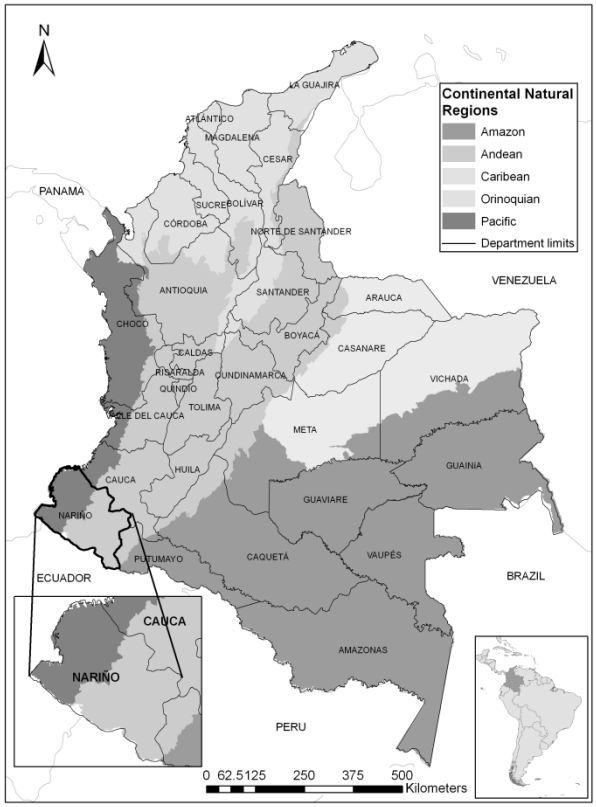
### 4.1 Displacement and diffusion, not eradication.

Before the start of fumigations, most coca cultivations were concentrated in the northern region of Colombia, at the Colombian Amazon (Map 1). In 2000 the three departments of the Amazon region alone (Putumayo, Guaviare and Meta), out of a total of 32 departments in which Colombia is divided, accounted for 58% of the national production of coca. And it was there that 56% of the fumigations in 2000 concentrated. However, as a result coca production was displaced and dispersed to new regions principally in the Pacific region (Nariño and Chocó departments), as illustrated in Map 2 and 3. This map, which is based on our municipal database, compares fumigated area and coca-cultivated area in two subsequent years. In the municipalities where fumigations increased (black colour) a decrease of coca area was produced in the subsequent period (grey colour). However the cultivated area in the neighbouring municipalities increased. This confirms quantitatively that fumigations produced a geographical displacement of coca production[1], a phenomenon that has been called the

[1] In this study the policy of manual eradication was not taken into account, which can also be associated with the mentioned balloon effect.

"balloon effect" (Paredes and Correa, 2007), i.e. coca production shrinking in one part, but as a result expanding in other areas, like air in a latex balloon. In other words, although overall coca cultivation may be decreasing (according to official data sources), it is nonetheless diffusing in the territory.

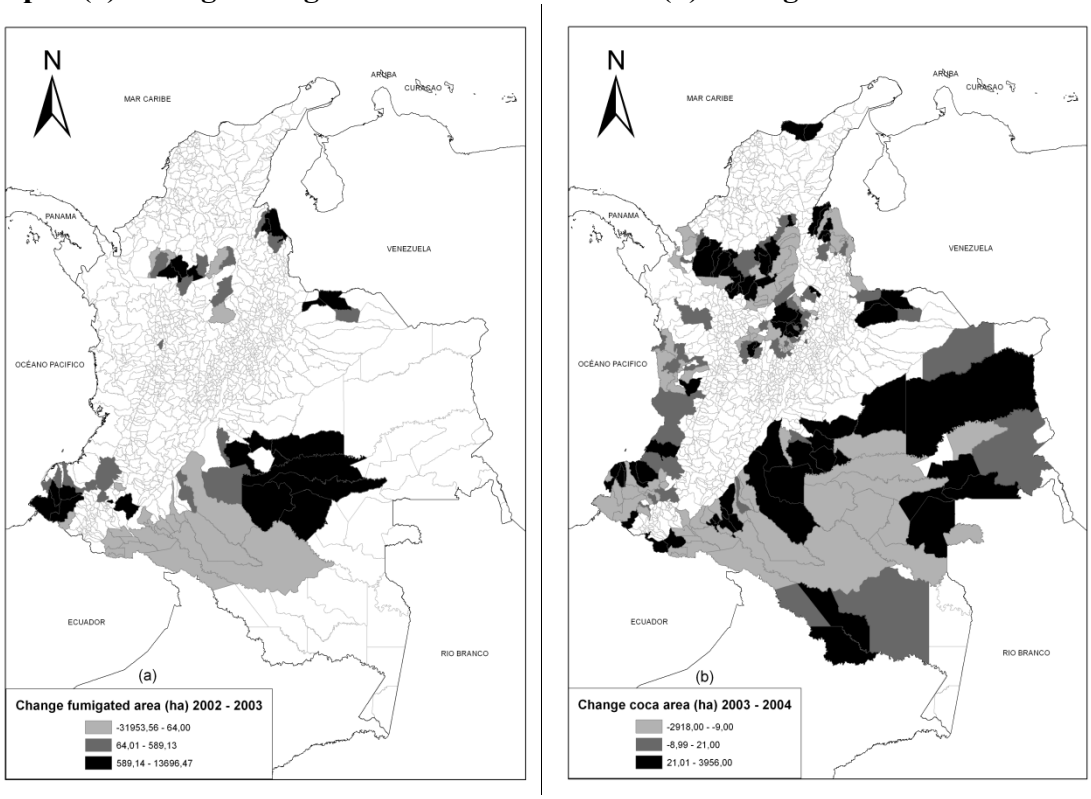
**Map 1. Departments and Natural (continental) regions of Colombia**




In addition to the visual representation of Map 2 and 3, we test the proposition of a balloon effect by analyzing statistically the spatial association between the fumigated area by municipality for the year n and the area under coca in the bordering municipalities in the year n +1. The estimation was done using the multivariate Moran's I coefficient, an indicator of spatial correlation (Anselin et al., 2002).. We found a positive association between the area fumigated in a municipality in year n, and the area under coca plantation in bordering municipalities in the year n +1 (Table 2). To put it

differently, the more a municipality is fumigated, the more coca is cultivated in its neighbouring municipalities the next year. In other words, there is a direct relation between aerial fumigation of a territory and subsequent spatial displacement of coca production to a nearby area. Our data therefore supports the thesis of displacement and diffusion, not eradication, of coca production after fumigation.

**Map 2. (a) Change fumigated area 2002-2003 and (b) Change coca area 2003-2004**



**Map 3. (a) Change fumigated area 2006-2007 and (b) Change coca area 2007- 2008**

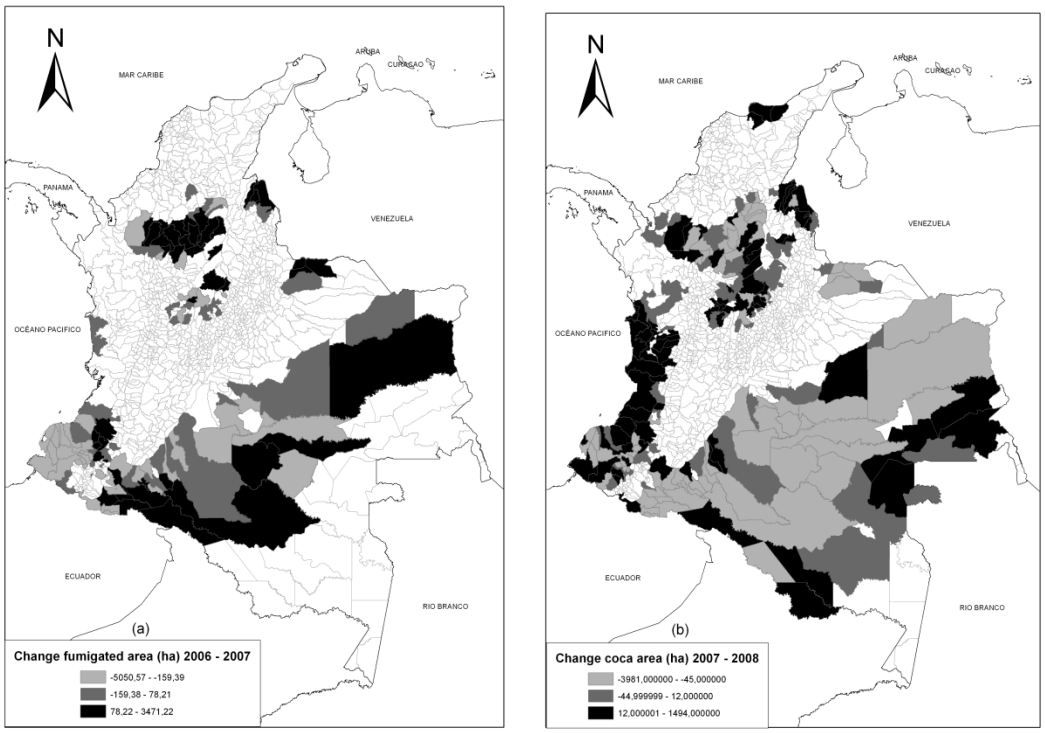



**Table 2 Moran´s I – Spatial correlation of area fumigated per municipality in year n with area under cultivation in the same municipality in year n+1 / * Significant correlation (0,05)**

| Area sprayed by municipality in the year n | coca area in the neighborhood municipalities in year n +1 | Moran´s I |
|---|---|---|
| 2001 | 2002 | 0,105* |
| 2002 | 2003 | 0,102* |
| 2003 | 2004 | 0,217* |
| 2004 | 2005 | 0,192* |
| 2005 | 2006 | 0,121* |
| 2006 | 2007 | 0,235* |
| 2007 | 2008 | 0,179* |

*. Correlation is significant at the 0.05 level (2-tailed).

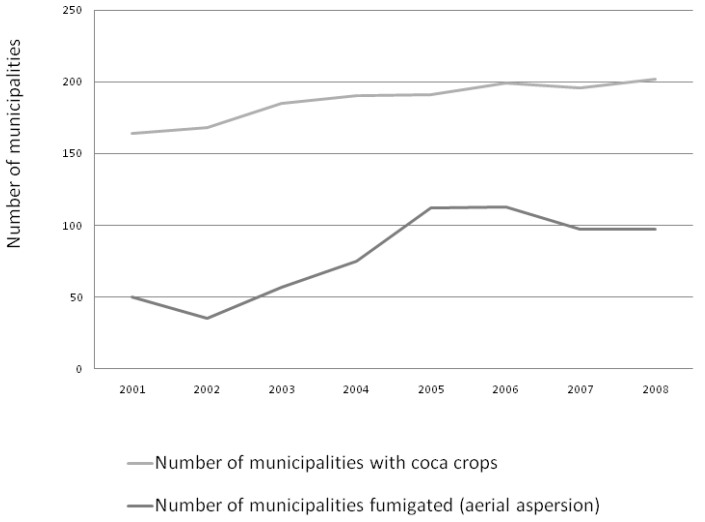
Further supporting the above result, the number of municipalities with coca plantations within their territories increased from 164 in 2001 to 202 in 2008 (Figure 1.) Rather than "uprooting" the coca problem, the fumigation policy is actually spreading it to new municipalities. All those new (to coca) municipalities have plantations that exceeded the 100 hectares, suggesting that there is extensive cultivation going on, and that this is not

a minor side-effect. Furthermore, while by 2001, only 85 municipalities had coca cultivations exceeding 100 ha, by 2008 the number of municipalities with such extensive cultivations had increased to 106.

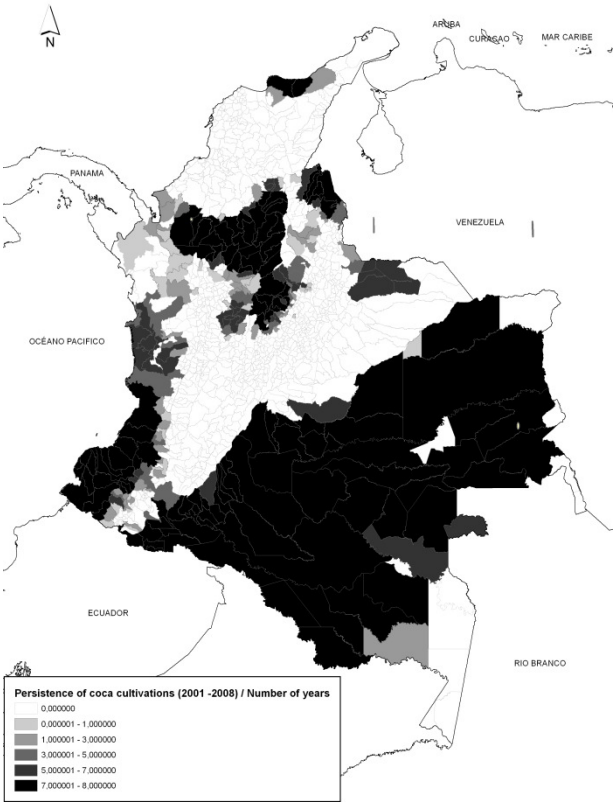
This balloon effect, i.e. the expansion of the cultivation to new territories, has produced a subsequent increase of aerial fumigation in the new territories. In turn, and in a vicious cycle mode, this has caused new displacement of coca cultivations, and in some cases, even a return to areas previously fumigated. A consequence is that the number of municipalities fumigated increased accordingly. Figure 1 shows that in 2001, 50 municipalities were fumigated, but this number increased to 97 in 2008. Rather than an intensification of the policy, this has to be seen as evidence of its failure to eradicate coca production in the targeted areas. The result is the geographical expansion of both coca and the war frontier. Map 4 illustrates spatially the persistence of coca production in the territory by indicating the number of years that each municipality has experienced coca cultivation (minimum 1, maximum 8): many municipalities have seen a continuous production of coca in their territory. In none of the municipalities fumigated during the study period were crops eliminated completely. In fact 81 of the 143 fumigated municipalities show an increasing trend of coca crops[2].

[2] The trend was estimated by lineal regression: coca area = f (time)

**Figure 1. Growth in municipalities with coca cultivations and in municipalities being fumigated (2001-2008)**




**Map 4. Persistence of coca cultivations. Number of years that the municipalities had coca cultivations in the 2001-2008 period**



Our data suggests also a further hypothesis: coca plantations go away during fumigation, but return after the territory stops being fumigated. Our evidence is the statistically significant correlation[3], between the size of the area fumigated between 2001 and 2008 and an indicator of variation in coca cultivation, measured as the standard deviation of the area of coca cultivated from the 2001-2008. In other words, the more a municipality is sprayed the more "back and forth" of coca it experiences. In addition we find that this variability is associated with a decrease in the deforestation by coca during the increase of fumigations, but is followed by an increase of deforestation by coca in these same zones after the fumigation decrease in departments such as Nariño (figure 2).

**4.2 Where does the coca go?**

What are some of the features of the areas where coca crops and fumigations take place? Based on a statistical analysis of our municipal database, a first observation is that coca production takes place predominantly and increasingly in impoverished areas with lack of institutional infrastructure. 73% of the municipalities exhibiting an increase in coca cultivation between 2001 and 2008 have a Rural Unsatisfied Basic Needs Index (RUBN) superior to 50% (generally considered the limit value indicating impoverishment). A second index of impoverishment and public services is the "municipal development index" (IMD): 83% of municipalities that have exhibited increasing coca cultivation between 2001 and 2008 have an index value less than 50.

[3] Pearson Correlation 0.728 / significant at the 0.01 level

This indicates that poverty is prevalent in the majority of the departments where coca advances (Dion and Russler, 2008).

Applying correlation analysis we can trace statistically significant correlations between coca production and other social and environmental features. Our data shows a statistically significant correlation between coca cultivation and the presence illegal armed groups, which are typically (though not always) those involved in the coca business, as well as with the remoteness of an area (Table 3). The presence of illegal armed groups, as captured in indicators such as the number of violent acts and murders by illegal armed groups, is positively correlated with (low) road density and (high) level of natural cover. These same factors correlate, as expected, with the percentage of area cultivated with coca. There is also a statistically-significant and strong inverse correlation between the percentage of the municipal area cultivated with coca and indicators of development (RUBN and IMD) (Table 3). We can conclude therefore that the coca frontier and illegal armed groups are predominantly present in remote, naturally rich areas where the local communities tend to be poor.

**Table 3. Pearson´s correlations between % municipal area cultivated with coca and other variables associated**

| % coca crops area / Road Density 2000 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Year | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
| Pearson Correlation | -,093(**) | -,168(**) | -,178(**) | -,174(**) | -,193(**) | -,179(**) | -,193(**) | -,216(**) |
| Sig. (2-tailed) | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| N | 1,125 | 1,125 | 1,125 | 1,125 | 1,125 | 1,125 | 1,125 | 1,125 |
| **% coca crops area / Municipal Development Index** | | | | | | | | |
| Year | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
| Pearson Correlation | -,101(**) | -,186(**) | -,194(**) | -,190(**) | -,207(**) | -,202(**) | -,235(**) | -,283(**) |
| Sig. (2-tailed) | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| N | 1,102 | 1,102 | 1,102 | 1,102 | 1,102 | 1,102 | 1,102 | 1,102 |
| **% coca crops area / Forced displacement of population - FDP (number of people)** | | | | | | | | |
| Year | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
| Pearson Correlation | ,192(**) | ,228(**) | ,138(**) | ,144(**) | ,264(**) | ,305(**) | ,262(**) | ,378(**) |
| Sig. (2-tailed) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| N | 1,124 | 1,124 | 1,124 | 1,124 | 1,124 | 1,124 | 1,124 | 1,124 |
| **% coca crops area / % Natural Cover 00** | | | | | | | | |
| Year | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
| Pearson Correlation | ,109(**) | ,256(**) | ,246(**) | ,220(**) | ,261(**) | ,238(**) | ,254(**) | ,316(**) |
| Sig. (2-tailed) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| N | 1,124 | 1,124 | 1,124 | 1,124 | 1,124 | 1,124 | 1,124 | 1,124 |
| **% coca crops area / rate of Forced displaced of population** | | | | | | | | |
| Year | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | |
| Pearson Correlation | ,152(**) | ,090(**) | ,094(**) | ,172(**) | ,167(**) | ,210(**) | ,275(**) | |
| Sig. (2-tailed) | 0.000 | 0.003 | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 | |
| N | 1,124 | 1,124 | 1,124 | 1,124 | 1,124 | 1,124 | 1,124 | |
| **% coca crops / Murders by illegal armed groups** | | | | | | | | |
| Year | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | | |
| Pearson Correlation | ,119(**) | ,108(**) | ,328(**) | ,286(**) | ,289(**) | ,259(**) | | |
| Sig. (2-tailed) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | | |
| N | 1,124 | 1,124 | 1,124 | 1,124 | 1,124 | 1,124 | | |
| **% coca crops area / rate murders by illegal armed groups** | | | | | | | | |
| Year | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | | |
| Pearson Correlation | 0.030 | ,129(**) | ,214(**) | ,291(**) | ,279(**) | ,226(**) | | |
| Sig. (2-tailed) | 0.320 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | | |
| N | 1,102 | 1,102 | 1,102 | 1,102 | 1,102 | 1,102 | | |
| **% coca crops / RUBN 05** | | | | | | | | |
| Year | 2005 | 2006 | 2007 | 2008 | | | | |
| Pearson Correlation | ,185(**) | ,130(**) | ,174(**) | ,176(**) | | | | |
| Sig. (2-tailed) | 0.000 | 0.000 | 0.000 | 0.000 | | | | |
| N | 1,116 | 1,116 | 1,116 | 1,116 | | | | |

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

The communities also where coca expands tend to be predominantly indigenous and Afro-Colombian. According to our analysis, during the early 2000s, 7% of the area of coca cultivation was found in indigenous territories, 4% in collective territories of black communities and 2% in natural parks. By 2008 there is a significant change, as the crops become located mainly in the collective territories of black communities (36% of the crops), the coca area in reserves, natural parks and indigenous territories remaining unchanged.

### 4.3 Who is fumigated?

The same type of statistically significant correlations is observed between fumigation, poverty and remoteness indicators; this makes sense, given that fumigations concentrate in the areas where coca is cultivated and coca cultivation also correlates with these indicators (Table 4). As a result it is poor indigenous and increasingly Afro-Colombian communities that have suffered the most from the terrible consequences of coca production and its fumigation. Afro-Colombian groups have denounced on several occasions the fumigation policy (OAIPC, 2010). That Afro-Colombian communities are suffering disproportionately from the effects of the war on drugs is beyond dispute (Walsh et al., 2008b) and confirmed by out in-situ observations.

A further question is whether there is intentional discrimination by the government on its fumigation targets, i.e. whether Afro-Colombians and indigenous areas more likely to be fumigated than whites, other factors equal? Our data does not suggest so, since there is no remaining correlation between area fumigated and the area occupied by

indigenous territories and Afro-Colombian communities if we control for the extent of coca cultivations in the municipality. In other words, the areas mostly fumigated are those that have the most coca, and those are now the ones where Afro-Colombian and indigenous communities are found. This does not mean however that these communities are selectively targeted.

**Table 4. Pearson´s correlations between aerial fumigation and other variables associated**

| Aerial spraying / complaints related to impacts by aerial spraying | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Year | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
| Pearson Correlation | ,661(**) | ,507(**) | ,301(**) | ,294(**) | ,567(**) | ,287(**) | ,402(**) | ,510(**) |
| Sig. (2-tailed) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| N | 1,124 | 1,124 | 1,124 | 1,124 | 1,124 | 1,124 | 1,124 | 1,124 |
| **Aerial aspersion / Municipal Development Index** | | | | | | | | |
| Year | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
| Pearson Correlation | -,109(**) | -,096(**) | -,122(**) | -,154(**) | -,095(**) | -,185(**) | -,159(**) | -,240(**) |
| Sig. (2-tailed) | 0.000 | 0.001 | 0.000 | 0.000 | 0.002 | 0.000 | 0.000 | 0.000 |
| N | 1,102 | 1,102 | 1,102 | 1,102 | 1,102 | 1,102 | 1,102 | 1,102 |
| **Aerial aspersion / Murders carried out by illegal armed groups** | | | | | | | | |
| Year | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | | |
| Pearson Correlation | ,110(**) | ,151(**) | ,140(**) | ,365(**) | ,347(**) | ,258(**) | | |
| Sig. (2-tailed) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | | |
| N | 1,124 | 1,124 | 1,124 | 1,124 | 1,124 | 1,124 | | |
| **Aerial aspersion / RUBN 2005** | | | | | | | | |
| Year | 2005 | 2006 | 2007 | 2008 | | | | |
| Pearson Correlation | ,066(*) | ,131(**) | ,124(**) | ,153(**) | | | | |
| Sig. (2-tailed) | 0.028 | 0.000 | 0.000 | 0.000 | | | | |
| N | 1,116 | 1,116 | 1,116 | 1,116 | | | | |
| **Aerial aspersion / Rural population 2005** | | | | | | | | |
| Year | 2005 | 2006 | 2007 | 2008 | | | | |
| Pearson Correlation | ,136(**) | ,104(**) | ,107(**) | ,089(**) | | | | |
| Sig. (2-tailed) | 0.000 | 0.001 | 0.000 | 0.003 | | | | |
| N | 1,112 | 1,112 | 1,112 | 1,112 | | | | |

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

### 4.4 Environmental effects of fumigation

The official government discourse is one that links fumigation and sustainability, in the sense that more fumigation means less coca production and hence less deforestation. Instead we find that the territorial diffusion of coca activities leads to continued and

expanding deforestation, and we attempt to characterise the environmental characteristics of the new areas of the forest affected by coca and fumigations.

On the basis of the crossing of the ecosystem map of Colombia in 2000 and the coca maps (2001 - 2008) in shape format, we estimated the extent of natural forest affected by coca diffusion year by year, based upon data on existing ecosystems and natural cover for 2000. Table 5 presents the extents of natural forest affected by coca during the period 2001 - 2008. At the beginning of the decade, the Amazon and Orinoco region ecosystems were those most affected, but impact upon them has decreased over time: 71920 ha of coca in 2001 were occupying natural forest in 2000, but in 2008 this area decreased to 22.270 ha. In contrast in 2008 the natural forests of the Caribbean region and especially of the Pacific region, which is considered one of the biodiversity hotspots of the world, showed significant increases in coca conversion. 1982 ha that were natural forests in 2000 in the Pacific became coca cultivations by 2001, and by 2008 this area had increased to 8166 ha[4].

Although fumigations have reduced the total area of coca cultivations in Colombia, they have increased deforestation since the balloon effect means that new areas of primary forest are continuously deforested as the war pushes the frontier to new territories. Furthermore, the primary forest that is lost to coca plantations is irreplaceable. Even though fumigation may displace coca, the previous state of the forest is not recoverable. According to the data of SIMCI the displacement of coca crops to new areas as a result of fumigation has generated a deforestation of primary forest of 110,026 ha between 2001 and 2008.

[4] We estimate the area in coca that was natural forest in 2000 year by year. This estimation not includes possible transformations from natural forest to other covers before to be transformed in coca area.

**Table 5. Natural forest in 2000 converted into coca cultivations between 2001 to 2008**

| Natural forest in 2000 that was transformed to coca area during the period 2001 - 2008 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|
| Amazon and Orinoquian Region | 71910 | 61536 | 39027 | 33616 | 39684 | 33120 | 35613 | 22270 |
| Pacific Region | 1982 | 4640 | 4526 | 3821 | 3792 | 2788 | 5839 | 8166 |
| Caribe Region | 3797 | 3352 | 3918 | 3258 | 4039 | 2336 | 6125 | 5712 |

## 4.5 Health effects

Deforestation is not the only negative consequence of aerial fumigation. Health effects on people directly or through impacts on other crops are also very important. In its raids, the anti-drug police spray the territory with a mixture of the herbicide ´Roundup Ultra´, commercial name by its proprietary ´Monsanto´ that holds glyphosate and the surfactant polyethoxylated tallowamine (POEA) and 'Cosmo-flux 411F'. In Colombia, pesticides containing glyphosate such as ´Roundup´ are registered under the toxicological class IV (slightly toxic). In USA glyphosate is registered in the EPA's Toxicity Category III, with Category I being the most toxic and IV the least (Sherret 2005). In several countries "Roundup" was among the first pesticides that caused human poisoning, and effects reported after exposure include nausea, dizziness, respiratory problems, increased blood pressure and allergic reactions (Nivia, 2001). The United States banned marijuana eradication through aerial fumigation with glyphosate because the forests were affected as the illicit crops were mixed with trees and undergrowth (Barón, 2007). And according to the Farm Chemicals Handbook (1990), it is not recommended to use glyphosate for aerial application due to environmental effects. In Denmark the Ministry of Environment banned glyphosate in places where there may be runoff, in order to prevent groundwater contamination (Legarth, 2003).

Colombia´s fumigations with glyphosate have generated environmental problems in neighboring Ecuador, as verified by government institutions and scientists (Ávila et al., 2007). Glyphosate has been developed to be applied directly to plant leaves and not through the air (Haney et al., 2000).

Health effects are very difficult to verify. Still, our data confirms a significant correlation between area fumigated and the number of complaints submitted to the Ombudsman and local authorities (Table 4). At the beginning of the decade, aerial fumigation was especially concentrated in the department of Putumayo, which received 47% of all aerial fumigation in Colombia (of 224.516 ha sprayed in Colombia between 2001 and 2002, 104.397 ha were in Putumayo). According to our analysis of archives between mid 2001 and mid-2002 the Ombudsman received 318 complaints concerning health impacts or the loss of (legal) crops from aerial fumigation in the 3 municipalities of Putumayo where 6076 families live. A 2002 study conducted by the health department of Putumayo on the impact of fumigations in community territories showed that 4883 (81.5%) of the 5,929 people that had filed complaints reported health problems when interrogated by municipal officials. Furthermore, a 2007 report of the Ombudsman's Office in Putumayo, based on direct observation of the people recovered in the local hospitals, revealed that vomiting and diarrhea, headaches and respiratory problems were common symptoms of those exposed to fumigation.

After the increase of claims between 2001 and 2003, there was a decreasing tendency of claims starting in 2004. Our interviews suggest that farmers stopped to report due to the lack of response by PECIG, the authority overseeing the program of eradication. People

no longer believe that the state will attend their claims and complaints. And this may explain why a total of 2559 claims in 2003 was reduced to 781 in 2008.

The impacts of aerial fumigation on the health of local population are intensely debated in Colombia. Some researchers cannot find statistically significant evidence given that local people usually have contact with many other toxic substances that can cause health effects (such as pesticides and herbicides used on crops) (Varona Marcela, 2009). Plan Colombia fumigation continues on this basis. On the other hand other researchers and NGOs working in the region have provided evidence on the negative impacts of the fumigations on the population's health (Ávila, Bravo et al. 2007; Mingorance 2008; Walsh, Sánchez et al. 2008). Local communities insist on their experience of the negative impacts of the aerial fumigation, and have denounced the crime perpetrated against them with national-level protests and communiqués (Defensoria del Pueblo, 2007; OAIPC, 2010). Of course, such struggle over scientific uncertainty and complexity in an environmental health issue is not unique to fumigation in Colombia, and the government continues to deny any link between fumigations and adverse health effects. NGOs have called for an application of the "precautionary principle", i.e. a precautionary banning of fumigation given its unknown and disputable, yet highly risky health effects, but in vain.

### 4.6 Social consequences

Another important impact of fumigation is displacement. 70% of the municipalities that experienced increased fumigations between 2001 and 2008 also present increasing tendencies in forced displacement of the population, as measured by the National Registry on forced population. There is also a significant correlation between fumigated areas and forced displacement for all the years analyzed. In other words, the more the area fumigated in a municipality, the higher the number of people that leaves it.

According to our interviews there are two factors at play here: first, part of the population was economically dependent on coca and traditional crops and the destruction of cultivation by the fumigations forced them to move to other municipalities. Second, the aerial fumigation impacted the traditional crops even of those families that were not involved in coca, affecting food security and forcing them to migrate. An additional reason for some are the perceived health impacts from the fumigation. Indigenous and black groups have denounced the displacement of population from their communities as a consequence of the water contamination, land degradation and loss of food security caused by fumigations (CODHES, 2011; El Tiempo, 2004; OAIPC, 2010; Quevedo, 2007; Walsh et al., 2008a)

The government emphasises the first driver, i.e. the displacement of coca farmers, and does not necessarily see their displacement as a problem due to their involvement in illegal activities. Furthermore, the government puts blame elsewhere or argues that the fumigations do not have impacts on the population (Solomon et al., 2005). The assumption here is that displacement is mostly a result of the general armed conflict and

the violence of the armed groups and not the fumigations *per se*. Fumigations target the areas where coca and illegal groups presence is strong; according to this narrative, it is not the fumigations that make the people leave but the violence of the coca business and the illegal groups. However other researchers and NGO´s (CODHES, 2008, 2009; Ibáñez and Moya, 2007; Ibáñez and Vélez, 2008) suggest that aerial fumigation is directly related and implicated in the armed conflict, and is in many and different ways a major cause of displacement in Colombia. To test the claim of a relation between fumigation and displacement we investigate whether there is a statistically significant correlation between the extent of area fumigated and the number of people displaced. To isolate this from the direct displacement effects of violence, we control for murder rate and violent acts by illegal groups (State-used indicators of violence). In both cases we find a statistically significant correlation (Table 6 and 7), which confirms that fumigation is a definite cause of displacement irrespective of the effects of violence.

**Table 6. Partial correlation between Aerial Fumigation (AF) and Forced Displacement of Population (FDP) controlled for Violence (number of murders by illegal armed groups)**

| Control Variable | Var 1 | Var 2 | Partil Correlation | Value |
|---|---|---|---|---|
| MIAG 2003 | AF 2003 | FDP 2003 | Correlation | 0.075 |
| | | | Significance (2-tailed) | 0.011 |
| MIAG 2004 | AF 2004 | FDP 2004 | Correlation | 0.189 |
| | | | Significance (2-tailed) | 0.000 |
| MIAG 2005 | AF 2005 | FDP 2005 | Correlation | 0.118 |
| | | | Significance (2-tailed) | 0.000 |
| MIAG 2006 | AF 2006 | FDP 2006 | Correlation | 0.131 |
| | | | Significance (2-tailed) | 0.000 |
| MIAG 2007 | AF 2007 | FDP 2007 | Correlation | 0.170 |
| | | | Significance (2-tailed) | 0.000 |
| MIAG 2008 | AF 2008 | FDP 2008 | Correlation | 0.217 |
| | | | Significance (2-tailed) | 0.000 |

**Table 7. Partial correlation between Aerial Fumigation (AF) and Forced Displacement of Population (FDP) controlled for Violence (number of violent acts by illegal armed groups) / There was not statistical significance for 2007.**

| Control Variable | Var 1 | Var 2 | Partil Correlation | Value |
|---|---|---|---|---|
| VAIA 2002 | AF 2002 | FDP 2002 | Correlation | 0.122 |
| | | | Significance (2-tailed) | 0.000 |
| VAIA 2003 | AF 2003 | FDP 2003 | Correlation | -0.019 |
| | | | Significance (2-tailed) | 0.535 |
| VAIA 2004 | AF 2004 | FDP 2004 | Correlation | 0.142 |
| | | | Significance (2-tailed) | 0.000 |
| VAIA 2005 | AF 2005 | FDP 2005 | Correlation | 0.080 |
| | | | Significance (2-tailed) | 0.007 |
| VAIA 2006 | AF 2006 | FDP 2006 | Correlation | 0.073 |
| | | | Significance (2-tailed) | 0.014 |

Furthermore, we investigate whether there there is a correlation between aerial fumigation and displacement, controlling for the number of people actively employed in coca, i.e. to exclude the possibility that a higher discplacement is simply the effect of more people working in coca, and being displaced as a result of fumigation kicking out the crop. In other words, our goal is to see whether people leave because of fumigation and not because coca leaves. Since there is no data available on the number of people employed in coca in each municipality, we use the ha of coca cultivated as a proxy for employment. Again, we find a statistically significant correlation, suggesting that fumigation displaces normal residents, and not only those involved in coca cultivation (Table 8)

**Table 8. Partial correlation between Aerial Fumigations (AF) and Forced Displacement of Population (FDP) controlled for coca crops area (CA) / There was no statistical significance for 2003 and 2008**

| Control Variable | Var 1 | Var 2 | Partil Correlation | Value |
|---|---|---|---|---|
| CA 2001 | AF-01 | FDP-01 | Correlation | 0.113 |
| | | | Significance (2-tailed) | 0.001 |
| CA02 | AF-02 | FDP-02 | Correlation | 0.156 |
| | | | Significance (2-tailed) | 0.000 |
| CA04 | AF-03 | FDP-04 | Correlation | 0.190 |
| | | | Significance (2-tailed) | 0.000 |
| CA05 | AF-04 | FDP-05 | Correlation | 0.169 |
| | | | Significance (2-tailed) | 0.000 |
| CA06 | AF-05 | FDP-06 | Correlation | 0.130 |
| | | | Significance (2-tailed) | 0.000 |
| CA07 | AF-06 | FDP-07 | Correlation | 0.077 |
| | | | Significance (2-tailed) | 0.014 |

## 5. DISPATCHES FROM A WAR FRONTIER

Nariño is one of the 32 departments of Colombia. It is located at the south-West of Colombia (Map 1) and has a population of 1.5 million people living in 64 municipalities in an area of 33 thousand km2. The grand majority of the population works on agriculture and livestock, with some active in forest exploitation. 19% of the population is of Afro-Colombian descent and 11% indigenous (DANE, 2006). Nariño stands at the epicentre of the expanding coca frontier. Between 2001 and 2008 the department of Nariño had an increase of 162% of the area cultivated with coca crops and as Table 9 indicates it has been a growing target of fumigations. When one considers that the total area of coca crops for Colombia as a whole decreased by 44%, the rate of coca increase in Nariño is especially striking. The displacement of coca crops concentrated to the municipalities at the Pacific coast of Nariño, which are the ones where mostly Afro-Colombians reside. About 40% of the area under coca in Nariño in 2008 was natural

forest in 2000. Nariño has ten eco-regions, five of them occupied by coca cultivations; between 2003 and 2008 18% of the total of deforestation caused by coca in Colombia took place in Nariño. According to SIMCI data, 13.000 ha or natural forest has been converted to coca in Nariño in 2003-2008. 22% of the total area cultivated with coca in 2008 was tropical rain forest in 2000. 8% was riparian forest. Whereas there is a clear link between coca production and deforestation, this should not be read as an argument in favour of fumigation (and the common replacement by oil palm plantations); as we argued above fumigation diffuses and expands deforestation, while an industrial tree plantation is no substitute for primary forest loss.

**Table 9 . Expansion of the aerial fumigations 2001-2008 in Colombia and Nariño (ha fumigated)**

| Aerial Spraying / año | 2000 | 2002 | 2004 | 2006 | 2008 |
|---|---|---|---|---|---|
| Aerial spraying in Colombia (ha) | 58,074 | 130,364 | 136,551 | 171,754 | 133,496 |
| Aerial spraying in Nariño (ha) | 6,442 | 17,962 | 31,307 | 59,865 | 54,050 |
| % of the total area sprayed in Colombia corresponding to Nariño | 11 | 14 | 23 | 35 | 40 |

Nariño has been one of the departments of Colombia that has suffered the most by forced displacement. In 2000 when aerial fumigation started in Nariño, 732 displaced cases were reported, representing a 0.3% of the total in Colombia. But between 2001 and 2008 and as production and fumigations increased so did displacements reaching a total of 31,314 in 2008, corresponding to a 10% of the total of the population displaced (301,754)[5]. Indicatively, Ecuador, which is in close proximity to the department of Nariño, granted refuge to more than 25,000 Colombians between 2000 and 2009.

[5] Displacement in Colombia and subsequent migration also had to do with the Pudricion de Cogollo (PC), a disease the oil palm had, and which hit gravely all the farmers that had adopted monoculture palm systems and dedicated less time to subsistence crops.

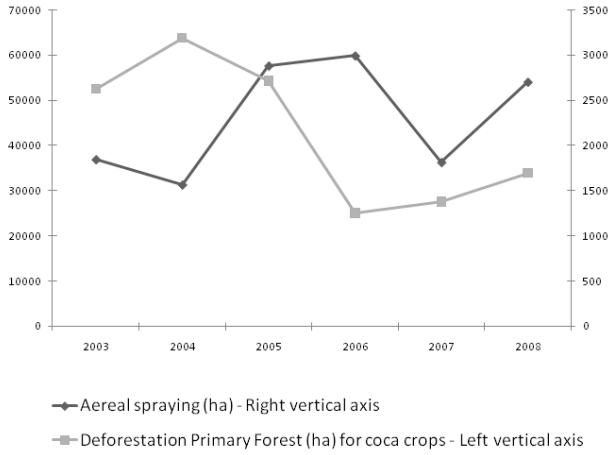
The arrival of aerial fumigation to Nariño was followed by an increase in formal complaints and claims by the local population. Of the reported claims on the aerial fumigation in the country between 2001 and 2008, 45% came from Nariño and concerned health and crops loss, while at the peak of 2003, 76% of the total claims (1950 claims) were from Nariño. (Defensoria del Pueblo, 2007, 2009; Policia Nacional de Colombia - Dirección de Antinarcoticos, 2010). Our analysis of the archive of the complaints shows that between 2000 and 2006, a total of 1177 families reported effects from aerial fumigation including death of domestic animals (ducks, chickens, pigs and cows), pollution and destruction of legal crops used for self-consumption (chiro, chilma, cassava, papacum, chontaduro, banana, coconut, cacao, corn, etc.) and impacts on population health. Indigenous testimonies reported the deaths of three children and two abortion cases between 2000 and 2006 due to the fumigation, additionally, CODHES (consultancy for human rights and displacement - acronym in Spanish) denounces the death of 25 indigenous children from starvation due to the impact of fumigation of food crops (El Espectador, 2008). During our interviews, indigenous leaders told us that there was no previous consultation or warning about the fumigations and claimed that their water sources have been contaminated and that they have lost seeds and medicinal plants. At the time of writing of this article, indigenous groups continue to denounce publicly the displacement that fumigations cause (Autoridades Indígenas AWÁ – UNIPA, 2011). There is still no evidence of any intervention or assistance from public or private entities as a response to the indigenous claims, despite the repeated denunciations of the terrible impacts (Oslender, 2010; Walsh et al., 2008b).

The Awá are some of the Indigenous people most affected by fumigations in Nariño. The constant oppression by the illegal armed groups, and the violence over disputes for

the occupation of the territory to grow coca, has caused assassinations and massacres in the Awá community. Indigenous leaders that we interviewed mentioned the assassination of 50 people from their community, among them children and women, in 2009, events that have been covered extensively by mass media (ACNUR, 2009; El Tiempo, 2009).

Figure 2 illustrates the persistence of coca crops and the vicious cycle of fumigation, that characterizes the area. We provide data on the relationship between deforestation of primary forest and aerial fumigation. An increase in fumigation is associated to a decrease in deforestation (without deforestation disappearing altogether). Nevertheless, when fumigation decreases, coca cultivation takes up again as coca cultivations that had moved to nearby territories return to where they had left from. Rather than an argument for a continuous or intensified fumigation, the point here is that fumigation causes merely spatial displacement and additional destruction, and is ultimately ineffective as a strategy of reduction of coca cultivation. In conclusion, the short Nariño case-study confirms our main thesis: fumigation does not eradicate the coca problem. It merely displaces it to new areas, spreading and diffusing misery and violence, as well as environmental degradation.

**Figure 2. Aerial fumigation (ha sprayed) and deforestation into coca crops in Nariño / Colombia (2001 – 2008)**



## 6. REFLECTION

Aerial fumigation may be reducing the total area of land devoted to coca, but at a high social and environmental cost. Instead of rooting out the problem it simply displaces and diffuses it. Why does this socially failing policy persist? Here we can only speculate and provide hypotheses for further research as we did not conduct a macro-analysis of the political-economic and political-ecological dynamics of Plan Colombia (for such work see (Ballvé, 2009; Dion and Russler, 2008; Oslender, 2008). We do this caution, as we recognize that we are stepping here out of the core of our contribution, which is the statistical, spatialized documentation of the negative effects of the fumigation policy.

One first observation is the striking resemblance between development policies in so-called "under-developed areas" and the fumigation policy in Colombia. (Norgaard, 1994) studying development policies in Amazon notes how far-distant bureaucracies tend to reduce local complexity to familiar models and apply universal, blanket policies, untailored to local specificities.(Scott, 1998) with the indicative title "Seeing like a State: How certain schemes to improve the human condition have failed" explains the ways in which States map, model and reduce the complexity of the areas to be "improved". State metrics and statistics are an important way in which States "see". Often this takes the form of a mono-dimensional emphasis on GDP or related indicators. A same dynamic may be seen in place in Colombia, with the Colombian State seeing a complex region from far away through the eyes of the pilots fumigating the jungled forest below, and from a safe distance. What counts is reducing the "total

area cultivated by coca". The complex interdependency of factors on the ground that make such a reduction back-fire are wilfully ignored.

However one should not assume that the implications of the policy and its failures are missed by authorities and that this is just a problem of "scale resolution". To explain why Colombia may be caught in an ineffective policy, the analytics of Martinez-Alier's (2002) ecological distribution conflicts may be of help. These call for attention to the actors involved at the conflict at hand, their interests, and the costs and benefits (in monetary and non-monetary terms) that they yield from different policy options. In an over-simplistic schematic, the main actors involved are on the one hand the Colombian and U.S. governments, and on the other hand the illegal armed groups and the paramilitaries controlling coca production and trade. In-between stand the local communities, which are divided between those who work on the coca farms and depend on the crop and those who do not, and are only in the receiving side of violence and dispossession. The Colombian government does not suffer a social cost from the cocaine business, given that the country is not a major consumer; on the contrary, it receives capital flows from the illicit international trade (not to mention the alleged involvement of officials in the trade through armed groups) and it might gain by receiving huge amounts of money and support from Plan Colombia. Indeed, some 2.2 billions US$ have been devoted to the war on drugs between 2000 and 2006 (Ministerio del Interior y de la Justicia, 2006), the capital flows through the fumigation policy estimated to between 63 and 93 million US$ per year (Mailer, 2003; Vargas, 2004). The beneficiaries in many cases are private, non-Colombian enterprises such as Textron and Sikorsky Helicopters, Monsanto (supplying Glyphosate), and Dyncorp, which has a contract of approximately 600 million US$ for managing the fumigations. Reportedly,

such businesses were instrumental in lobbying to pass the war on drugs bill in the U.S. Congress (Adams and Peralta, 2005). While the Colombian government, individual officials and the translational corporations may be making money out of this "disaster capitalism" (Klein, 2007), the rest of the society, and especially the communities at the fumigated areas, do not. The fumigation policy serves to maintain a pretext of action, while mobilizing and redistributing transnational capital; but the real losers are the local communities on the ground, incidentally those with the least economic and political power to change this unsustainable status quo.

## 7. CONCLUSIONS

This article offered new evidence about the socio-environmental consequences of Colombia's war on drugs, and particularly, its fumigation policy. Fumigations have diffused the frontier of coca cultivation, expanding deforestation to some of the world's most important biodiversity hotspots. The causal link is important here: it is not coca production alone that causes the deforestation; it is the fumigation that is continuously pushing it to new areas. More and more people are being displaced, particularly from the more vulnerable segments of the population, including Afro-Colombian descendant and indigenous communities. Although fumigations have reduced the cultivated area, their goal of total eradication is not feasible; the illegal groups have easily adapted and respond to fumigation with fast relocation, forest clearance and production anew. While the intention of the fumigation policy may have been to make coca cultivation too costly to maintain, illegal groups have managed to shift the cost to producers and the local people, and maintain the lucrative cocaine trade going on.

A starting premise of political ecology is that the materiality of the resource at stake and its concomitant political-economic organization matters, and creates particular territorial dynamics. What does our study add to broader understandings of the geography of political-ecological change? The dynamics of the coca frontier are very different than those of other, formal, extraction or plantation activities. In most accounts, raw commodity frontier expansion is typically linear with a sequential development of the less distant and more abundant resources and lands, moving outwards and to new territories as exploited resources are exhausted (Martinez-Alier et al, 2010). Social resistance by those suffering the impacts of the related territorial change may be encountered at different stages of this expansion, typically at important nodes where new projects or land-use developments are enacted. Coca plantations instead, by their very illegal nature tend to be located from the outset in the most remote, less "developed" and often in relation environmentally-rich areas. The frontier takes an awkward, constantly changing, balloon-shape; this is not the result of market or resource dynamics, but the consequence of the particular State strategy of confrontation, which privileges distant engagement. This combination of State and illegal practices has dramatic environmental consequences as new patches of forest are constantly cleared out. Furthermore, the local population has little room for resistance, caught as it is in-between two enemies which are, at least on the surface, in conflict: ruthless criminal organizations and a distant State, indifferent to local pledges. This documentation and analysis of the coca frontier serve as a reminder of the multiple and diverse forms that the expansion and frontier development of global social metabolism can take (Martinez-Alier et al, 2010).

Even though the frontier and its dynamics and determinants are different, the essence of the issue, as in other political ecology studies, remains one of Environmental Justice. Whereas the State and the illegal organization benefit from the existing status-quo, it is the local populations and the forest upon which they depend for their livelihood that are loosing. Correcting this grave injustice is not easy as there are strong political-economic forces and interests at play. Hopefully, studies like this, which reinforce the documentation of the social and environmental effects of the war on drugs for local places and people, can mount pressure for a real public debate on the social and environmental costs of the policy, and provide fodder to those who are arguing for alternative approaches and justice to be given. (Defensoria del Pueblo, 2007)

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