PART 2. ENVIRONMENTAL EFFECTS OF ILLICIT DRUG CULTIVATION AND PROCESSING

THE ENVIRONMENTAL EFFECTS OF ILLICIT DRUG CULTIVATION AND PROCESSING

This chapter is based on a report commissioned by the Research and Analysis Section of the United Nations Office on Drugs and Crime (UNODC) to the UNEP World Conservation Monitoring Centre. The report is a desk study intended to aid UNODC in understanding the status of knowledge on the environmental impact of illegal drug production and manufacture in the Andean region. This chapter focuses on the environmental effects of illicit drug cultivation in Colombia, Peru and Bolivia and provides a summary of knowledge on coca cultivation and its impact on forests, rivers, and groundwater. It also summarises the known impact on protected areas and biodiversity in the region, and includes some new spatial analyses. The effects of illicit drug cultivation on local people and of eradication measures are also briefly covered.

Deforestation and illicit crops

The most obvious environmental effect of coca and opium poppy cultivation is the clearance of forests. This section first gives an overview of the forest types and their extent in Colombia, Peru and Bolivia, as the context for an analysis of the relative importance of coca and opium cultivation in deforestation. This analysis includes an examination of the dynamics of coca cultivation as part of other agricultural activities and socio-economic factors, such as eradication, lawlessness and colonisation policies.

The natural environments of the Andean region have been classified into seven major biomes, or types of vegetation (Table 4). The illicit drug crops of opium poppy, coca and marijuana are all grown in the wet or humid forest biomes. Coca is principally grown in lowland and lower-montane regions, from sea level up to 2,000 m altitude. Opium poppy is usually grown at higher altitudes, from 1,000 m to 3,500 meters above sea leavel (m.a.s.l.), and so affects lower and upper montane forest areas, which include the tropical cloud forests.

Table 4: Biomes of the Andean region and illicit crops

Biomes of the Andean region	Illicit crops cultivated
1.a) Tropical and subtropical wet forests. Include tropical 1.b) Wet forest in lowlands up to 600 m.a.s.l.; tropical montane forests (600 to 1200 m.a.s.l) and tropical cloud forests (1200 to 2000 m.a.s.l.)	Poppy, coca
2. Tropical and subtropical dry forests	
3. Grasslands, savannas, tropical and subtropical shrubs	Coca
4. Seasonally-flooded savannas and grasslands	
5. Grasslands and shrubs: *punas* in the drier and *paramos* in the wetter areas	Poppy
6.Deserts and xerophytic shrubs	
7.Mangroves	Coca

Source: UNEP & Comunidad Andina (2003). The crops cultivated in each biome have been compiled by this review.

The lowland and montane forests form a major part of the natural resources of Colombia, Peru and Bolivia, still covering 48 to 58% of these countries. Deforestation rates are calculated by the relevant national forest agencies and compiled by FAO. The latest available figures are for the period 1990 to 2000 and show significant rates of deforestation. Differences between figures from different sources are due to differences in the methodologies used for forest definition and measurement.

Table 5: Forest Coverage Indicators in the Andean region for 1997

Country	Forest Area (ha)	Forest ha per capita	Natural forest/ total land	Annual changes in forest cover (ha)
Bolivia	49 670 000	6.5	48.6%	-581 000
Peru	67 562 000	2.8	58.9%	-217 000
Colombia	52 988 000	1.5	49.1%	-262 000

Source: FAO (1997); UNEP & Comunidad Andina (2003).

Table 6: Forest cover & change 1990 - 2000 in the Andean region

Country	Forest cover	Forest cover change 1990-2000	
	(ha)	(ha/year)	(%/year)
Bolivia	53 068 062	-161 075	-0.3
Peru	65 215 364	-268 794	-0.4
Colombia	49 601 300	-190 470	-0.4

Source: FAO (2000)

For Colombia, a more detailed analysis of the extent of clearance of forest and reduction in area of other biomes is available. This shows that whilst the tropical wet forests ('rain forests') are the largest biome, covering over 32 million hectares in 1998, over 11 million hectares have been lost. The Sub-Andean and Andean forests have lost 69 to 76% of their original cover. These are favoured areas for the production of coca and opium, but have also been the most densely populated parts of the country for centuries.

Forest logging and establishment of new coca fields in mountain areas, Antioquia and Bolivar department, Colombia

Table 7: Alteration of biomes in Colombia, 1998

Ecosystems	Original area (ha)	Area (1998) ha	Current (%)	Illicit crop cultivation
Tropical wet forests	44 050 000	32 316 500	73	coca, opium
Tropical dry forest	5 822 000	168 500	3	
Sub-Andean forests (<1000m)	9 652 050	3 035 000	31	coca
Andean forests (1000 – 2000 m)	10 359 325	2 437 500	24	coca, opium
Wet high-Andean forests (>2000 m)	8 114 500	3 382 000	42	opium
Orinoquian Savannas	13 500 000	12 714 500	94	?
Caribbean Savannas	750 000	416 000	55	
Amazonian Savannas	807 500	807 500	100	?
Amazonian hills and shrub forests	2 555 575	2 555 575	100	?
Semiarid forests and shrubs	375 500	350 500	93	
Arid Shrubs	709 750	685 000	97	
Andean dry forests and shrubs*	2 255 000	1 198 500	53	
Caatingas (Amazonia)	2 805 000	2 805 000	100	
Alluvial TWF*	7 327 150	5 210 000	71	
Flooded forests and shrubs	2 377 950	990 000	42	
Andean wetlands*	29 000	17 000	58	
Mangroves	585 000	501 000	86	
Paramos and Sub-paramo*	1 622 000	1 381 000	85	opium
* Ecosystems very degraded in several areas				

Source: Adapted from Etter and Wyngaarden (1999).

Coca cultivation is, of course, only one factor in deforestation in Colombia, Peru and Bolivia. The clearance of forests is driven by a complex set of factors, ranging from the decisions of local people and government, commercial enterprises, national and international governmental policies to market forces.

The relative role of coca cultivation and eradication activities in deforestation varies between countries and regions. Unfortunately, UNODC is not aware of a quantitative analysis of the relative importance of the factors causing deforestation in the region. Much of the literature on the environmental effects of illicit drug cultivation and processing in the region asserts that the cultivation of illegal drugs has caused the deforestation of tens of thousands or even millions of hectares. These statements are, however, rarely supported by specific studies of the role of illegal drugs in deforestation.

Colombia

Although there are several estimates of the area deforested in Colombia as a result of coca cultivation, these estimates are usually based on extrapolations from the area of coca crops, rather than specific surveys of forest loss due to coca. Several authors refer to an estimate of 425,600 hectares of accumulated deforested areas between 1987 and 1998, produced by Bernal (2002). This is based on a calculation of the estimated annual accumulation in area of coca cultivation multiplied by four.

This ratio has been cited widely, but there is no explanation of how it was determined. An alternative estimate suggests that for each hectare of coca, another hectare of forest is cleared (Thoumi, 2001). Again, it is not clear how this ratio was calculated.

It is not valid to simply extrapolate the area deforested from annual figures of area of coca crops, as new coca plots may be established on existing agricultural land or secondary forest (cleared forest in the process of regeneration).

Clearly, the deforestation caused by illicit crop cultivation is not limited to the area planted with illicit crops, as forest is also cleared for subsistence crops, cattle pasture and housing, and in some cases for airstrips. In any individual case, the ratio of forest cleared will depend on local conditions, the agricultural system in use and the type of producer (small, medium or industrial). The area of forest cleared for coca will be much greater where growers have moved to a new region, compared to that seen in already settled lands.

Coca fields in the Sierra Nevada region, Colombia

Álvarez (2002b) states that:

"It would be safe to assume that at least 60% of illicit crops are grown in newly deforested land, that growers clear at least twice the surface of deforestation, and that area under illicit crops is not cumulative due to eradication".

From the 101,800 hectares of coca and 7,466 hectares of opium poppy cultivation reported in 1998, using these assumptions, Álvarez (2002b) estimated that 131,119 hectares of forest were cleared for illicit crops and associated activities in 1998.

Diaz-Torres (2002), in his dissertation on the economic and social dynamics surrounding coca cultivation, reports that:

"Between 1974 and 1998, illicit crops have brought direct devastation to more than 850,000 ha of forest in Colombia" (Defensoria del Pueblo, 2000 in Diaz-Torres, 2002).

Juan Mayr, a former Colombian Minister of Environment (1998-2002), suggested in a workshop on environment, illicit crops and alternative development (September 2000) that a million hectares of native forests had been eliminated as consequence of the cultivation of illicit crops.

The only data source which gives a reliable figure for the area of primary forest loss due to coca cultivation is the annual UNODC coca cultivation surveys for the years 2001 to 2005 (UNODC Colombia, 2002; 2003; 2004; 2005). These surveys provide calculations of not only the area under coca cultivation, but also the land use converted to coca, areas abandoned and newly cultivated each year. The surveys are produced from satellite data and ground truthing. Table 8 shows the extent of new, stable and abandoned coca plots for the four years from 2000 to 2004. The total area under coca is slightly less than the national totals in the UNODC reports because of areas classified as 'uncertain changes and corrections'.

Many coca plots are abandoned each year to evade eradication. One of the consequence is that new plots are established in other areas, although the extent to which new plots are made by new farmers or by existing farmers responding to eradication measures is unknown. Another indicator of the high mobility of coca cultivation and the short life of coca plots is the area of plots under coca cultivation in the 2003 period that were also cultivated in 2000 - only about 2,085 hectares, just 2% of the area under cultivation in 2003 (UNODC Colombia, 2004).

The area of new coca plots established each year has steadily decreased from a peak of 102,650 hectares in 2000 -2001 to 47,068 hectares in 2003 - 2004. This is a decrease from 71% to 59% of the total area in coca cultivation each year. In contrast, the area of stable coca plots from one year to the next had returned in 2003 – 2004 to virtually the same as that in 2000 - 2001, at 33 281 hectares, after dropping to 11,558 hectares in 2002 - 2003. This increase in stability, along with the reduction of the area of land abandoned from coca cultivation in that period to 53,068 hectares, compared to 121,099 hectares two years earlier, could indicate that eradication was less effective in 2003 – 2004. However, the continued reduction in the total and new area of coca plots in 2003 - 2004 indicates that the disincentive measures for coca cultivation are having an impact on behaviour.

UNODC data are also available for a more detailed classification of the areas under coca for the period 2000 to 2004. These data, based on comprehensive analysis of remote sensing imagery, enable the first calculations of the extent of deforestation for coca cultivation and analysis of the dynamics of associated land use. They estimate the areas of primary forest, secondary forest and other vegetation (grassland and crops) converted to coca in each year over this period. Land no longer cultivated for coca is classified as either abandoned to regenerate to (secondary) forest, or converted to other land uses. The large areas of land for which land use changes are uncertain and corrections have been made should be noted when drawing on this data.

Table 8: Extent of stable, new and abandoned coca plots in Colombia (ha), 2000-2004

	2000-2001	2001-2002	2002-2003	2003-2004
Stable coca area	33 419	15 229	11 558	33 281
New coca plantings	102 650	79 239	67 325	47 068
Coca to other land use	117 681	121 099	79 152	53 068
TOTAL	253 750	215 567	158 035	133 417
Total coca cultivation	145 000	102 000	86 000	80 000

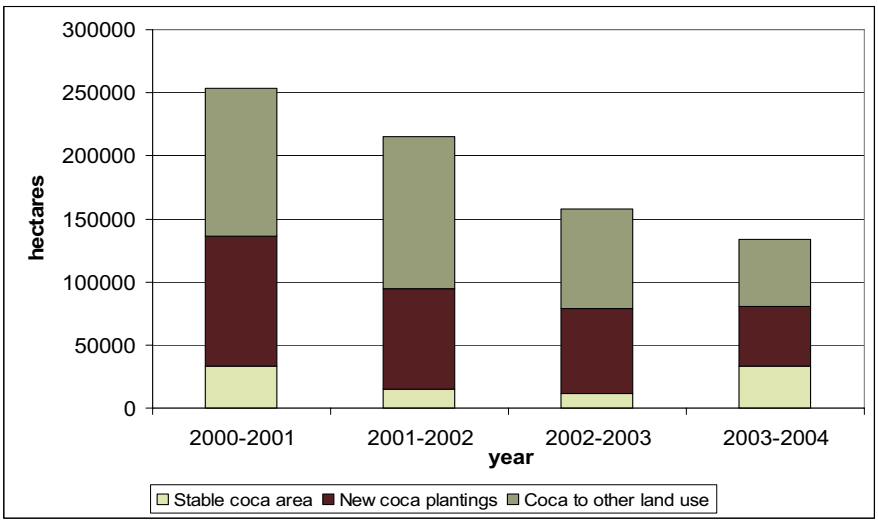
Source: (UNODC Colombia, 2002; 2003; 2004; 2005)

These data (Figure 11) estimate that over the four years from 2000 to 2004, a total of 97,622 hectares of primary forest was converted to coca cultivations in Colombia. The annual loss of primary forest was similar in 2000-2001 and 2001-2002 at about 34,000 hectares, but decreased by over 50% to 16,017 hectares converted in 2002-2003. This decrease continued in 2003-2004 to 13 202 hectares, which is only 39% of the area in 2000-2001. The high percentage of 20% of the converted land area that was classified as 'uncertain changes and corrections' in 2002-2003 should be noted.

Over the four year period of 2000 to 2004 the annual percentages of coca cultivation on land cleared from primary forest were 25%, 37%, 20% and 20%, with an average of 26%. The percentage of coca cultivation on land cleared from secondary forest, grassland and crops was

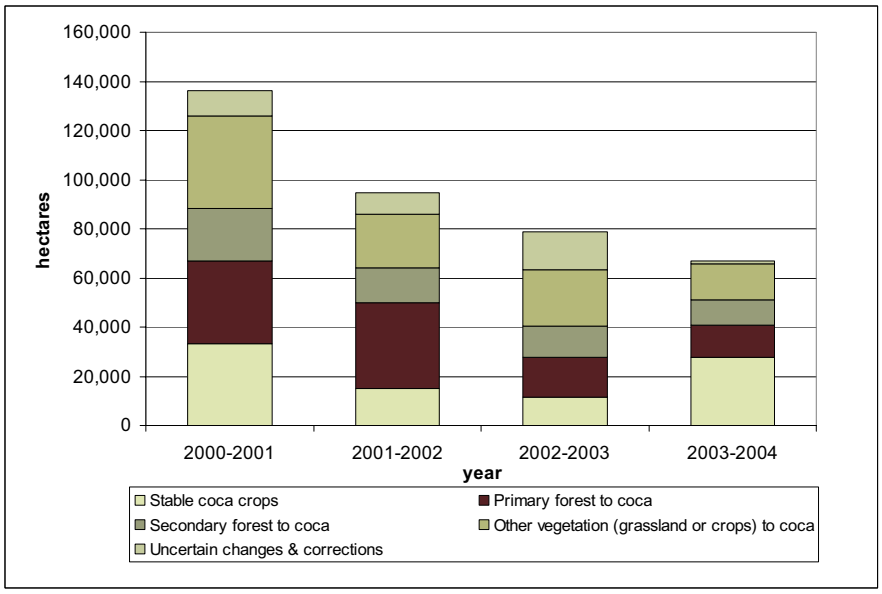
43%, 38%, 45% and 37% respectively over the same period. Thus, the ratio of new coca plots established from primary forest compared to plots established from other land uses varied from 1:1.7 to 1:1.0 to 1:2.2 to 1:1.9 over these four years. New coca plots were as least as likely to be established on areas other than primary forest in 2001-2002, and much more likely to be on land other than primary forest in the other three years.

Figure 11: Extent of stable, new and abandoned coca plots in Colombia (ha), 2000-2004



Source: (UNODC Colombia, 2002; 2003; 2004; 2005)

Figure 12: Land use converted to coca in Colombia (ha), 2000-2004

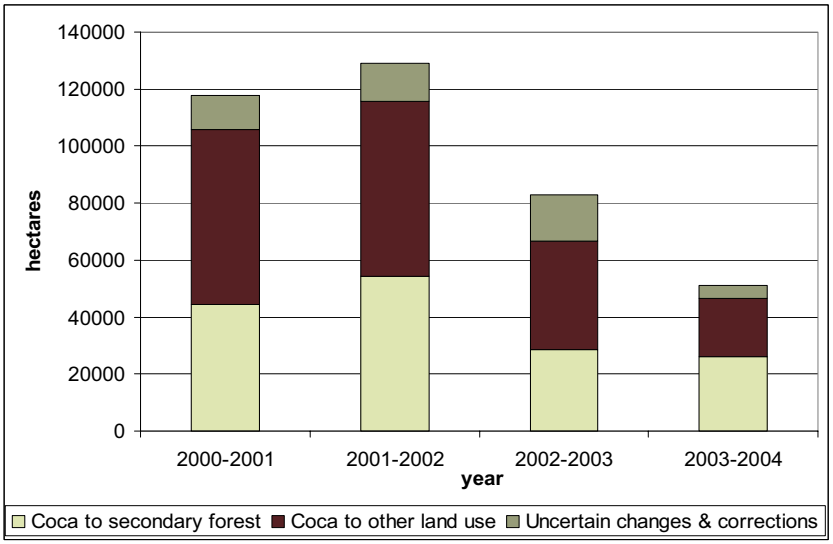


Source: (UNODC Colombia, 2005)

The data on total reduction of forest cover over Colombia and that on losses resulting from coca cultivation span different periods of time, so only rough comparisons of the two can be made. It is likely that several hundred thousand hectares of forest were cleared due to the direct and indirect effects of coca cultivation prior to 2000, before UNODC estimates from remote sensed data were available. Forest cover change in Colombia for the period 1990 – 2000 is estimated at –190,470 hectares per year. If this rate was assumed to have continued from 2000 to 2004, the total area deforested in those four years would have been 761,880 hectares, of which the 97,622 hectares of primary forest identified as converted to coca cultivations in this period would form 13%. As already noted, the actual of primary forest cleared due to coca cultivation is greater than the area

being directly cultivated for this purpose, because of the other crops and activities of the farmers including the opening of roads and airstrips for transport of coca products.

Figure 13: Land use of abandoned coca plots in Colombia (ha), 2000-2004



Source: (UNODC Colombia, 2005)

Two studies of particular regions of Colombia provide insights to the relative importance of coca cultivation in deforestation processes. Viña *et al*. (2004) used satellite data to analyse land cover change along a portion of the Colombia-Ecuador border, where coca cultivation is widespread. Ramos and Ramos (2002) analysed the environmental impacts resulting from coca crops and the coca laboratories in the municipality of Tibú, in the northeast of Colombia.

The Viña *et al*. (2004) study area consisted of the Putumayo Department of Colombia and the province of Sucumbios in Ecuador, where the natural vegetation is lowland tropical rain forest. During the early 1980s, coca cultivation appeared in the Department of Putumayo. By 2000, the Department hosted 41% (66,022 hectares) of the national total of coca cultivation. Eradication measures had reduced the area to 4,386 hectares by 2004 (UNODC Colombia, 2005). Viña *et al*. (2004) analysed three dates of Landsat imagery for the 23 year period from 1973, 1985 and 1996 and the following quotations are from their paper:

"*Between 1973 and 1996, the forest landscape of the entire study area was transformed by the land-use practices of the local people who responded to multi-scale social and economic forces. The Colombian side showed a forest-cover reduction of approximately 43%, while the Ecuadorian side showed a forest-cover reduction of half that value (approximately 22%).*"

"*Between 1973 and 1985, the replacement of forested areas with agricultural lands was the most predominant land-cover change observed. Most of this change corresponded to a replacement of forests by pastures for cattle grazing, although cropland areas also constitute an important component. Between 1985 and 1996 the increment in barren lands is the most conspicuous type of land-cover change observed, particularly on the Colombian side, where these areas almost doubled those of agricultural lands. This pattern may reflect a settler's tendency to abandon already established agricultural areas and to colonize new forest areas. Forest regeneration was also very conspicuous in the Colombian side of the study area, although most of the abandoned agricultural areas did not experience forest recovery, and were converted to barren lands.*"

"*Rates of deforestation on the Colombian side during the 1973 – 1985 period may be directly associated to colonization pressures induced mainly by the intensification of oil-industry operations. This conclusion does not seem valid for the 1985 - 1996 period, since the rate of population growth during this time showed a significant reduction, while population rates increased. We suggest that during this period, deforestation was directly related to coca cultivation. The areas under the illegal crop increased drastically in the second half of the 1980s,*

responding to both increase in the international market for illegal drugs and in increase in lawlessness and political instability in Colombia."

"*Road construction was a dominant feature in the government-sanctioned colonization process on the Ecuadorian side of the border. Approximately 90% of the areas deforested between 1973 and 1996 on the Ecuadorian side occurred within a 5 km buffer area either side of a road. Only 30% of the deforestation on the Colombian side occurred within the 5 km buffer area [...] This difference can also be explained by the predominance of coca cultivation on the Colombian side of the border. Due to its illegal nature, areas planted with coca are usually placed in regions that are remote and inaccessible; thus they are located preferably in areas recently cleared of forests and isolated from already established cropland areas, as well as distant from roads and other penetration routes (e.g. rivers)."*

Ramos and Ramos (2002) analysed satellite images for the years 1999-2001, which had been interpreted as part of the UNODC-Government of Colombia SIMCI (*Sistema Integrado de Monitoreo de Cultivos Ilicitos*) project, to determine land use change in the municipality of Tibú. The municipality has an area of about 236,460 hectares. Coca cultivation started in the area in the late 1980s. Table 9 shows the distribution of different land uses in Tibú for 1999, 2000 and 2001.

Table 9: Land use in the Municipality of Tibú for 1999, 2000 and 2001

Land use	Area (ha)		
	1999	2000	2001
Coca cultivation	10 143	3 533	10 390
Primary forest	122 279	118 923	77 870
Secondary forest, scrub	55 605	81 242	90 602
Pasture, low vegetation	41 422	43 627	76 100
Water bodies	3 217	4 764	4 209
Sand banks	-	177	274
Other crops	49	9	-
Clouds and shadows	1 333	9 563	5 280
Roads and urban zones	2 325	1 471	1 985
Bare soil	88	1 287	1 491

Source: Ramos & Ramos 2002

The area of coca cultivation decreased by 65% between 1999 and 2000 due to aerial eradication measures, but had recovered to the 1999 level a year later. The area of primary forest decreased by 36% of the three year period whilst the area of secondary forest increased by 62%. This is predominantly due to two causes: (1) primary forests are being cleared due to diverse reasons, including an increase in timber extraction, and an increase in the areas of both illicit and licit crops and (2) abandonment of areas with illicit crops, which indicates a high rotation of crops.

Table 10: Areas deforested in the Municipality of Tibú by land cover, 1999-2001

Type of land cover	Area (ha)	%
Primary forest felled for coca cultivation	3 130	4
Secondary forest felled for coca cultivation	1 371	2
Primary forest felled for non-coca use	19 636	28
Secondary forest felled for non-coca use	14 830	21
Degraded primary forest	32 081	45

Source: Ramos & Ramos 2002

The loss of primary and secondary forest between 1999 and 2001 in Tibú was principally caused by the establishment of non-coca land uses. However:

"Analysis of the mobility of land covers indicates that the principal agent driving the establishment of these coverages is coca cultivation. The tendency is for primary forest to be converted to coca […], to be later transformed from secondary forest to other land uses. It can be concluded that the forest cover replaced directly by coca in the period of analysis is of 0.5 ha of forest for 1 ha of coca cultivated" (Ramos & Ramos, 2002).

"It is noteworthy that 86% of the affected primary forests are converted to land covers other than coca. This indicates that rather than resulting from operations for forestry purposes, forest deterioration is related to the establishment of communities in the area. The social conditions of the area mean that this process of colonization is disorderly and generates additional social and environmental impacts. The development of coca cultivation gives some economic sustainability to the local population, which permits them to pay for the labour of expansion and ownership of the land. This colonization behaviour is different from other regions of the country, where the cultivation of coca is characterised by a high dynamic of abandonment and planting, which leads to the presence of forests in different states of succession" (Ramos & Ramos, 2002).

The study also examined the rate of forest fragmentation in the Municipality of Tibú, where the number of fragments increased from 15,308 in 1999 to 16,024 in 2001. The average size of fragments decreased from 7,988 hectares in 1999 to 4,860 hectares in 2001. Similarly, the size of the largest fragment decreased by 45% from 33,632 hectares to 15,062 hectares over these three years. It was noteworthy that 81% of the non-forested islands created in the interior of the forest fragments were covered by coca at some point during the study.

"This allows confirmation that the coca fields are the driving force in the process of the loss of forest cover" (Ramos & Ramos, 2002).

The Institute of Environmental Studies in Colombia (IDEAM) is currently developing a pilot study on the effects of coca cultivation in deforestation in the Magdalena Medio region of the Serrania of San Lucas, to assess deforestation indexes resulting from the cultivation of illicit crops in the Forest Reserve. The results from this study were not yet available.

Peru

Coca cultivation has clearly been a significant factor in deforestation processes in the Andean valleys of Peru where it is grown. Young (1996) reports that the establishment of 'hill agriculture' from 1975 in the Huallaga Valley (through colonization) was motivated at least in part by the increasing value of coca leaves. This study has not found any calculations of the area deforested in Peru due to coca cultivation based on the analysis of field data, or even published estimates of the current extent of the country's vegetation types. One deforestation estimate comes from Young (2004a), who states,

"Roughly a third of Peru's deforestation is in places where coca is grown, which would mean 700,000 to 1 million ha of tropical forest cut as a result".

The basis for these figures is not given, but in an earlier paper, Young (1996) agrees with other authors that:

"The area in coca fields must be multiplied many times in order to approximate the total area of degraded pre-montane forest. Thus, by extrapolation, perhaps 500,000 to 1,000,000 ha have been degraded in Peru as a result of conversion to 'hill agriculture".

Young (1996) also reports an estimate from Dourojeanni *et al*. (1989) that deforestation associated with coca in Peru had affected about 700,000 hectares.

The increase of 6,100 hectares in coca cultivation between 2003 and 2004 was mainly in the regions of Alto Huallaga, Apurimac–Ene and La Convencion–Lares (UNODC Peru, 2005), with evidence from the satellite imagery and ground-truthing that this expansion includes deforestation as well as conversion of existing agricultural plots. The types of land use being converted to coca cultivation have not been quantified by UNODC for Peru as they have been for Colombia. An annual increase of 6,100 hectares of coca cultivation could represent a significant level of deforestation at the local and regional scales for the pre-montane humid forests where it occurs,

but is a small fraction of the national mean deforestation rate of 268,794 hectares reported by FAO for 1990 - 2000 (FAO, 2000).

Young (2004b) concludes that:

"What coca/cocaine has done as an economic and social phenomenon is to provide the financial means and motives for deforestation. It has also inverted typical spatial expectations of deforestation. [Typically] people tend to [first] clear forests near roads and choose first the flattest lands with the best soils. This logic is reversed with coca/cocaine: The best coca fields are those that are most inaccessible to narcotic control efforts, that is, on isolated sites in hilly areas. Thus, coca-related deforestation affects forests that otherwise would not have been attractive to colonists."

The same review also reports the effect of coca fields causing forest fragmentation, as small plots within forests create patchwork landscapes with considerable forest edge that is unfavourable for the survival of many species.

Bolivia

This study has not identified any national scale estimates of the area deforested in Bolivia due to coca cultivation based on the analysis of field data, but some detailed studies have been conducted for the Chapare region. Steininger *et al*. (2000b) calculated the rate of tropical deforestation in the Amazonian lowland moist forest zone of Bolivia (>1000 mm/yr precipitation and below 1500 m elevation). 152,900 hectares/yr of forest was lost from 1985 – 1986 to 1992 – 1994. They reported that:

"*Roadside deforestation has expanded most quickly in the Chapare municipality of Cochabamba, where clearance for traditional crops and coca have reached from the highway to the Andean foothills. Continued expansion in this area threatens to completely isolate over 4000 km^2 of foothill and montane forest from all neighbouring lowland forest."*

According to Salm and Liberman (1997), between 1985 and 1990, around 260 000 hectares of primary forest were deforested in the Chapare region as part of the colonization process. Much lower figures of primary forest loss in Chapare for this period were calculated by Henkel (1995), from an analysis of Landsat satellite imagery to determine the rate and area of primary and secondary forest conversion for the Chapare region from 1978 to 1990. During this period coca cultivation increased from approximately 15,000 hectares to 61,000 hectares. This analysis found that approximately 1,000 to 2,000 hectares per year of primary forest and 3,000 to 5,000 hectares of secondary forest were converted to cultivation during this period. It was concluded that:

"*Although this loss is significant, when compared with loss of primary forest during the 1960s and 1970s, when the Bolivian government built roads to and within the Chapare and promoted colonization of this region, it is relatively small. During the period 1960 – 1978, 202 000 ha of land were allocated to incoming colonists. Virtually all of this land had been cleared and cultivated by 1978. At that time, vast areas of the older settled zones has been farmed out, and colonists had begun to move inland to occupy and clear new forest lands" (Henkel, 1995).*

The analysis estimated that approximately 45,000 hectares of new coca were planted between 1978 and 1990, of which 25,000 – 30,000 hectares came from secondary forest, 4,000 – 5,000 hectares from converting other cropland, and 8,000 – 10,000 hectares from converting primary forest remnants in settled areas:

"*The advantage to converting existing cropland and secondary forest to coca in the older settled areas is one of accessibility. [In existing cultivated areas,] a well-developed road network already existed, whereby coca leaves and chemicals could be moved easily to processing sites. Also, the large numbers of labourers needed to produce, harvest, and process the leaves into coca paste preferred to live and work in the areas of established settlement, rather than on new coca farms in more remote areas. Moreover, the Bolivian government has attempted to restrict land occupancy in the tropical forests around the fringes of Chapare. The 8 000 to 10 000 ha of primary forest converted to coca came from clearing most of the remaining areas in primary forest on farms in the old settled areas. Virtually all the primary forest in the old settled region of Chapare had been cleared and placed in coca cultivation by 1990" (Henkel, 1995).*

Bradley (2005) has also analysed impacts of coca cultivation on land-use and land-cover change in the Chapare region, using satellite imagery from 1975 to 2000, participatory rural appraisal and socio-economic data. Three communities were studied: Arequipa, dominated by coca production and alternative development crops; Bogotá, a cattle rearing community; and Caracas, where fruit cultivation dominated. Three major periods were determined from a land-management synopsis in each community:

(i) pre-coca dominant, driven by weak national policies and economics, with high rates of deforestation;

(ii) coca-dominant, influenced by the international coca / cocaine economy, with the lowest rates of forest clearance; and

(iii) post coca-dominant, driven by strong international anti-narcotics policies, when forest clearance accelerated again.

Bradley (2005) reported that the deforestation trajectories (rates) in his study differ from published models. The variations are attributed to the rising dominance of coca being ascended by an enforced substitute economy. Specific fragmentation patterns developed because of the spatial arrangement of plots planned in the 1960s and the subsequent variation in land-use management strategies between, as well as, within individual plots over time. Bradley concludes that:

"Overall, in the pursuit of global social gains, anti-narcotics policies caused rates of forest clearance to increase in Chapare and because of non-conservationist planning, the connectivity between montane and humid tropical forests at the margins of a biodiversity hotspot is severely compromised".

More detailed information on deforestation rates and driving forces from this study are in progress, but were not available in time for this report.

Henkel (1995) also considered the role of the productivity of coca plantations and coca eradication policies in Chapare on deforestation. The data sources for his analysis of the changes in the farming system and its productivity are not given, but the conclusions are consistent with other studies such as Bradley (2005). Henkel (1995) stated:

"The ability of farmers to make a living from 1 ha of coca and 1 ha of food crops has greatly reduced the pressure on the land resources of Chapare. The monocultivation of coca, a crop that lasts 15 to 20 years, requires much less land than the old system of agriculture, which resulted in the clearing of extensive areas of primary forest to grow rice, maize, and bananas for cash crops. Most of the primary forests of the Chapare had been cleared during the 1960s and 1970s, so very little primary forest habitat was destroyed because of increases in coca cultivation during the 1980s."

Henkel (1995) predicted that coca eradication and crop substitution programmes would increase deforestation, because:

"Of the farms of the Chapare, approximately 80% are less than 10 ha in size, too small to support a family under the agricultural systems and cropping combinations proposed by crop substitution programmes. To create viable systems of agriculture to replace coca, farmers would have to be able to increase farm size to at least 20 ha. Thus large numbers of farmers would have to be moved out of the Chapare or additional land now in primary forest would have to be opened to agriculture".

This prediction of increased forest clearance appears to have been supported by the findings of Bradley (2005). UNODC recognized that although there is a reduction in coca cultivation in some regions such as Puerto Villarroel (Chapare), the increase in other areas such as Tiraque, Chimore and Totora could be a knock-on result:

"This pressure for eradication may have pushed farmers to plant coca in more remote areas" (UNODC Bolivia, 2004).

UNODC Bolivia (2005) reports new coca plots being established in areas of primary forest in the Chapare and Yungas regions.

Preparation of coca fields in the Yungas, Bolivia

Illicit drug cultivation and processing impacts on soils and water sources

The effects on soils of illicit drug production and eradication are not well studied. Little information could be found for Colombia or Peru, but some field research has been carried out in Bolivia. For Peru, Dourojeanni (1992) reviews the impact of coca cultivation on soil erosion. Cultivation is in areas described as humid tropical subtropical forest, located between 700 and 2,000 m.a.s.l., where the rainfall ranges between 1,000 to 4,200 mm / year. The growers prefer steep slopes with soils are of sandy clay texture because they provide good drainage. Control of weeds and frequent harvesting result in bare soil, which can increase erosion, especially on slopes:

"The highly erosive character of coca is due to the ecological regions where it is planted and the current cultivation practices" (Dourojeanni, 1992).

For Bolivia, Salm and Liberman (1997) describe traditional techniques used for soil preparation and the terrace cultivation techniques of coca, which provide protection against erosion and maximise the use of rainfall. However, Henkel (1995) reported a study of the effects of coca cultivation on soil fertility in abandoned coca fields in Chapare. The soils were very low in organic matter, nitrogen, phosphorous and other nutrients, and very high in acidity and aluminium toxicity (Table 11). This makes colonisation by other plant species difficult. Low levels of organic matter diminish retention of moisture; low levels of nutrients limit the growth of emergent species and high concentrations of aluminium and acidity favour only tolerant species.

The main difference between cultivation in the Las Yungas and Chapare regions of Bolivia is that traditional soil-protection measures such as terraces are absent in Chapare. This may be the cause for quicker degradation of soils in Chapare and the *cocales*' viability limit of 10-15 years (Salm & Liberman, 1997).

Table 11: Effects of coca cultivation on soil fertility in the Chapare Region in Bolivia

Soil characteristic	Virgin forest	Abandoned coca fields
pH	4.8	4.1
Soluble cations	2.05	1.1
Calcium (mEq/100g)	2.1	0.08
Potassium (mEq/100g)	1.69	0.60
Magnesium (mEq/100g)	0.22	0.03
Sodium (mEq/100g)	6.8	1.3
Phosphorous (ppm)	4.6	7.4
Acidity (mEq/100g)	3.6	4.9
Organic material (%)	6.7	2.4

Source: Henkel, 1995.

In Colombia, coca farmers do not use traditional cultivation methods as in parts of Peru and Bolivia, as coca cultivation is mostly for cocaine production. Coca growers are frequently people displaced from other areas, with no knowledge of local and traditional agricultural activities. Their main goal is to maximise the harvest rather than to maintain long-term soil productivity.

Damage to soils resulting from cultivation and elimination of the natural vegetation is widely reported in reference to the environmental impacts of illicit drug cultivation, as are the likely effects of the discharge of the chemical wastes from coca processing to soils and waterways. However, very little field assessment on the quantity of discharges and their effects on the environment (soils, fauna, flora or water) has been carried out by government agencies or universities. The only analysis found by this study was conducted in Chapare (Bolivia) in 1992 (Southwest Research Associates, 1993, quoted by Henkel, 1995). Here, a study of three cocaine-processing laboratories found that pollution was concentrated in a small area at the processing site. Most chemicals were disposed of in holding ponds constructed for the purpose and were not dumped into nearby streams. Chemical spills at the site were quickly diluted by the high rainfall received in the region. Because coca processing sites are widely scattered in the Chapare, pollution is widely dispersed rather than concentrated at a few large sites. Some loss of soil microorganisms was noted, but no damage to wildlife, vegetation, fish species or bird life was detected near the processing laboratories. However, the study did not assess the long-term effects of pollution.

For Colombia, DNE (2002) states that the agrochemicals used in coca processing are capable of polluting freshwater sources for human consumption, but no specific cases of this are given. Ramos and Ramos (2002) provide an assessment of the toxicity and environmental risk of five agrochemicals used in the production of coca in Colombia – the herbicides Anikalmina, Glyphosate, Paraquat, and the insecticides Tamaron and Manzate. These descriptions include their recorded half-life in soils and water. No field data are included.

In the Huallaga Valley, Peru's leading cocaine production zone, 28 of the 180 rivers had reached the critical state by last year, warned Alex González, of the non-governmental organization 'Alternativa Verde' (Green Alternative).

"In all the area's rivers there was a great deal of contamination and in those where the damage was most serious, valuable species of flora and fauna had disappeared, and even the surviving species showed signs of genetic deterioration," González affirmed.

"The waters that used to be a crystal-clear source of life acquired a reddish, dead hue. And in the rivers, fish were found with deformed spines and other anomalies," added the expert. Comprehensive studies are not yet available, but it is estimated, based on global levels of coca paste outputs, that thousands of tons of chemical waste are dumped into the Peruvian Amazon region's rivers each year.

Contradrogas research in the areas where basic cocaine paste is produced reveals highly contaminated areas along the jungle rivers Bocaz, Cacazú, Ene, Perené and Panga.

Repressive actions against paste production must also seek to eliminate its negative effects on the environment, Batallanos stressed.

The Peruvian health directorate's office of water resources assures, for its part, that it has not yet detected any impact of the polluted water on human health, though its officials acknowledge that the contamination is a risk factor.

"Because of its illegal nature, the production of coca paste occurs in isolated and unpopulated areas. The lack of a riverside population in those regions has meant we have not been able to detect specific cases of poisoning," explained Fausto Roncal, head of the water resources division.

"The water currents carry everything downstream, such that the contamination is most lethal for plant and animal species living in the aquatic environment," Roncal explained. (quoted from http://www.tierramerica.net/2001/0225/acent.shtml)

Effects of illicit drug cultivation on protected areas

Many protected areas in the region have been affected by illicit drug cultivation. As well as the direct effects of deforestation, the presence of illegal settlers, who are often associated with armed groups, can significantly impede the management of the protected areas. These areas have been designated with the intention of conserving the region's biodiversity and associated ecosystem services, so negative impacts on their vegetation represent a serious deviation from national policy.

National Park Puinawa, Colombia, affected by licit crops

Colombia

Through the SIMCI Project, UNODC and the Government of Colombia have monitored the presence of illicit coca crops in Colombian National Parks and provided updated data on extent and trends. UNODC Colombia (2005) reported the presence of 5,400 hectares of coca in 13 of 50 National Parks. This represents about 0.05 % of the country's protected area and 7 % of the total

surface under coca cultivation. Only a few protected areas appear to have experienced severe deforestation. However, the data do not cover opium poppy cultivation in protected areas. Cavelier and Etter (1995) report that the Nevado de Huila National Park and surrounding areas of moist Andean forest has been one of the protected areas most affected by this crop.

Coca cultivation in Colombian National Parks has slightly decreased from 6,057 hectares in 2001 to 5,351 hectares in 2004. This decrease of 21% is less than the 45% decrease in the total area of coca cultivation in Colombia over this period. Within this figure, an increase of 30% in the area of cultivation between 2003 and 2004 is mainly due to better detection of existing coca plots in the Sierra de Macarena National Park in 2004, because of cloud cover on the satellite images for 2003. There are no available data on the mobility of the crops in these areas. It should be noted that aerial eradication of coca has not been allowed in protected areas.

The protected areas located in the lowland rain forest of the Colombian Amazonian region of Sierra La Macarena, Nukak and La Paya are the most affected by coca cultivation, with 2,707 hectares, 1,044 hectares and 230 hectares of coca respectively in 2004. A particularly large increase was observed in the Sierra La Macarena National Park, which is located in the Departments of Meta and Guaviare. On a regional scale, the greatest area of coca cultivation in the country was recorded in these departments, with about 28,509 hectares in 2004 (36% of the national total). This is also the region where the greatest number of new coca plots were identified in 2004, - 9,134 plots, covering 15,827 hectares. Furthermore, about 34,700 hectares of coca was subject to aerial fumigation in the Meta - Guaviare region in 2004.

Table 12: Coca crops in national protected areas in Colombia, 2001-2004

Protected area	Area-Ha 2001	Area-Ha 2002	Variation (02-01)	Area-Ha- 2003	Variation (03-02)	Area-Ha- 2004	Variation (04-03)
Alto Fragua - Indi Wasi	0	16	16	8	-8	12	4
Catatumbo -Bari	72	85	13	129	44	107	-22
Cordillera de los Picacho	243	34	-209	13	-21	15	2
Cocuy	0	0	0	1	1		-1
Tuparro	18	0	-18	0	0		0
Farallones de Cali	62	55	-6	2	-54	1	-1
Paya	640	600	-40	310	-290	230	-80
Katios	3	0	-3	0	0		0
Munchique	21	42	21	1	-41	8	7
Nukak	1 342	1 464	123	1 469	5	1 044	-425
Paramillo	295	48	-247	110	62	461	351
Puinawai	182	108	-73	33	-75	139	106
Sanquianga	6	49	43	7	-42	14	7
S. Chiribiquete	5	2	-3	0	-2		0
S. Macarena	1 618	1 450	-168	1 152	-297	2 707	1 555
S. Nevada de Santa Mart	326	246	-79	212	-34	241	29
Tama	17	0	-17	0	0		0
Tayrona	8	4	-4	4	0	0	-4
Tinigua	1 201	413	-787	340	-73	387	47
Total coca area (ha)	**6 057**	**4 617**	-1 440	**3 790**	-827	**5 351**	1 561

Source: Modified from Projecto SIMCI 2003

Parks with a significant increase in coca crops
Parks with a significant decrease or where coca crops appeared for the first time
Parks in which coca crops have now disappeared
Parks in which coca cultivation fluctuates

Paramillo National Park, located in northern Antioquia and southern Cordoba departments, contains diverse ecosystems including paramo, cloud forest, Andean forest and tropical forests, and suffered an increase from 110 to 461 hectares of coca between 2003 and 2004.

Coca cultivation has fluctuated for the past four years in several Parks. Tinigua National Park in Meta department predominately contains tropical wet forest. Coca cultivation has diminished here to only 30% of the original area, from 1 201 hectares in 2001, to about 400 hectares by 2004. The area of coca in Sierra Nevada de Santa Marta has fluctuated between 326 and 241 hectares in the past four years. Catatumbo-Bari Park, in Norte de Santander Department, is covered by tropical wet forest and Andean forests and has contained about 100 hectares of coca over the last four years.

In some other protected areas, cultivation of coca has diminished significantly or has disappeared since 2001. Examples are Tama in Norte de Santander Department, dominated by Andean forests,

and Tayrona National Park in Magdalena Department, dominated by coastal and marine ecosystems and some tropical dry forest. According to Andrade *et al*. (2004), in an essay on 'forest without law' in Colombia for the National Environmental Forum in 2004, the pressure from illicit drug cultivation on the agricultural frontier has also threatened the following protected areas: Nukak Reserve, Chiribiquete National Park, La Paya National Park (Putumayo) and the Nevado del Huila National Park.

Peru

For the current study, a map of the protected areas in Peru and coca cultivation density in 2004 was produced by the UNODC office in Peru, using data on the coverage of protected areas of Peru obtained by UNEP-WCMC from the Peruvian Instituto Nacional de Recursos Naturales (INRENA). Only two of the 47 protected areas in Peru are currently affected by coca cultivation. Impacts are relatively minor in terms of the area affected and the conservation status of the sites.

Table 13: Protected areas in Peru with coca cultivation in 2004.

Protected area	Coca (ha)
Alexander von Humboldt National Forest	390
Tingo Maria National Park	15
Total	**405**

Source: UNODC and INRENA, 2005.

Of the two areas affected, Alexander von Humboldt National Forest is in the region of Aguaytia, where a total of 500 hectares of coca was recorded in 2004, of which 78% is located in the National Forest. 500 hectares represents only 1% of the national area of cultivation in 2004 (UNODC Peru, 2005). A similar figure of 510 hectares was recorded in Aguaytia in 2003, reduced from about 1,000 hectares in 2001 and 2002. The protected area designation of National Forest is not a strict designation for the conservation of biodiversity or natural features, rather, the goal is forest management and timber production.

Tingo Maria National Park has an area of 4,777 hectares and is located near Haunuco in the south of the Alto Huallaga region. Coca cultivation in the area is reported to lead to an unusual invasive successional vegetation, and to the establishment of a fungus (*seca seca*) that inhibits growth of alternative crops (Fernández-Dávila, 2004). The National Park was described by Young (1996) as:

"...established in 1965, but has never been actively protected and probably no longer serves an important conservation purpose".

Later efforts to improve the conservation situation have been made through the BIOFOR/USAID project, which started in 2000 and whose aims include spreading the initially limited local awareness of the park (Fernández-Dávila, 2004). Local people were involved in developing a Master Plan for conservation and in defining the park's boundaries (including a buffer zone), which had not been especially well established in law.

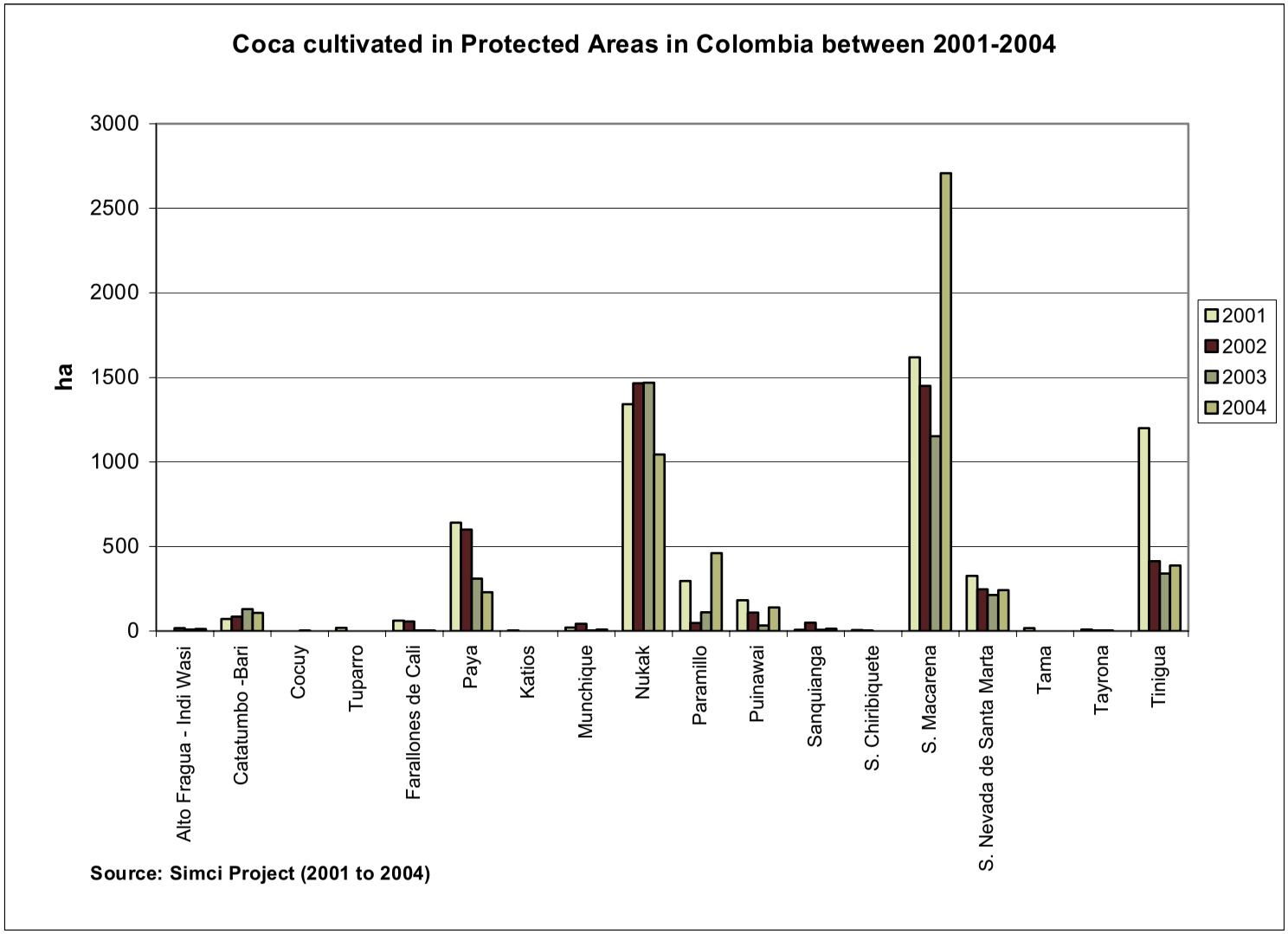
Bolivia

UNODC Bolivia (2005) have analysed the extent of coca cultivation in the protected areas of Bolivia for 2003 and 2004. There are 21 protected areas, including National Parks, in Bolivia, totalling 165,000 km^2, or 15% of the national territory. In 2004, coca cultivation was recorded in three national parks. In Madidi National Park, in the Apolo region, only about 10 hectares of coca cultivation were found. In contrast, 4,100 hectares of coca cultivation was found in the two National Parks of Isiboro Sécure and Carrasco, in the Chapare region. Isiboro Sécure National Park has an area of 1,200,000 hectares and Carrasco National Park covers 694,320 hectares. Both sites protect complex ecosystems of mountain and lowland forests.

Between 2003 and 2004, coca cultivation increased by 71% within the National Parks, from 2,400 hectares to 4 100 hectares. A possible explanation could be that eradication measures in the existing centres of production have led to the planting of new fields in more remote areas.

Between 2003 and 2004, the increase of 1 700 hectares within the National Parks represented 60% of the total (2,800 hectares) increase in Chapare. While coca cultivation increased by 71% within National Parks, it increased only by 22% outside their boundaries. Coca cultivation within Isiboro Sécure and Carrasco National Parks represented 40% of the coca cultivation in Chapare.

Figure 14: Area of coca cultivated in protected areas in Colombia (ha), 2001-2004



Effects of illicit crops on biodiversity

The ecosystems of the northern Andes have been identified by some authors as a global biodiversity conservation priority due to their biological richness, high rates of endemism, complex biogeographical patterns and multiple anthropogenic threats (Olson & Dinerstein, 1997, quoted by Dávalos, 2001; Mittermeier et al, 1998; Stattersfield, 1998). The tropical Andean region is the most species rich and diverse region on Earth, containing, for example, about one sixth of all plant species in less than one percent of the world's land area. Thus, the last remnants of Andean forest are targetted in both national and international conservation agendas (IVH, 1997; WWF, 1996). The abundance of endemic species associated with humid mountain regions at equatorial latitudes reflects the overwhelming effect of mountain geography and climate on the generation and maintenance of regional species richness (Rahbek & Graves, 2001).

The Tropical Andes is home to an estimated 30,000 - 35,000 species of vascular plants, accounting for about 10% of all the world's species and far surpassing the diversity of any other biodiversity hotspot. It is also the world leader in plant endemism, with an estimated 50% (and perhaps 60% or more) of plant species found nowhere else on Earth. This means that nearly seven percent of the world's vascular plants are endemic to the 0.8% of the earth's land area represented by the Tropical Andes.

The Tropical Andes also harbour more than 1 700 bird species, nearly 600 of which are endemic, a level of endemism that is unequalled in the world. 66 bird genera are also endemic.

There are nearly 570 mammal species in the Tropical Andes; about 75 of these are endemic and nearly 70 are threatened. The region also has six endemic genera. Other large mammals found in the area include the woolly or mountain tapir (*Tapirus pinchaque*), which is Endangered according to the IUCN Red List, and the spectacled bear (*Tremarctos ornatus*), the only bear in South America, which is listed as Vulnerable to extinction (IUCN 2004). Both of these highland species are likely to be affected by deforestation for opium poppy cultivation.

More than 600 reptile species have been identified in the Tropical Andes, over 270 of which are endemic, including those belonging to the three endemic genera. This level of endemism is unequalled in the world for this class. The Andes is also the most important region in the world for amphibians in terms of species diversity, with around 980 species and more than 670 endemics. Eight amphibian genera are endemic to the Andes. The most speciose of these is the frog genus *Telmatobius*, with about 45 species. Many other non-endemic genera are highly speciose; the frog genus *Eleutherodactylus* has more than 330 species, of which more than 250 are restricted to the Tropical Andes.

There are more than 375 documented species of freshwater fishes in the Tropical Andes, and it is likely that many more will be found along the Amazonian flanks of the mountains. Of these, more than 130 are endemic.

Lowland Amazonian rain forests also contain very high levels of species richness. Lowland species often have more widespread distributions than those of the mountain regions, so are less likely to be threatened with extinction as a result of an equal area of deforestation.

The most important effect of illicit crop cultivation on biodiversity is the loss, fragmentation and degradation of forest habitat. Complex ecological impacts have been reported wherever tropical deforestation is studied (e.g. Cosson *et al*., 1999; Goosem, 2002; Laurance, *et al*., 1997). However, there are very few Andean field data on biodiversity impacts (Fjeldsa *et al.,* 2005). Only one relevant site-specific study was found, in which:

"Thickets and forest fragments in the principal coca-growing district in the middle Huallaga valley in Peru had a very impoverished avifauna – with almost total lack of genuine forest species and potential game birds (Schellerup, cited in Fjeldsa et al., 2005).

A summary of the many effects of tropical deforestation and fragmentation on habitat degradation is given in Steininger *et al*. (2001a). These effects include structural changes in forests near clearing edges, such as increased tree mortality and large differences in temperature and humidity. This leads to an increased potential for fire and a change in the regeneration niche, favouring pioneer tree species over core forest species. Changes in faunal composition and reductions in diversity have been recorded in forest fragments smaller than 5 km^2. The composition of fauna such as leaf-litter insects, butterflies

and birds is affected as much as 250 m from clearing edges. These responses to small patch size and edges are highly species-specific, with the range of edge effects varying from 50 to 250 m. Hunting extends such effects up to 10 km into a forest.

As well as the direct habitat loss, wild animals are also affected by hunting by farmers for food and perhaps for sale in local markets. Even light hunting pressures on large bird and mammal species in tropical forests can have significant effects on forest ecology and structure (Robinson & Redford, 1994). Furthermore, Henkel (1995) found that with the arrival of coca processing in the Chapare region of Bolivia, wildlife was smuggled on the narcotrafficking planes, involving mainly monkeys, reptiles and birds, as well as other species hunted by for their skins. This has been the only report of this trade, but it could well be happening in Peru and Colombia too.

The contamination of soils and water, from agrochemicals used in the production and eradication of the crops and the chemicals for processing the products, are also likely to have significant local and downstream impacts on biodiversity, but these have not been quantified.

Our knowledge of the impacts of illicit crops on biodiversity in the Andean region includes some analyses of the distribution of birds in relation to coca cultivation and a few records from some sites, but almost no site-level research. Here follows a summary of the findings of sites and species identified as being affected in Colombia, Peru and Bolivia. Most conclusions are based on two regional analyses and an analysis of priority sites for conservation in Peru.

One regional analysis was carried out by Fjeldsa *et al.* (2005), mapping on priority areas for biodiversity conservation, based on the distribution of bird species in relation to areas with armed conflicts and coca cultivation. They report that Andean areas with illicit crops overlap the distribution of 1,950 bird species (67.3% of all South American resident land birds). Illicit crops are produced through the entire range of variation in species richness and endemism in the Andean region, except for the most species-poor parts.

Areas with high richness and high endemism are often identified as priorities for biodiversity conservation. 39% of such grid cells in the Fjeldsa *et al*. (2005) analysis overlap by more than 20% with coca growing areas. This compares with 20.4% of grid cells in the areas with low richness and high endemism, 5.2% in areas where there are high richness and low endemism, and 8.2% in areas with low richness and low endemism. Very similar patterns would emerge if bird species endemism was replaced with numbers of threatened species (Fjeldsa *et al.* 2005).

A further regional analysis was conducted for the present study with the assistance of the UNODC office in Peru, to identify those Important Bird Areas (IBAs) in the Andean region in which coca cultivation was recorded in 2004. IBAs are sites identified according to standard criteria, which hold significant numbers of one or more globally threatened bird species and/or are one of a set of sites that hold a suite of restricted-range species or biome-restricted species (Birdlife International, 2005c). An analysis of the 455 IBAs of the tropical Andes has just been published (Birdlife International, 2005b; CI, 2005) and identifies a set of protected and unprotected sites of importance for biodiversity conservation. The IBA boundaries were overlaid with the distribution of coca cultivation in 2004 to estimate the area planted in each IBA.

Colombia

Álvarez (2002b) conducted a first assessment of illicit crops and bird conservation priorities in Colombia. This has largely been superseded by the more comprehensive analysis of Fjeldsa *et al*. (2005), which identified a minimum set of 89 areas in the Andean region required for a single representation of all 987 bird species. Of these areas in Colombia, the most important are the Sierra Nevada de Santa Marta in the northwest, with 12 endemic species and the presence of coca cultivation, and the mountains of Tolima in central Colombia, with 8 endemic species and the presence of opium poppy cultivation. It was found that coca and armed conflict could seriously constrain the effectiveness of the Sierra de Perija (Perija Mountains) National Park for conservation of *Pyrrhura caeruleiceps* and *Pauxi pauxi guilliardi*. Conservation actions are also reported to be increasingly limited in South western Darien, (where bird species of conservation interest include *Crypturellus kerriae* and especially *Psarocolius cassini*), Paramillo (*Pyrrhura*

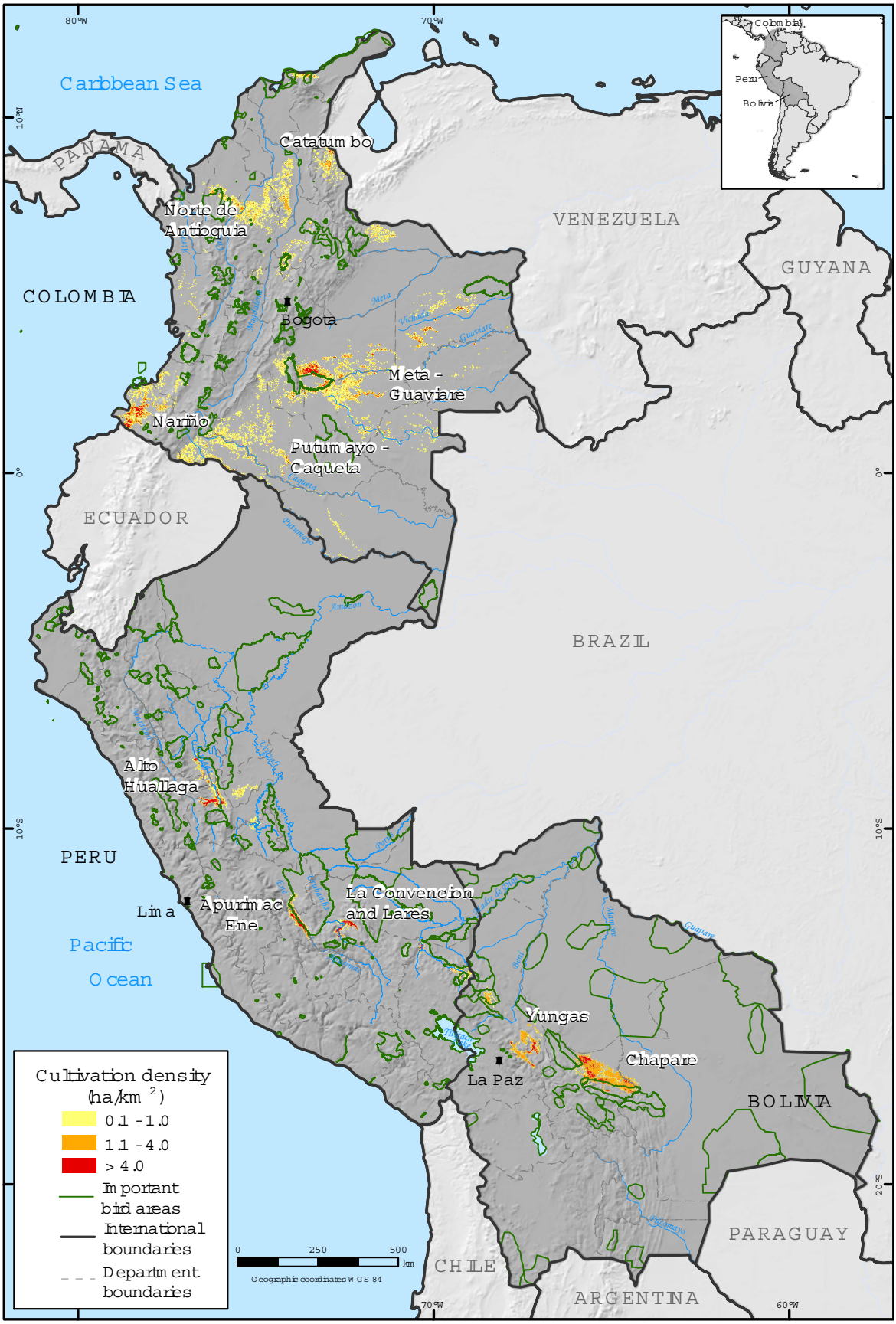
Table 14: Important Bird Areas (IBAs) in Colombia with coca cultivation in 2004

IBA	Region	IBA area (ha)	Coca area, 2004 (ha)	No. of important bird species	Altitude (m)	Illicit crops recorded by Bird Life
Blade of San Lorenzo	Guajira	58 000	99.3	23	0- 2400	
La Forzosa - Santa Gertrudis	Antioquia	9 000	1.8	15	1200- 1900	
Mountainous area of las Quinchas	Santander and Cundinamarca	86 088	506.6	9	200 - 1700	
Mountainous area of los Yariguies	Santander	175 000	80.4	12	2000- 3200	
Mountainous area of Los Churumbelos	Cordillera Oriental	150 000	10.6	34	300- 3000	
National Natural Park Los Farallones	Valle del Cauca	150 000	0.6	9	200 - 4100	x
National Natural Park Munchique	Cauca	44 000	2.3	43	500 - 3020	
National Natural Park Paramillo	Antioquia and Cordoba	460 000	120.7	6	500-3400	x
Natural National Park El Cocuy	Boyacá, Casanare and Arauca	306 000	0.3	2	600 - 3000	
Natural National Park El Tuparro	Vichada	548 000	2.0	5	100 - 330	
Natural National Park Sanquianga	Nariño	89 000	0.3	2	0-20	
Natural National Park Sierra de la Macarena	Meta	630 000	2 626.3	8	400 - 2500	
Valley of San Salvador	Guajira	58 000	242.2	23	0 - 2400	x
Western riberas of the Duda river	Meta	17 000	6.2	7	350 - 400	
Cerro Pintado ∇	Guajira	15 000		14	1500 - 3200	x
National Natural Park Las Orquideas∇	Antioquia	32 000		3	300-3850	x
El Oso Reserve∇	Huila	5 500		5	1800 - 3600	x

∇ These IBAs have been reported as threatened by illicit drug cultivation by BirdLife, but did not contain coca in 2004. Opium poppy may have been present.

Source: Birdlife International (2005b) and UNODC Colombia (2005)

Map 5: Important bird areas and coca cultivation density in the Andean Region, 2005



Sources: Governments of Bolivia, Colombia y Peru, National monitoring systems supported by UNODC
The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations

subandina), and Choco (*E. mirabilis* and *H. negreti*). Conflict is also evident in the Serrania de San Lucas (*Crax alberti*), at the head of the Magdalena Valley (*Tinamotis osgoodi, Atlapetes fuscoolivaceus,* and *Scytalopus* sp.) and in the Eastern Andean Slope (*Grallaria kaestneri*).

The areas of frontier agriculture in the lowlands of eastern Colombia, where much new coca cultivation is found, are not particularly rich in bird species or unique compared to the Andean highlands (Fjeldsa *et al*., 2005).

"This is not meant to devalue such forests, but rather to emphasize that the regional species pool is likely to persist in spite of local habitat loss" (Fjeldsa et al., 2005).

However, Fjeldsa *et al*. (2005) suggest that even fairly widespread species may be affected if large portions of their range lie in armed-conflict zones. Bird species in this situation include the two large green macaws, *Ara ambigua* and *Ara militaris*, and possibly for *Crypturellus duidae* (Macarena Mountains population), *Odontophorus atrifrons* (Santa Marta to Santander), western Colombian populations of *Chloropipo flavicapilla, Dacnis hartlaubi, Penelope perspicax*, and the north Colombian endemics *Chlorochrysa nitidissima, Clytoctantes alixii, Leptotila cassini, Pionopsitta pyrilia*, and (especially) *Habia gutturalis*.

Fourteen Important Bird Areas (IBAs) in Colombia contained some areas of coca cultivation in 2004 (Table 16), although nine of these had ten hectares or less of coca. The Natural National Park Sierra de la Macarena in Meta province was the most severely affected IBA, with 2,626 hectares of coca in 2004. The second largest area, 506 hectares, was found in the Mountainous Area of Las Quinchas IBA.

Peru

Peru is an extremely diverse country with both high species richness and endemism (Rodríguez & Young, 2000). The high levels of endemism in Ecuador and Peru are broadly associated with montane and arid conditions produced by the high mountain ranges that subdivide each country. Peru's biodiversity is also augmented by contact with floras from more temperate latitudes (Young *et al*., 2002).

Biodiversity is under pressure from coca cultivation in the centre of upper Huallaga Valley, within the Tingo, Maria and Taparoto areas, where very little natural habitat is left. Other highly affected areas are in the Palcazu – Pichis district and in areas with logging and colonization along the Huancayo-Satipo-La Merced – Pucallpa road and along the lower Apurimac river. The traditional coca cultivation in the submontane Zone of Cuzco has also become more intense (Fjeldsa *et al*., 2005).

Conservation options are limited in the Marañon River and in the middle Huallaga as coca cultivation areas expand, with biologically important sites in Cordillera of Colán, Abra Patricia and Moyobamba (bird species of concern being *Xenoglaux loweryi, Grallaria blakei, Grallaricula ochraceifrons, Picumnus steindachneri, Herpsilochmus parkeri, Zimmerius vallerejoi, Hemitriccus cinnamomeipectus, Poecilotriccus luluae, Henicorhina leucoptera,* and *Loddigesia, mirabilis* in the adjacent Utcubamba basin). Fjeldsa *et al*., (2005) consider that the coca districts in the Upper Huallaga and Pachitea-Aguaytia and other areas in Pasco and Junin do not seem to raise particular conservation concern.

The coca-related activities in Cuzco are just to the north of the core areas for endemic bird species in the Cordilleras Vilcanota and Velcabamba, but conservation options may still be somewhat constrained for the bird species *Amazilia viridicauda, Grallaria erythroleuca,* and *Thryothorus eisenmanni* (Fjeldsa *et al*., 2005).

Rodríguez and Young (2000) identified national level priority areas for biodiversity conservation in Peru, based on the distributions of mammals, birds, fish, amphibians, reptiles, invertebrates and vascular plants. Thirty-eight priority areas were identified (Figure 9). Comparison of these areas with coca cultivation in Peru in 2004 (UNODC Peru, 2005) indicates that several of these areas are affected. The Alto Huallaga region of coca is located in the northern section of the Huacrachuco-Huamachuco priority area and adjacent to the Cordillera Azul-El Diablo area, both of which are considered unprotected. The Oxapampa-Chanchumayo area is affected at its southern end by the Apurimac-Ene coca region. The La Convencion and Lares coca region lies within the

Vilcanota priority conservation area. The Inambari Tambopata coca region is within the Tambopata-Heath priority conservation area.

None of the Important Bird Areas (IBAs) in Peru have been reported by BirdLife to be threatened by illicit drug cultivation, but spatial analysis indicates that five IBAs included areas of coca cultivation in 2004. Of these, the Cordillera Vilcanota Norte - Abra Málaga-Vilcanota IBA was the most affected by a large margin, containing 4,351 hectares of coca in 2004 (12% of the IBA's area).

Table 15: Important Bird Areas (IBAs) in Peru with coca cultivation in 2004

IBA	Region	IBA area (ha)	Coca area, 2004 (ha)	No. of important bird species	Altitude (m)
Bajo Madidi			7.5		
Balsas	Amazonas	6 200	94.4	6	850 - 2900
Cordillera Vilcanota Norte - Abra Málaga-Vilcanota	Cusco	35 200	4 351.5	30	3000 - 4200
Hacienda Limón	Cajamarca	10 000	12.4	6	900 - 2700
Maruncunca	Puno	57 100	241.2	7	1500 - 2800
Parque Nacional Tingo María	Huánuco	4 777	14.9	2	650 - 1849

Source: Birdlife International (2005b) and UNODC Peru (2005).

Bolivia

The priority area in Bolivia for conservation of endemic Andean bird species is Cocapata at the Cochabamba-La Paz boundary, with eleven restricted range species. This area includes the Isiboro Sécure National Park, where coca cultivation increased in the north of the Chapare region between 2003 and 2004. Clearing for coca cultivation could seriously limit conservation options for the bird species *Pauxi unicornis* and *Terenura sharpei* (Fjeldsa *et al*., 2005).

Seven Bolivian IBAs contained some coca cultivation in 2004 (Table 18). Of these, the Bajo Carrasco IBA in the Cochabamba region has been most seriously affected, with 1,286 hectares of coca in 2004. The Apolo IBA contained 250 hectares, the second largest area of coca in 2004.

Table 16: Important Bird Areas (IBAs) in Bolivia with coca cultivation in 2004

IBA	Region	IBA area (ha)	Coca area, 2004 (ha)	No. of important bird species	Altitude (m)	Illicit crops recorded by BirdLife
Apolo	La Paz	200 000	250.8	3	1500 – 2500	
Alto Madidi –(Yungas Superiores de Madidi)	La Paz	200 000	4.7	50	1500 – 3600	
Alto Apolobamba - Apolobamba	La Paz	483 743	0.2	81	2000-4000	
Cristal Mayu y Alrededores	Cochabamba	40 000	90.5	4	1000-2000	
Bajo Carrasco	Cochabamba	470 000	1 286.5	6	800-2000	x
Bajo Isiboro-Sécure -Yungas Inferiores de Isiboro-Sécure/Altamachi	Beni, Cochabamba	250 000	160.2	10	800-2000	x
Alto Mosetenes y Cocapata - Yungas Superiores de Mosetenes y Cocapata	Cochabamba	350 000	1.1	44	1800-3000	

Source: Birdlife International (2005b) and UNODC Bolivia (2005).

Effects of illicit drug cultivation on local people

Human health

This study did not identify any field-based research on the direct effects of illicit drug cultivation on farmers' health. Probably the most significant health risk is from direct exposure to growers and processors of the large quantities of agrochemicals used in the production of cocaine and opium, followed by potential contamination of food and water supplies by these chemicals.

Although some of these substances are highly toxic to mammals and might have serious environmental consequences, accurate information on the quantities used, frequency of application and conditions of use is not available. There is no evidence to separate the effects that could be attributed to illicit crop production from those produced as a result of legal farming, mining and infrastructure development that accompanies the settlement of new tropical forest areas.

Migration, violence and insecure conditions and land use change involving coca

The widespread violence in Colombia with the involvement of different armed groups has undoubtedly played an important role in the location and mobility of illicit crops (Dávalos, 2001), with consequent effects on deforestation and environmental degradation. The main incentives for growing illicit crops are economic, but growers in Colombia may also be forced at gunpoint (Álvarez, 2001a; Fjeldsa *et al*., 2005), as paramilitary and left-wing guerrilla groups are involved in trafficking to varying degrees. In Peru, the leftist guerrilla movement *Sendero Luminoso* (Shining Path) has also been involved in coca production, in the Selva Alta (Fjeldsa *et al*., 2005).

Ferro *et al.* (1999) describe the social transformation in areas under intensive cultivation in Colombia from the perspective of young people. In the colonization process, some farmers had received incentives from the government to convert forest into grassland for ranching and household cultivation. The typical methods employed are unregulated timber exploitation followed by grass monoculture. As more farmers continue to arrive, deforestation intensifies. As coca is more profitable than any other economic activity, many farmers have chosen to change from cattle ranching to coca plantations. The coca crops do generate enough income for the settled farmers to remove their need to cut more forest, but that same income attracts new farmers, resulting in increasing deforestation.

In Colombia lowland indigenous groups such as the *Korebaju* (nomads until 50 years ago) and *Ingas* have experienced an increase conflicts over land ownership, both between themselves and with the new farmers. Indigenous people are often involved in coca production as the *raspachines* (leaf harvesters).

In Bolivia, road blockages and demonstrations by coca growers against eradication programs are fairly common. Although there is a tradition of coca cultivation, it has been reported that many of the coca growers in Chapare, Bolivia, consider themselves temporary inhabitants of the area, seeing their real home as their birthplaces in the Andes mountains (Mansilla, 1994 in Thoumi, 2001). On the basis of interviews, it was concluded that migration to the area would have happened anyway, but that coca accelerated the process.

Effects of illicit drug eradication on the environment and local people

Current eradication policy in Colombia aims to make illicit crop cultivation and narcotic production less attractive. The aim is to diminish the supply of cocaine and heroine, leading to an increase in prices and subsequent decrease in consumption. The methods employed include crop eradication, cargo interception, arrest and imprisonment, equipment confiscation, and confiscation of any products of drug trafficking. Central to this strategy is the aerial spraying of the herbicide glyphosate ('Roundup') to eradicate coca and opium poppy, as well as manual eradication. There is no use of any biological control agents, such as fungus, because of the risk of damaging surrounding ecosystems (Diaz-Torres, 2002). The Colombian government has set restrictions on the use of aerial spraying, including limits to the proximity to human communities and its application only under certain climatic conditions (Moya, 2005). Only coca crops that are considered commercial, that is areas over 3 hectares in extent, are fumigated. Cultivation areas

smaller than 3 hectares are eradicated manually. It has been argued that since aerial fumigation the size of coca plots has decreased (Diaz-Torres, 2002).

Peru and Bolivia do not use aerial spraying. In Peru, the only eradication of coca fields is manually conducted, without the use of chemicals. Similarly, in Bolivia, only manual eradication is carried out.

Solomon *et al*. (2005) conducted a study on the effects on human health and the environment of aerial spraying of glyphosate herbicide for the illicit crops eradication programme in Colombia, based on a review of literature. It was found the formulation of glyphosate used could produce temporary irritation in eyes and skin, but no effects on reproduction were observed. No ecological field data were collected from the region, but a review found that glyphosate had low toxicity to non-target organisms other than plants. The formulation used in the eradication programme in Colombia is of low toxicity for mammals and vertebrates, although some temporary impacts may occur. Amphibians are the group most sensitive to this formulation, and it has been suggested that other formulations be tested when eradication is conducted near to water bodies, in order to minimise impacts on amphibian populations (Solomon *et al*., 2005). Relyea (2005) tested the impacts of glyphosate on amphibians and concluded that it could cause high rates of mortality in larval stages and lead to population decline.

There appear to have been no systematic field studies on the possibility of loss of forest from unintended drift of glyphosate during aerial spraying. Cavelier and Etter (1995) reported that opium poppy fumigation was very accurate and that the effects on adjacent ecosystems would be low compared with the removal of the entire forest for opium poppy cultivation. The effects of drifting spray could be greater when fumigation occurs at night or in windy conditions (Álvarez, 2001a; Dávalos, 2001; Salaman *et al*., 2001). The Andean relief and other factors not permitting fumigation to be conducted at the specified altitude of 10 m could also increase the area affected.

Guio (2003), in his study in Samaniego, Nariño (Colombia), reports that aerial fumigation of poppy crops also affect household crops and alternative crops promoted by UNODC. Intensification of fumigation has lead to an increase in complaints to the *Defensoria del Pueblo* regarding impacts on farmers' health, domestic animals, fishes and legal crops. Ortiz *et al*. (2004), in an essay about agriculture, illicit crops and the environment for the National Environmental Forum (Colombia), mentions that recent studies in Putumayo have concluded that more than 2,700 hectares of licit crops, including fruits, and more than 200,000 fish, were lost because of fumigations. These figures are for people that submitted their cases to local authorities.

Velaidez (2001) visited the Municipality of Cartagena de Chaira in the Department of Caquetá between November 1998 and February 1999 to investigate the impact of aerial fumigation on farmers and their crops. This study reported unintended effects of aerial glyphosate spraying but no quantitative data, with affects on rubber and cocoa plantations and food crops such as plantain, maize, yucca, rice, vegetables and fruits. Cattle were reported to lose hair after eating pastures previously affected by the fumigation. The death of young chickens and farmed fish was reported as a result of related water contamination.

Issues for analysis of the environmental effects of illicit drug cultivation in the Andes

Drug cultivation practices and farming systems

Bolivia and Peru have areas where coca has been traditionally grown for local use of coca leaf, in the Yungas and the Huallaga valley, as well as very limited cultivation by some indigenous groups in Colombia. In these areas there is relevant traditional knowledge that includes soil conservation techniques such as terracing. Although some authors suggest that such practices are in decline, the environmental impact of coca in terms of forest clearance and land degradation, appears to be moderate. It is in the areas of coca cultivation for cocaine in Bolivia, Peru and all of Colombia that the absence of soil conservation measures and intense use of agrochemicals have a considerable negative impact on the immediate environment. The illegal nature of the crop and the eradication measures are strong disincentives for farmers to invest in soil conservation and other measures to

promote the sustainability of this land use. In Colombia in particular, there is a very high mobility and short life of coca plots.

Some researchers have expressed the view that coca is a suitable crop for the tropical humid forest biome, because coca plants adapt very well to the infertile soils, and are more productive than other crops studied (e.g. Salm & Liberman, 1997; Morales, 1990). This may be the case for small-scale producers, but would only be relevant if conditions favoured long-term investment in a coca plot. The crop's illegality in most regions and subsequent eradication measures do not favour this investment.

The economic role of coca income for farmers is of more relevance to analysis of the environmental impact of coca cultivation. Notwithstanding the illegal nature of coca/cocaine and opium/heroin production, several authors express the view that the high profitability of illegal coca or opium poppy compared to other land exploitation activities could limit farmers' impact on natural resources, requiring smaller areas for production than other land uses (Andrade *et al*., 2004; Henkel, 1995; Laserna, 1999; Thoumi, 2001). This may be the case for the small-scale farmers of Chapare and in situations of relatively stable communities or secure land tenure. However, for larger scale producers, like many of those found in Colombia, the expansion of coca cultivation is driven by maximising income rather than subsistence needs.

In Colombia, Peru and Bolivia, coca farming could be broadly classified into two broad categories, in terms of its impact on forest. One category is in areas that have already been populated or colonization is encouraged, and so farming of some form is already established. In this case, any new coca cultivation is likely to be from conversion of existing farmland or secondary forest, as well from clearance of remaining fragments of forest. This was reported to be the case in the Chapare, Bolivia in the 1990s (Henkel, 1995). In Colombia during 2000 to 2004 about a third of new coca cultivation was on land nearly cleared from primary forest (Table 10), with the remaining two thirds from secondary vegetation and crops or pasture. This indicates that the replanting of eradicated coca plots and the establishment of new plots is often in areas already colonized and farmed.

The other category is where new coca cultivation is being established in previously unpopulated areas, opening up a new agricultural frontier. Rather than existing settlers adding coca to the suite of activities already undertaken, whole new settlements are established. This has been the case over much of the Colombian Amazonian region, and on a smaller scale in Peru and the Chapare and Apolo regions of Bolivia. The environmental impact of coca plots in these areas of colonization is much greater than in already settled lands, because of the associated deforestation for food crops, pasture, infrastructure and transport, and the hunting of wildlife.

Illicit drug processing

The chemicals used in the processing of coca leaf to cocaine, and of opium latex to heroin, are thought to have a much greater impact on the environment than the agrochemicals used in their production. Each year millions of tons and litres of processing chemicals and materials are released into the environment, both as wastes from processing laboratories and from the destruction of confiscated chemicals. However, only one specific study on the environmental effects of these chemicals has been identified, that conducted in the Chapare region of Bolivia in 1992 (Southwest Research Associates, 1993, cited by Henkel, 1995). Here, chemical spills were quickly diluted by the high rainfall received in the region. Some loss of soil microorganisms was noted, but no damage to wildlife, vegetation, fish species or bird life was detected in areas near the processing laboratories.

The discharge of chemicals from illicit drug processing undoubtedly has some environmental impact, but it is impossible to assess the scale of this impact due to the lack of data of almost any kind on soils, water supplies or biodiversity or the health of local people.

Impacts on biodiversity

The most important effect of illicit crop cultivation on biodiversity is the loss, fragmentation and degradation of forest habitat, as well as local hunting of wildlife. However, there are almost no field data with which to assess these effects. In Colombia, the scale of deforestation and

fragmentation of tropical and Andean forests due to coca cultivation has certainly had major impacts on the country's biodiversity. The impact is more localised in Peru and Bolivia due to the more restricted regions of coca cultivation. Fjeldsa *et al.* (2005) have identified the sites and bird species most likely to be affected in each country. An analysis carried out for the present study complements this work by identifying Important Bird Areas in which coca is cultivated.

The centres of species endemism, which make the Andes one of the most biodiverse regions of the world, are generally found at altitudes higher than the preferred conditions for growing coca. This reduces the probability of species extinction as a result to coca cultivation, because lowland species typically have wider distributions.

Aerial fumigation and forced eradication of coca crops is one factor in the dynamics of coca cultivation and deforestation. Several studies report that in response to coca eradication measures farmers have been deforesting new plots in more remote areas. These new plots can be in the local region or in other parts of the country, since migration and displacement of people is widespread, especially in Colombia. It has also been suggested that farmers create more scattered plots of smaller size in response to fumigation. This further fragments the forest and increases the impact on biodiversity. The relative importance of this phenomenon compared to the other drivers of coca cultivation and deforestation have not been determined.

Moya (2005), in a statistical modelling exercise, concluded that forced eradication policies have an ambiguous effect on the area of coca cultivated. Fumigation increases the risks and costs of growing the crops and so discourages coca cultivation, whilst at the same time increasing production costs and consequently market prices, which in turn encourage cultivation (unless complementary interdiction measures keep market prices low). The impacts of eradication are uncertain and depend on the interaction and magnitude of many aspects, including the types of farmers involved as well as those involved in the trade of coca leaf.