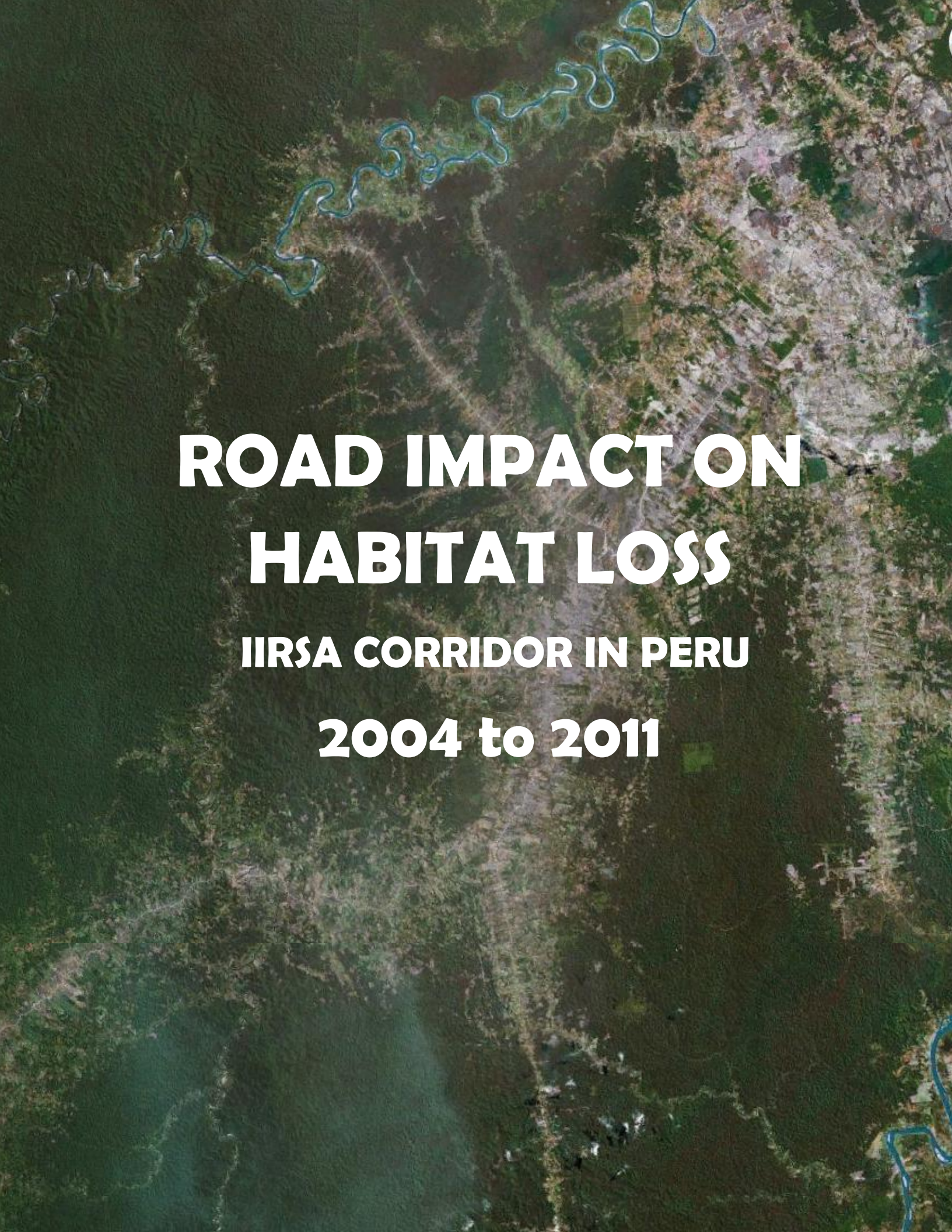

ROAD IMPACT ON HABITAT LOSS

IIRSA CORRIDOR IN PERU

2004 to 2011

ROAD IMPACT ON HABITAT LOSS
IIRSA CORRIDOR IN PERU
2004 to 2011

CIAT
Centro Internacional de Agricultura Tropical
International Center for Tropical Agriculture
Consultative Group on International Agricultural Research

IDB

BMZ Federal Ministry for Economic Cooperation and Development

The Nature Conservancy
Protecting nature. Preserving life.™

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terra-i
An eye on habitat change

March 2012

Content

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Executive Summary

The following document presents a study of the impact on ecosystems generated by the construction and development of a series of IIRSA roads projects in Peru. The analysed roads have a total length of 1,584 km and traverse Peru from the Pacific Coast to the Acre state in Brazil. The road was analysed in three different sections: Section 1, Patia-Tarapoto, Section 2, Tarapoto-Tingo Maria and Section 3, Tingo Maria-Cruzeiro. The route goes through multiple ecoregions, from the desert through the Andes mountain range and extending to the Amazon Basin, making it an area of high importance for global biodiversity. The ecoregions in the study area include: Central Cordillera páramo, Eastern Cordillera real mountain forest, Iquitos varzeá, Marañon dry forest, Napo moist forest, Peruvian yungas, sechura desert, South American pacific mangroves, tumbes-piura dry forest and Ucayali moist forest.

The monitoring system Terra-i was used to quantify the impact of the road on the ecoregions present in the area. Terra-i is a near-real time monitoring system that mines satellite based rainfall and vegetation data to detect deviations from the usual pattern of vegetation change, which it interprets as possible anthropogenic impacts on natural ecosystems. As Terra-i is based on vegetation index data, it cannot identify the root causes of vegetation change. Therefore, all information on deforestation drivers in this report is derived from secondary sources. Terra-i monitored the habitat in Peru every 16 days from the 1st of January 2004 until the 10th of June 2011 and detected a cumulative loss of habitat during the 7.5 years analysed of 350,894 hectares nationwide, equivalent to an annual rate of 46,786 ha / year. The highest rates of deforestation were detected in the departments located in the Amazon such as Loreto, Madre de Dios, San Martin and Ucayali. The main deforestation driver, according to a study by the Peruvian Ministry of the Environment, is agricultural expansion.

The road impact analysis shows that the buffer zone of 10 km around the road is the most impacted area. For Section 1 (Patia-Tarapoto) which crosses the departments of Piura, Lambayeque, Cajamarca, Amazonas and San Martin an average annual loss rate of 2,464 hectares was measured between 2004 and 2011. Section 2 (Tingo Maria – Tarapoto) lost 1,148 hectares/year and Section 3 (Tingo Maria-Cruzeiro) lost 1,623 hectares year. The 1,584 km of analysed road is located close to various protected areas. Section 1 runs through the protected Alto Mayo Protection Forest area in the department of San Martin, Section 2 goes by one side of the Blue Mountains National Park and lies 2 km from Tingo Maria National Park and Section 3 runs through Alexander Von Humboldt National Forest (Ucayali department) and the Serra do Divisor National Park in the state of Acre in Brazil. The result is greater deforestation pressure on these protected areas, threatening the conservation of the plant and animal species that live there.

Area of Study

Peru is one of the ten most diverse countries in the world with immense biological (expressed as ecosystems, species and genes) and cultural richness (CONAM 2001).

Peru's high levels of biodiversity are evident in the 84 of the 104 global Holdridge life zones present in the country. These life zones are distributed in 11 ecoregions, and they demonstrate the profusion of flora, fauna and yet unexplored genetic diversity which gives the country both great opportunities and great challenges for sustainable development. Such diversity is a source of a number of goods, such as food, genetic and medicinal resources and raw material for clothing and construction, as well as environmental services, such as coastal protection, climate regulation, watershed protection, water harvesting, energy fixation, biomass production, biological control, habitat for flora and fauna and provision of cultural and recreational benefits (MINAM Perú, PNUMA 2008).

The analysed roads have a total length of 1,584 km and traverse Peru from the Pacific coast to the Acre state in Brazil. The road was split into three different sections for the analysis:

Section 1: This section has a total length of 752 km. It starts in Paita on the Pacific coast in the Piura department, crosses the river Para and passes through the departments of Lambayeque, Cajamarca and Amazonas. It then crosses the Maranon River to arrive in the department of San Martin, where it passes through the Alto Mayo Protection Forest and finally reaches the city of Tarapoto.

Section 2: With a total length of 381 km, this section starts at the town of Tarapoto, continues through the department of San Martin, and crosses the river Huallaga. It passes by one side of the Cordillera Azul National Park until the department of Huanuco, where it passes 2 km away from Tingo Maria National Park.

Section 3: This section has a total length of 451 km. From the town of Tingo Maria in the Via Huanuco department it travels through the department of Ucayali, crosses the Alexander Von Humboldt National Forest, and passes across the Ucayali River up to the Peru-Brazil border. It then crosses the state of Acre through the National Park Serra do Divisor and continues until Cruzeiro do Sul.

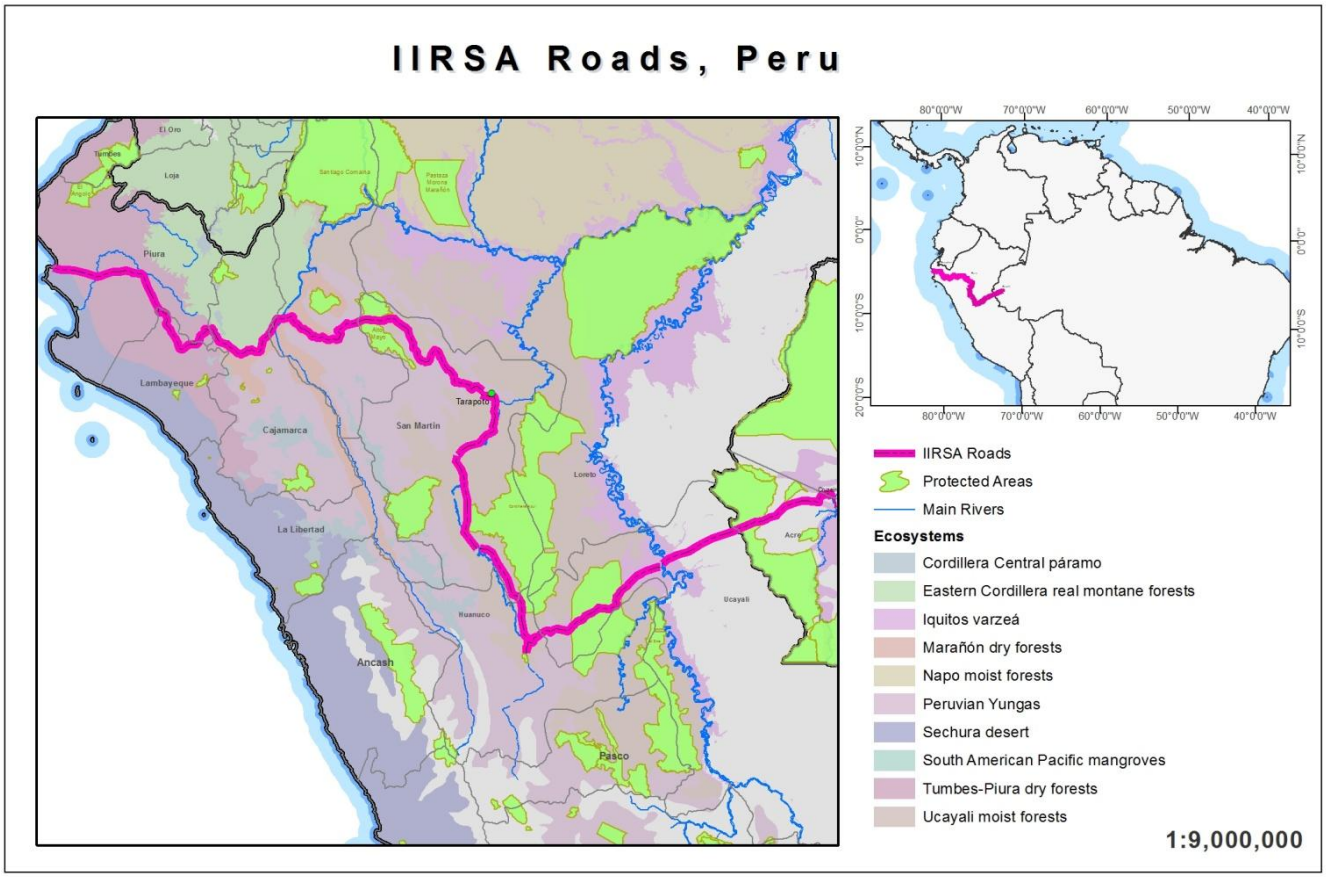

Figure 1. IIRSA Roads study area, Peru.

The route goes through multiple ecoregions, from the desert through the Andes mountain range and finally to the Amazon basin, making it an area of high importance for global biodiversity. The ecosystems in the study area are: Central Cordillera Páramo, Eastern Cordillera Real Mountain Forest, Iquitos Varzeá, Marañon Dry Forest, Napo Moist Forest, Peruvian Yungas, Sechura Desert, South American Pacific Mangroves, Tumbes-Piura Dry Forest and Ucayali Moist Forest.

Habitat Change Monitoring

Previous studies

Natural forests in Peru have high diversity, reflected in the wide variety of forest types associated with the climatic zones and geomorphological features of the country. According to estimates by the Natural Resources Institute (INRENA) in the framework of the Natural Resources Assessment of the FAO in 1990, Peru once had more than 70 million hectares under forest cover, which up until the year 2005 has been reduced with an annual rate of change of -0.1%. As it is the case in most Latin American countries Peru has neither updated nor validated data of forest status, only values calculated from estimated rates of deforestation.

In 2010, according to FAO, the area most affected by deforestation was still the so-called high forest, mainly due to its easy road access allowing migration of the population living in the Sierra region. The departments with the largest deforested areas are the Amazonas and San Martin. In the case of northwestern Peru (Tumbes, Piura and Lambayeque), where the largest area of dry forests are found, the vegetation is threatened mainly by deforestation but additionally by forest fires, perhaps the most prominent cause of vegetation cover reduction in the area (FAO 2010).

Terra-i Monitoring in Peru

Terra-i is a near-real time monitoring system that mines satellite based rainfall and vegetation data to detect deviations from the usual pattern of vegetation change, which it interprets as possible anthropogenic impacts on natural ecosystems. The model uses a multilayer Perceptron (MLP) neural network combined with Bayesian theory (MacKay 1992) (Bishop 2002) to identify abnormal behaviour in a time-series of vegetation change. The implementation of the system pan-tropically is a considerable challenge from a computer science perspective, as the resolution of the MODIS sensor (250m) means that even the Amazonian basin alone represents more than one billion individual values for each time-frame (every 16 days). As Terra-i is based on vegetation index data, it cannot identify the root causes of vegetation change. Therefore, all information on deforestation drivers in this report is derived from secondary sources.

Terra-i monitored habitat loss in Peru every 16 days from the 1st of January 2004 until the 10th of June 2011 and detected a cumulative loss of habitat during the 7.5 years analysed of 350,894 hectares nationwide, equivalent to an annual rate of 46,786 ha / year.

Table 1. Habitat Loss in Peru, Terra-i detection.

Department	%NoData	2004	2005	2006	2007	2008	2009	2010	2011	Accum.	Annual Rate
Amazonas	14.6%	150	2,531	481	394	500	900	2,994	2,613	10,563	1,408
Ancash	5.6%	19	44	13	6	19	0	13	13	125	17
Apurimac	0.0%	0	13	19	44	6	6	0	0	88	12
Arequipa	0.4%	100	81	19	594	225	269	275	50	1,613	215
Ayacucho	3.1%	25	313	119	100	100	156	319	163	1,294	173
Cajamarca	3.1%	1,550	2,975	950	19	13	69	5,275	69	10,919	1,456
Callao, Provinci	5.3%	0	0	6	0	0	0	169	0	175	23
Cusco	6.0%	488	881	1,325	1,550	2,025	2,706	4,331	3,513	16,819	2,243
Huancavelica	0.1%	0	6	0	25	0	0	0	0	31	4
Huanuco	19.0%	244	3,375	3,575	1,494	6,456	6,206	3,131	1,488	25,969	3,463
Ica	1.4%	175	313	675	788	731	656	688	631	4,656	621
Junin	21.9%	119	8,838	438	363	2,250	1,594	1,300	644	15,544	2,073
La Libertad	1.2%	731	569	75	25	50	0	25	13	1,488	198
Lambayeque	0.2%	675	719	50	200	13	0	113	6	1,775	237
Lima	1.9%	56	13	13	81	56	94	213	188	713	95
Loreto	0.9%	8,625	7,169	6,294	7,381	9,300	8,394	11,988	30,000	89,150	11,887
Madre De Dios	0.2%	1,056	5,350	2,706	3,619	5,794	6,006	11,406	2,731	38,669	5,156
Moquegua	0.2%	0	0	0	0	0	0	0	0	0	0
Pasco	11.4%	275	388	894	775	1,913	638	1,144	944	6,969	929
Piura	2.8%	3,988	1,588	125	50	69	88	75	0	5,981	798
Puno	1.0%	225	225	388	825	506	606	1,931	613	5,319	709
San Martin	22.1%	2,475	5,581	4,850	5,938	8,063	11,731	11,619	4,013	54,269	7,236
Tacna	0.1%	0	0	0	0	0	0	0	0	0	0
Ucayali	2.2%	3,600	11,000	6,300	5,581	9,175	9,250	7,244	6,619	58,769	7,836
Total Country	**4.2%**	**24,575**	**51,969**	**29,313**	**29,850**	**47,263**	**49,369**	**64,250**	**54,306**	**350,894**	**46,786**

The highest rates of deforestation were detected in the departments located in the Amazon, including Loreto, Madre de Dios, San Martin and Ucayali. During the 7.5 analysed years Loreto lost 89,150 hectares of forest, Madre de Dios 38,669 hectares, San Martín 54,269 hectares and Ucayali 58,769 hectares.

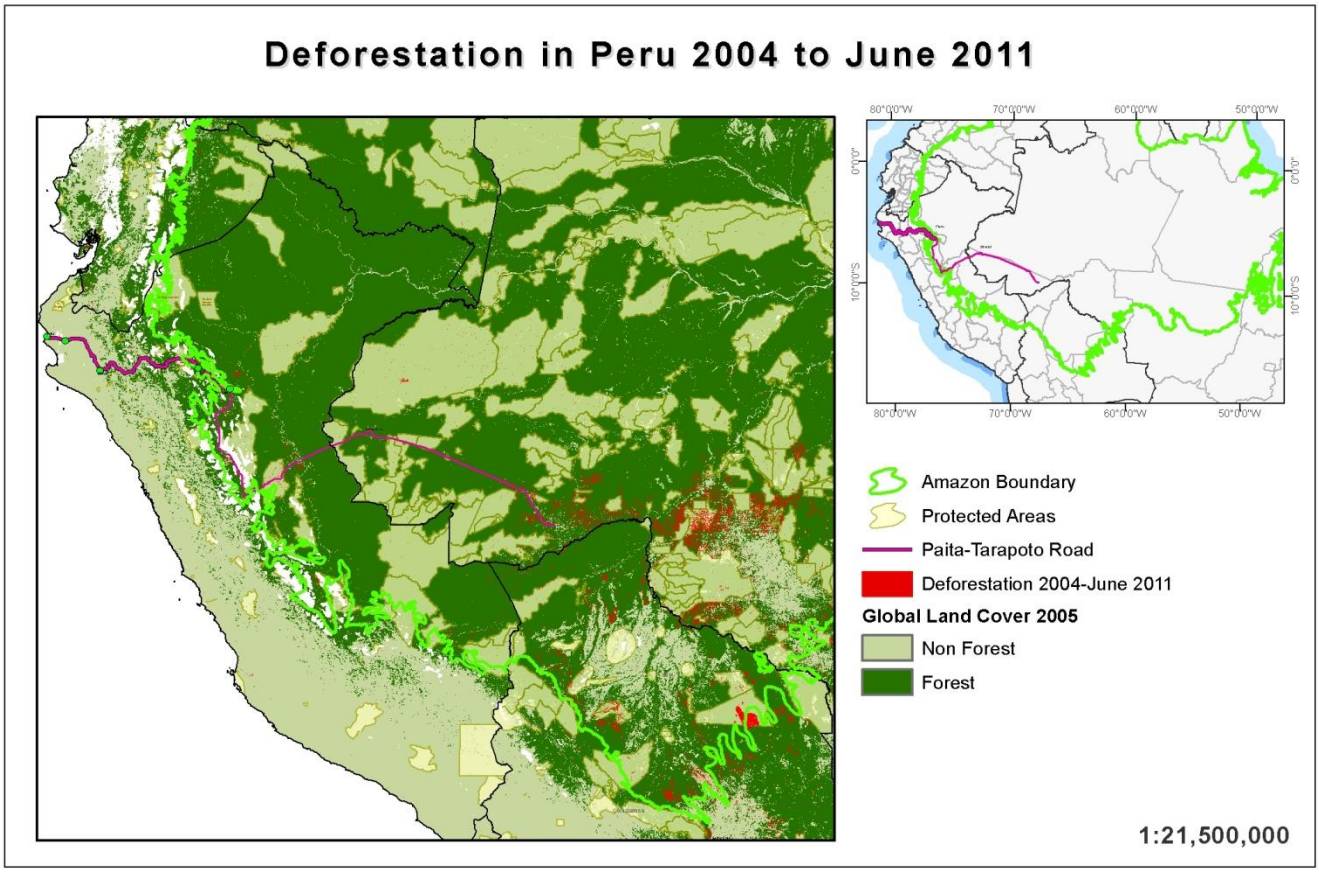

Figure 2. Habitat loss map, Terra-i monitoring (2004-2011).

Studies by the Ministry of Environment (MINAM Peru 2009) identify agricultural expansion as the main direct cause of deforestation in Peru. Agriculture in the country is based on slash-and-burn systems used by settlers for subsistence purposes. However, this system results in the expansion of agricultural impact; soil fertility eventually decreases and settlers must move to another place to start again with the same method.

In addition to agricultural expansion, other historical factors identified by the Peruvian Ministry of the Environment (Peru MINAM 2009) as deforestation drivers are:

- National policies between the years 1940 to 1970 that encouraged migration to the forests to expand the agricultural frontier,
- The opening of access roads in forest regions resulting in increased migration of the population to forested areas,
- Inadequacy of forest soils in the Peruvian Amazon for agricultural or grazing purposes (86% are only suitable for forestry),
- The clearing of woodland by companies or individuals for grazing,

- Alluvium mining in the department of Madre de Dios and exploitation of hydrocarbons in the Amazon, and
- Illegal coca plantations in parts of the Peruvian Amazon. The area planted with coca crops involves high and low tropical forest in 12 of the 24 regions of Peru: Cajamarca, Amazonas, San Martin, Loreto, La Libertad, Pasco, Huanuco, Ucayali, Junin, Ayacucho, Cusco and Puno. The largest areas are concentrated mainly in the region of Cusco with 18,122 hectares, then Huánuco with 17,976 hectares, and thirdly in the Ayacucho region with 10,359 hectares (UNODC 2009).

Road Impact

The IIRSA Roads have a total length of 1,584 km and traverse Peru from the Pacific coast to the Acre state in Brazil. The road was analysed in three different sections, as described in the section "Area of Study."

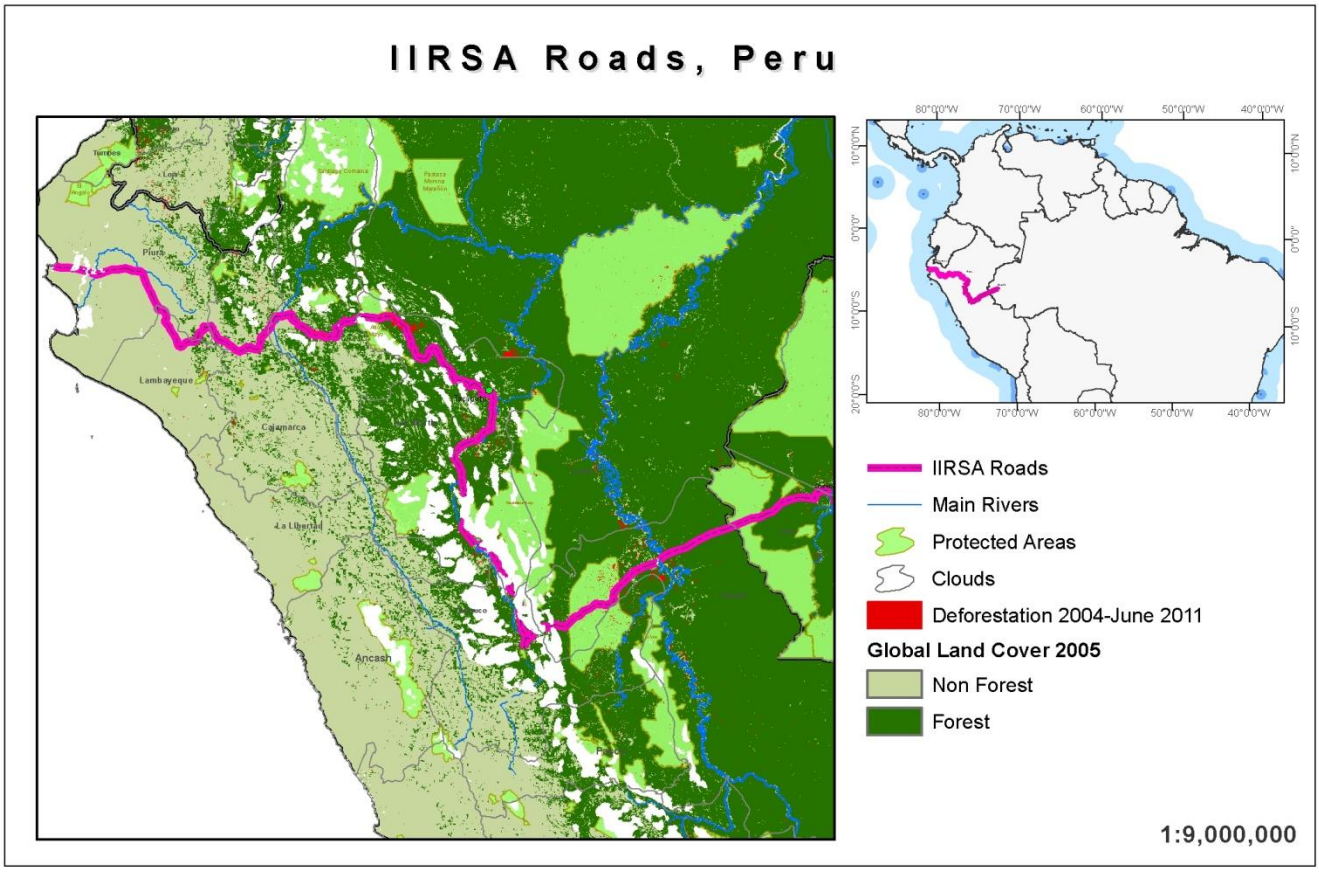

Figure 3. IIRSA Roads habitat loss map, Terra-i monitoring (2004-2011).

Table 2 shows the results obtained by analyzing the impact from each of the sections in buffer zones of 10, 20, 30, 40 and 50 km from the road.

Table 2. Results obtained in the impact analysis on each of the sections of the IIRSA Roads.

Section	Buffer(km)	%NoData	2,004	2,005	2,006	2,007	2,008	2,009	2,010	2,011	Annual Rate
Section 1 Patia-Tarapoto	Road to 10	5.6%	456	3,125	1,800	1,994	2,331	3,319	4,919	538	2,464
	10 to 20	10.3%	344	306	450	719	656	981	2,063	606	817
	20 to 30	13.8%	519	225	238	75	50	194	1,500	219	403
	30 to 40	9.1%	1,375	1,525	200	81	331	319	1,150	150	684
	40 to 50	6.3%	869	1,613	1,575	1,094	1,106	244	1,225	313	1,072
	Road to 50	9.0%	3,563	6,794	4,263	3,963	4,475	5,056	10,856	1,825	5,439
Section 2 Tarapoto-TingoMaria	Road to 10	29.4%	163	1,325	750	488	1,369	2,013	2,063	438	1,148
	10 to 20	30.0%	319	1,275	1,150	1,394	1,213	2,625	2,569	756	1,507
	20 to 30	34.8%	31	550	300	700	931	2,244	1,375	906	938
	30 to 40	45.3%	25	244	75	75	481	594	169	394	274
	40 to 50	33.6%	631	113	31	38	250	194	213	294	235
	Road to 50	34.5%	1,169	3,506	2,306	2,694	4,244	7,669	6,388	2,788	4,102
Section 3 TingoMaria-Cruzeiro	Road to 10	4.7%	531	2,069	1,019	794	2,350	1,825	1,838	1,744	1,623
	10 to 20	6.2%	719	6,231	2,975	1,344	3,031	2,569	1,675	2,613	2,821
	20 to 30	4.4%	1,244	2,525	1,456	1,175	2,500	2,588	1,744	900	1,884
	30 to 40	6.4%	406	1,263	550	375	1,281	1,013	763	425	810
	40 to 50	7.1%	356	1,000	525	494	1,219	988	500	288	716
	Road to 50	5.8%	3,256	13,088	6,525	4,181	10,381	8,981	6,519	5,969	7,853

The 1st section (Patia-Tarapoto) which crosses the departments of Piura, Lambayeque, Cajamarca, Amazonas and San Martin, recorded in the 50 km buffer zone a loss of 40,794 hectares, accumulated during the 7.5 analysed years, which is equivalent to an average annual deforestation rate of 5,439 hectares. It also shows that the most heavily impacted areas are located in the buffer from 0 to 10 km from the road.

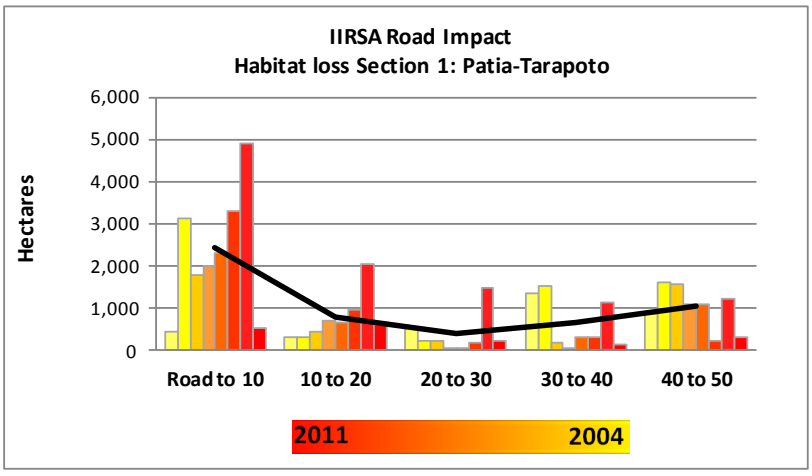

Figure 4. Habitat loss section 1: Patia-Tarapoto.

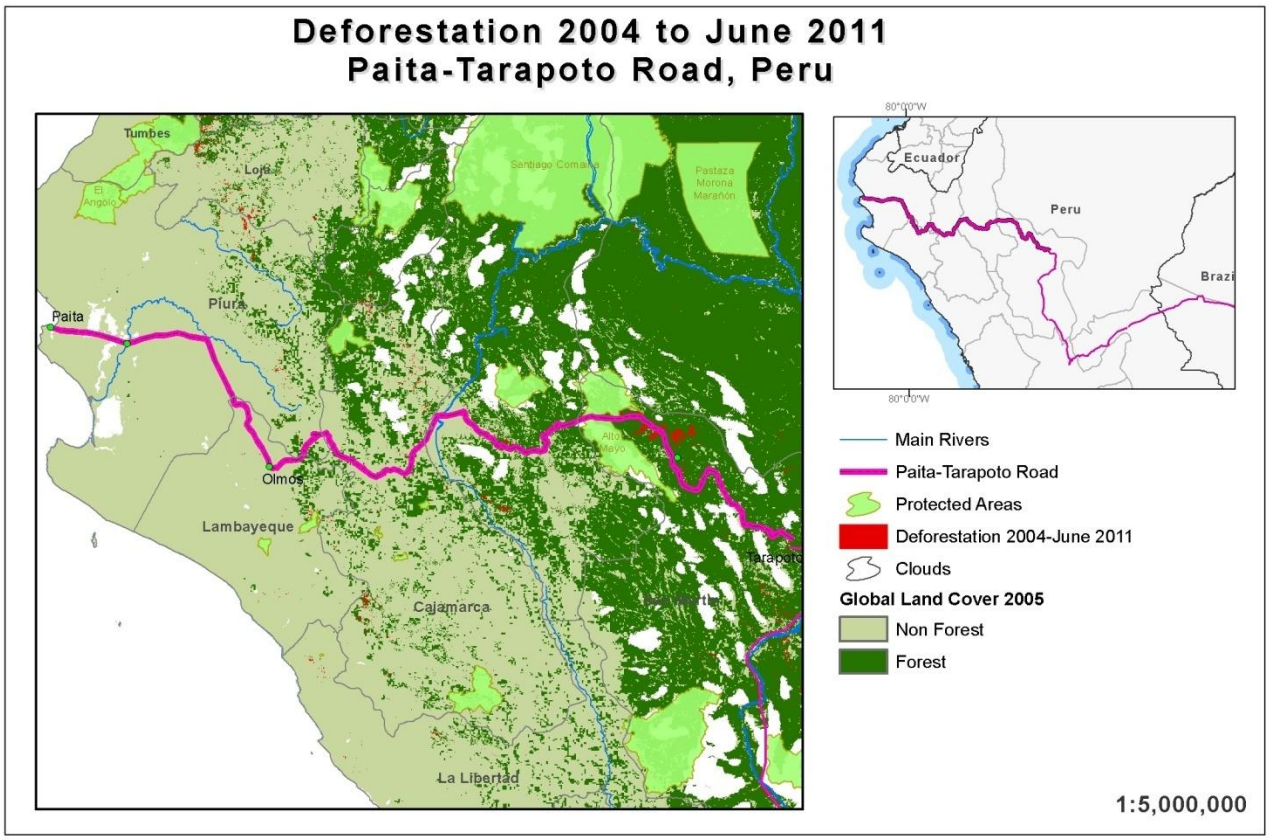

Figure 5. Section 1: Patia-Tarapoto habitat loss map, Terra-i monitoring (2004-2011).

Section 2 (Tarapoto-Tingo Maria), which crosses the departments of San Martin and Huanuco, recorded a loss of 30,763 hectares in the 50 km buffer zone around the road accumulated during the 7.5 analysed years, equivalent to an average annual deforestation rate of 4,102 hectares. It also shows that the most heavily impacted areas are located in the buffer zones from 10 to 30 km from the road.

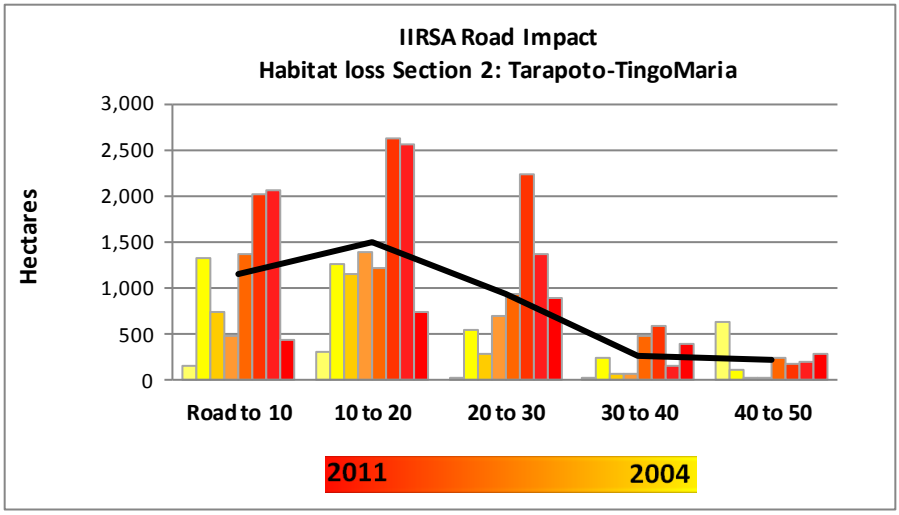

Figure 6. Habitat loss section 2: Tarapoto-TingoMaria.

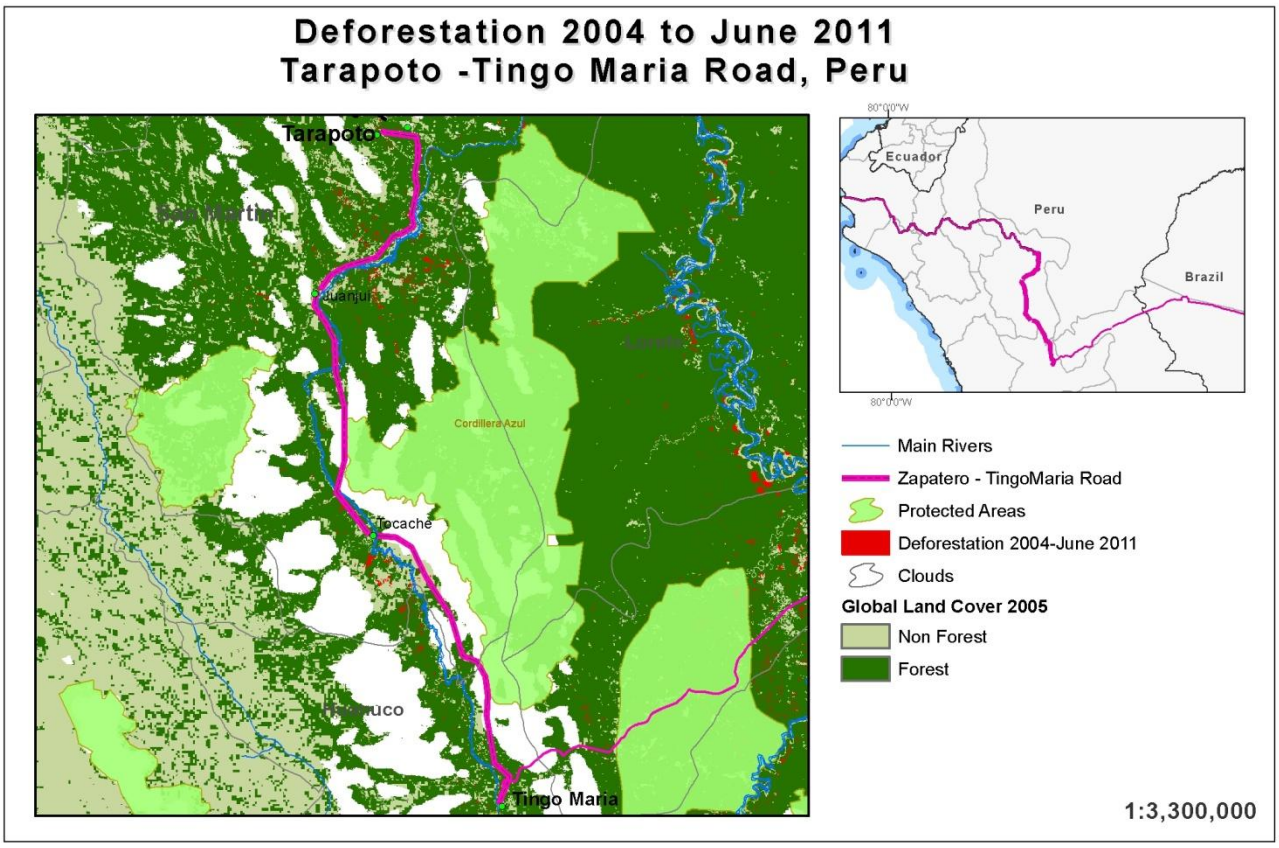

Figure 7. Section 2: Tarapoto Tingo Maria habitat loss map, Terra-i monitoring (2004-2011).

Finally, section 3 (Tingo Maria-Cruzeiro), which crosses the department of Huanuco and connects with the state of Acre in Brazil, recorded a loss of 58,900 hectares in the 50 km buffer zone around the road accumulated during the 7.5 analysed years, equivalent to an average annual deforestation rate of 7,853 hectares. It also shows that the most impacted areas are located in the buffer zones from 10 to 30 km from the road.

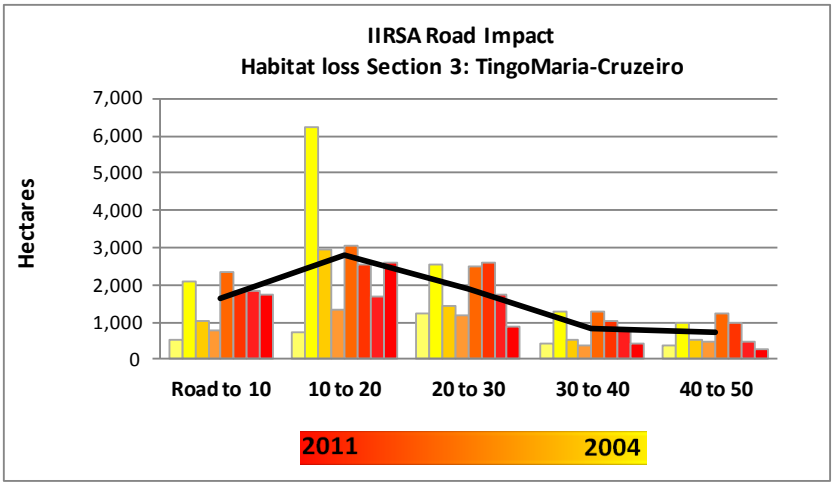

Figure 8. Habitat loss section 3: Tingo Maria-Cruzeiro.

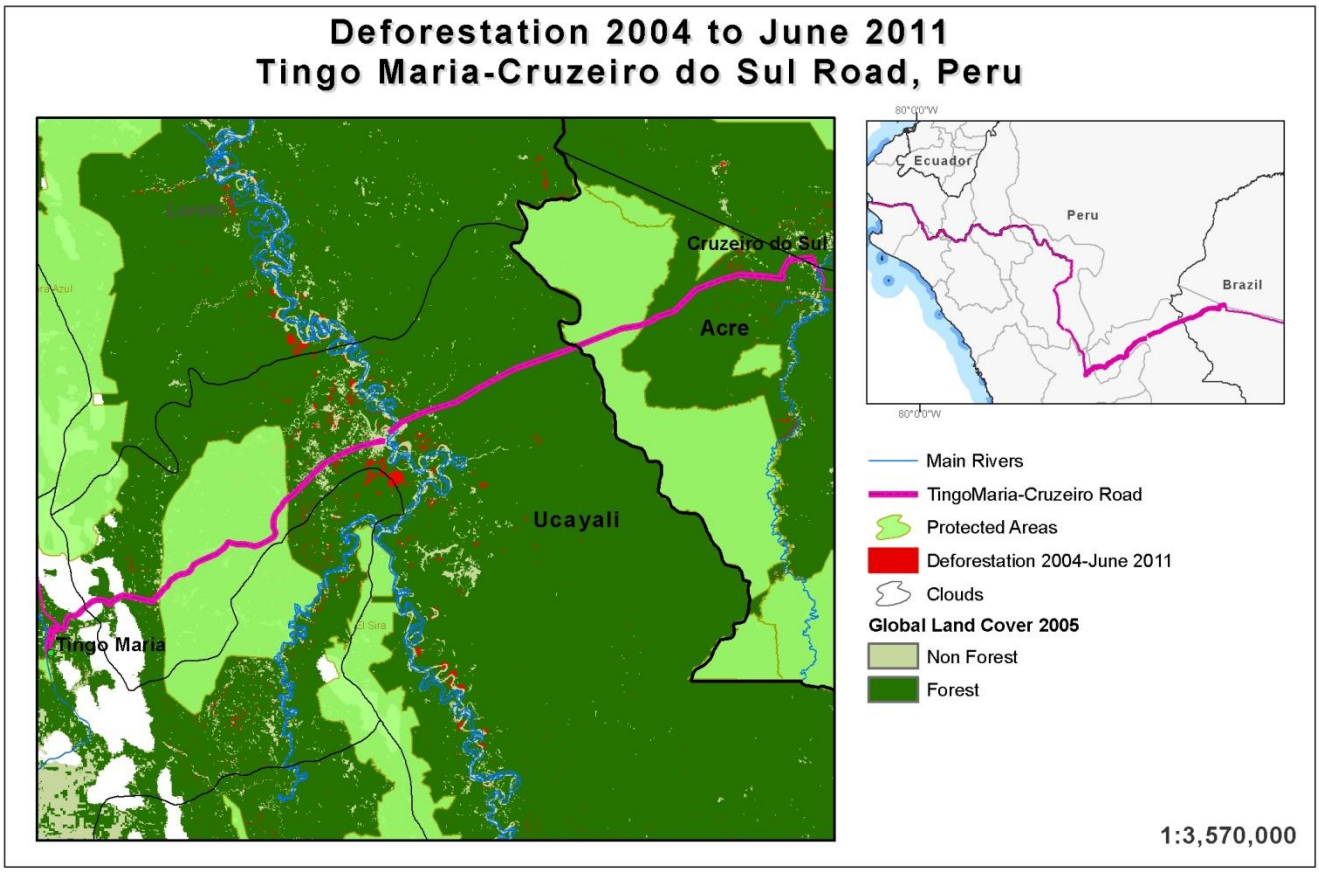

Figure 9. Section 3: Tingo Mari-Cruzeiro habitat loss map, Terra-i monitoring (2004-2011).

Contrary to popular belief, timber harvesting is not the main cause of deforestation in the Peruvian tropical forests. The fundamental cause of the problem is land use change from forest to agricultural purposes, precipitated by migration of farmers from the highlands. It should be noted that deforestation by shifting cultivation and livestock is directly related to the accessibility of forested lands. With this in mind, road construction should always be accompanied by development plans and a strong politic commitment from local and governmental authorities. Otherwise, such projects can be the catalysts that start a complex process of degradation and desertification (Universidad del Pacifico, 2003).

Protected Areas

One of the main tools in existence to protect the Amazon rainforest is the implementation of a set of protected areas to ensure the survival of this ecosystem and its species. However, recent years have seen the worrisome encroachment of illegal crop production, principally cocaine, on Protected Natural Areas (UNODC 2009). The repression of drug trafficking forced production of these illegal crops to shift to increasingly inaccessible areas, multiplying demand for derivatives of cocaine, especially in border areas. Among the protected areas that are experiencing this problem are the Tingo Maria National Park, the Blue Mountains and the Abiseo River which are very close to the cocaine basin of the Alto Huallaga. Also affected are the Bahuaja Sonene and Tambopata National Reserves, which are in close proximity to the cocaine-growing valleys of Inambari - Tambopata and San Gaban. Likewise, the Güeppi Reserved Zone is threatened by the coca-growing area of Yubineto in Loreto (UNODC 2009).

In addition to illicit crops, natural protected areas face also environmental problems such as illegal logging and unregulated trade of flora and fauna, which go hand in hand with the social problems that stem from lack of development opportunities in these areas (UNODC 2009).

The 1,584 km of analysed road passes close to various protected areas. Section 1 runs through the Alto Mayo Protection Forest in the department of San Martin, Section 2 borders the Blue Mountains National Park and passes 2 km away from Tingo Maria National Park, and Section 3 goes through Von Humboldt National Forest (Ucayali department) and the Serra do Divisor national Park in the state of Acre, Brazil. The result is greater deforestation pressure on these protected areas, threatening the conservation of the plant and animal species that live there.

The Protection Forest of Alto Mayo and its buffer zone are located in the northwest of Peru in the regions of San Martín and Amazonas. This is an area of significant value for conservation of biodiversity and freshwater resources. It has an area of 182,000 hectares and was set aside with the aim of protecting watersheds, forest, wildlife and the landscape of the area to promote tourism, recreation, education and research, thereby generating benefits for local people. The native Aguaruna or Awajun populations live in this area, along with many settlers from the past few decades. Today an excessive and disorganized human presence is a serious threat against the conservation of natural resources.[1]

[1] National Service of Protected Areas by the State, Protection Forest of Alto Mayo
http://www.sernanp.gob.pe/sernanp/zonaturismoi.jsp?ID=27

In a 20 km buffer zone around the Protection Forest of Alto Mayo Terra-i detected a total deforested area of 11,250 hectares over the 7.5 years analysed, equivalent to an annual loss rate of 1,500 hectares per year.

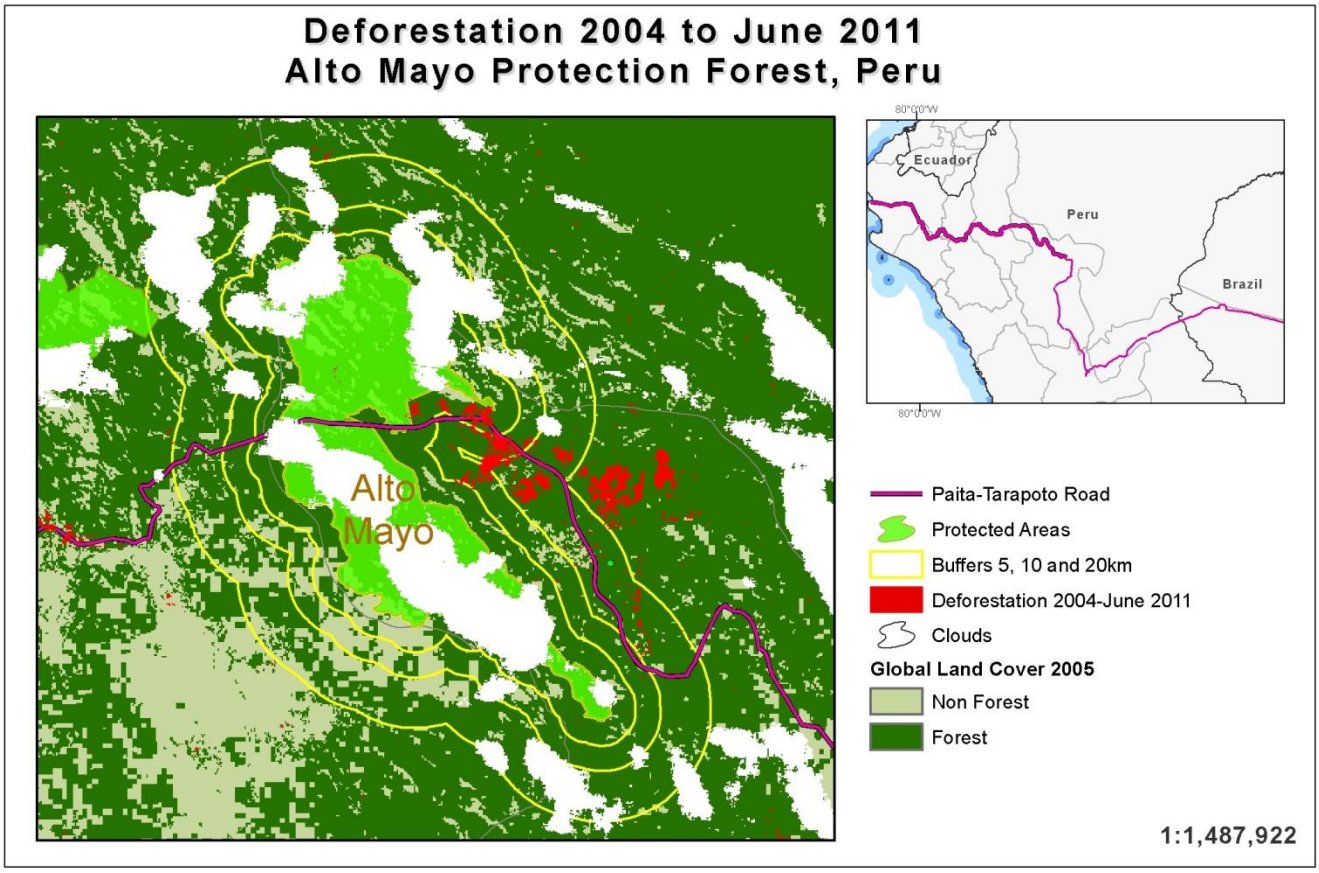

Figure 10. Map of Impact in Alto Mayo Protection Forest, Terra-i detection.

Table 3. Impact in Alto Mayo Protection Forest, Terra-i detection.

Buffers (km)	%NoData	2004	2005	2006	2007	2008	2009	2010	2011	Accum.	Annual Rate
Area	43%	0	6	13	25	0	0	38	19	100	13
Area to 5km	22%	56	100	19	138	294	881	825	75	2,388	318
5km to 10km	16%	100	406	525	513	819	606	481	163	3,613	482
10km to 20km	14%	94	1,138	638	844	769	725	788	156	5,150	687
Area to 20km	**22%**	**250**	**1650**	**1194**	**1519**	**1881**	**2213**	**2131**	**413**	**11,250**	**1,500**

A similar analysis of the impact on the Alexander Von Humboldt National Forest was also performed. In a 20 km buffer zone around the protected forest Terra-i detected a total deforested area of 30,650 hectares over the 7.5 years analysed, equivalent to an annual loss rate of 4,087 hectares per year.

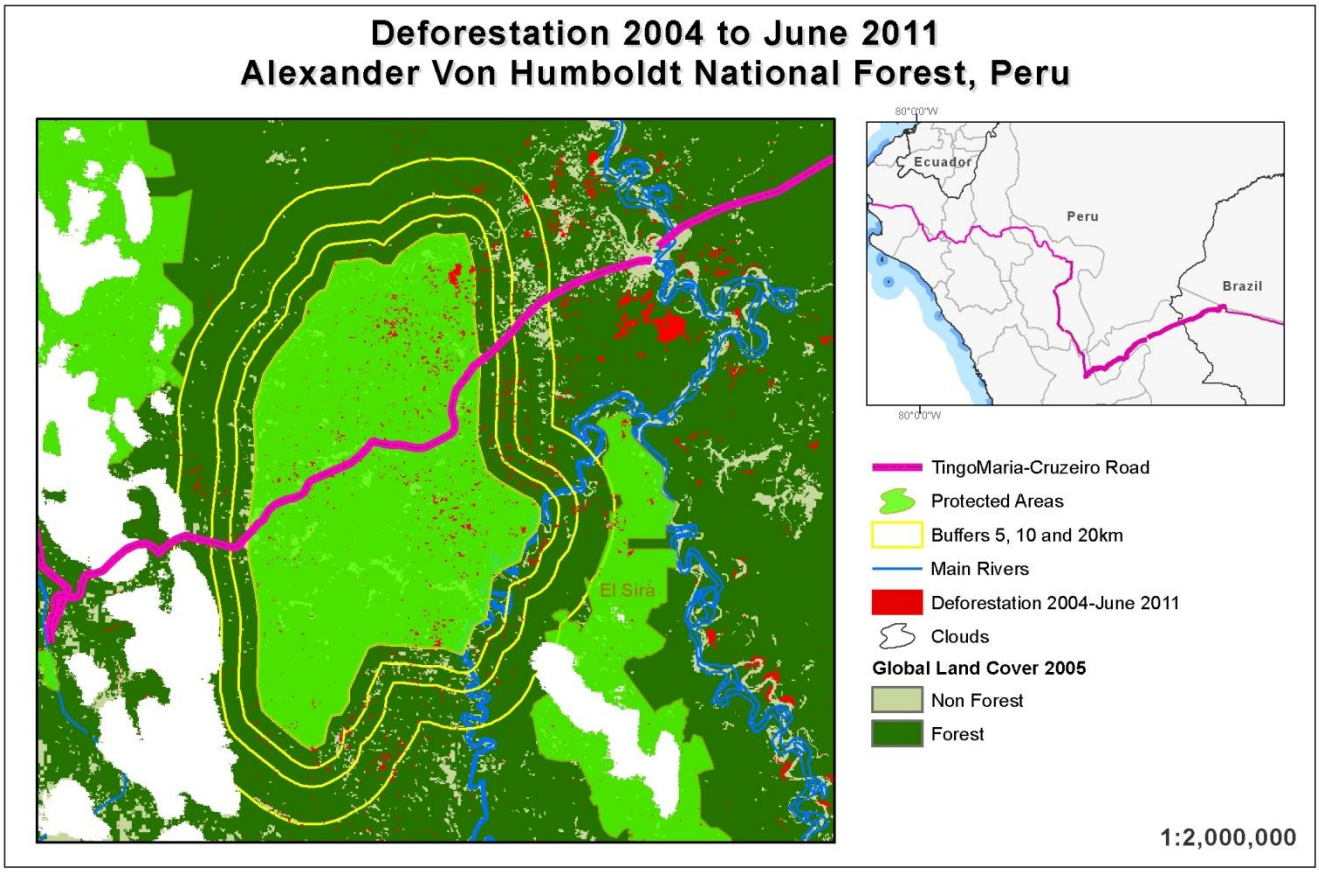

Figure 11. Map of Impact in Alexander Von Humbolt National Forest, Terra-i detection.

Table 4. Impact Analysis buffer area in Alexander Von Humbolt National Forest.

Buffers (km)	%NoData	2004	2005	2006	2007	2008	2009	2010	2011	Accum.	Annual Rate
Area	0.0%	769	1,344	819	706	4,244	4,281	2,088	1,094	15,344	2,046
Area to 5km	0.0%	169	306	250	325	1,119	1,506	406	225	4,306	574
5km to 10km	0.1%	125	406	219	156	1,563	1,294	456	181	4,400	587
10km to 20km	12.2%	519	1,400	438	250	1,656	1,500	506	331	6,600	880
Area to 20km	**3.7%**	**1,581**	**3,456**	**1,725**	**1,438**	**8,581**	**8,581**	**3,456**	**1,831**	**30,650**	**4,087**

The Blue Mountains National Park (PNCAZ) is located between the rivers Huallaga and Ucayali, in the departments of San Martin, Loreto, Ucayali and Huanuco and has an area of 1,353,190.85 hectares. It protects the country's most intact high tropical forest and is home to unique plants and animals. Its steep altitudinal gradient, from high forest to the Amazon plain, is comprised of various types of biologically rich ecosystems with global value. A variety of unique flora and fauna are concentrated here, including a high number of endemic species.

In a 20 km buffer zone around this protected forest Terra-i detected a total deforested area of 11,131 hectares during the 7.5 years analysed, equivalent to an annual loss rate of 1,484 hectares per year.

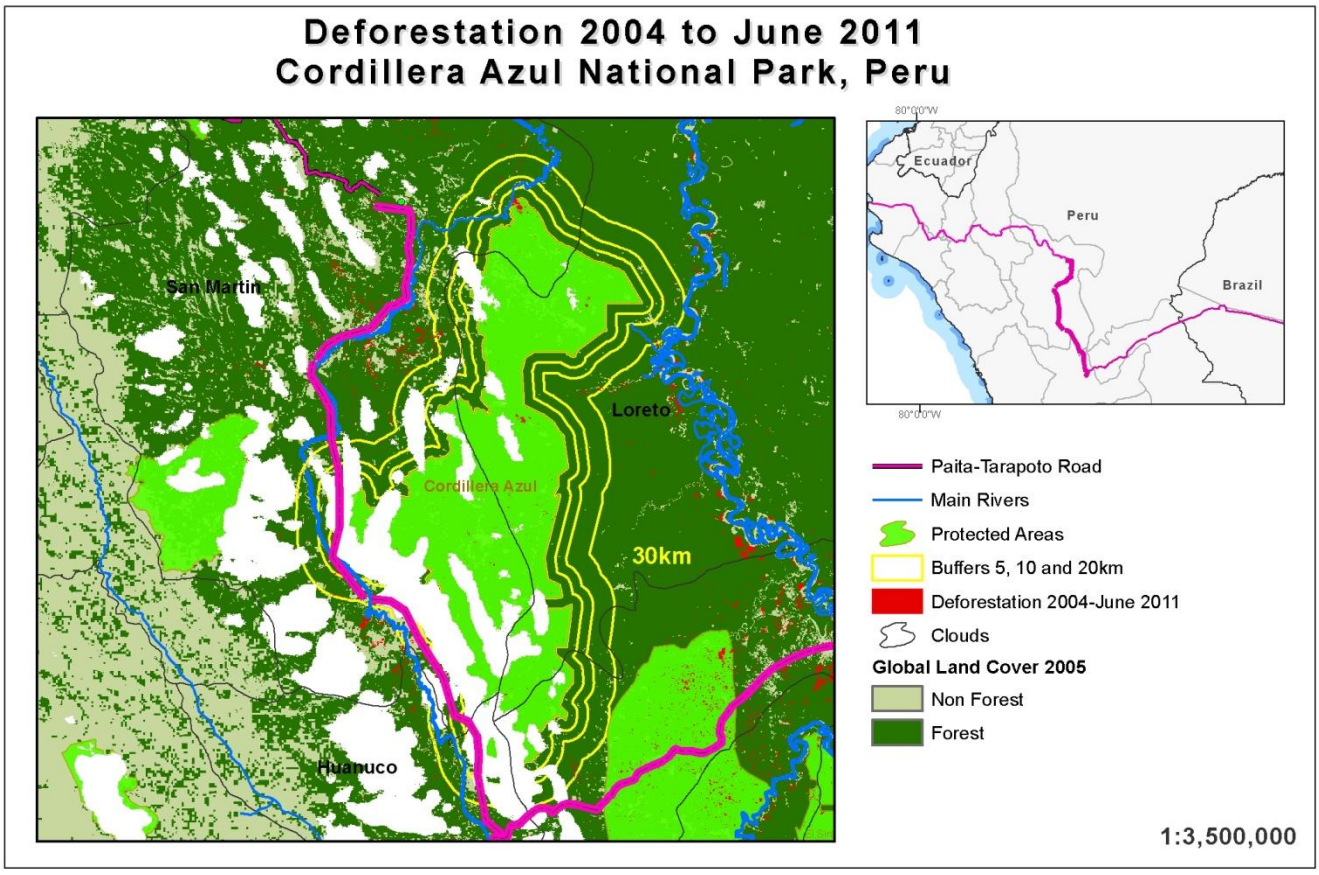

Figure 12. Map of Impact in Cordillera Azul National Park, Terra-i detection.

Table 5. Impact Analysis buffer areas in Cordillera Azul National Park

Buffers (km)	%NoData	2004	2005	2006	2007	2008	2009	2010	2011	Accum.	Annual Rate
Area	22%	1,794	81	256	150	369	175	75	538	3,438	458
Area to 5km	32%	419	38	13	19	106	194	44	63	894	119
5km to 10km	22%	50	69	150	56	156	288	581	150	1,500	200
10km to 20km	14%	144	425	313	463	975	1,481	844	656	5,300	707
Area to 20km	**21%**	**2,406**	**613**	**731**	**688**	**1,606**	**2,138**	**1,544**	**1,406**	**11,131**	**1,484**

Carbon Stocks and Biodiversity

As part of ongoing projects in the pan-tropical region, Woods Hole Research Center scientists and their collaborators generated a national level aboveground dataset for tropical countries. Using a combination of co-located field measurements, LiDAR observations and imagery recorded from the Moderate Resolution Imaging Spectroradiometer (MODIS), WHRC researchers produced national level maps showing the amount and spatial distribution of aboveground carbon (WHRC n.d.).

As shown in Figure 13, the major carbon stocks are concentrated mainly in the area within the biogeographical boundary of the Amazon. One can observe that the carbon stock are very low, less than 200 megagrams per hectare in the area of influence of the IIRSA highway (from 0 – 50 km away). This is also the case with nearby rivers. Therefore, we concluded that the rate of deforestation in Peru is strongly associated with the disordered colonization processes of population migration from the Andes to the Amazon plain. Migrant farmers establish their farms in areas with easy access, i.e. close to rivers and roads, and by applying the slash and burn method they transform the existing forest cover to agriculture and extensive livestock land.

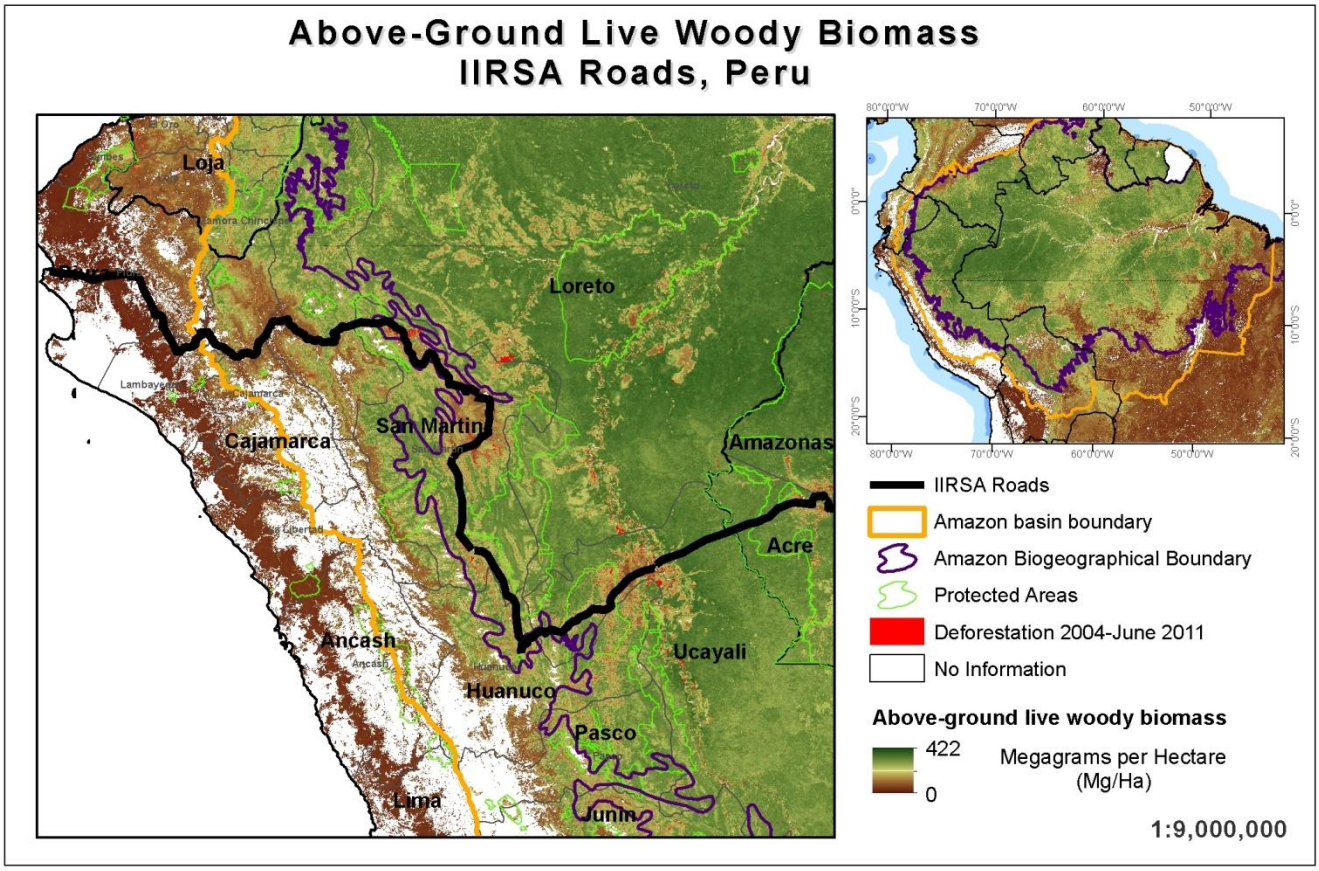

Figure 13. Above-ground live woody biomass in Peru.

Furthermore, about 61% of the Peruvian territory is registered by The Center for applied Biodiversity science at Conservation International as a High biodiversity wilderness area. The Amazon rainforest of Peru is one of the most biologically diverse areas on earth; it is second only to Colombia in species of birds, and third in terms of mammals.[2]

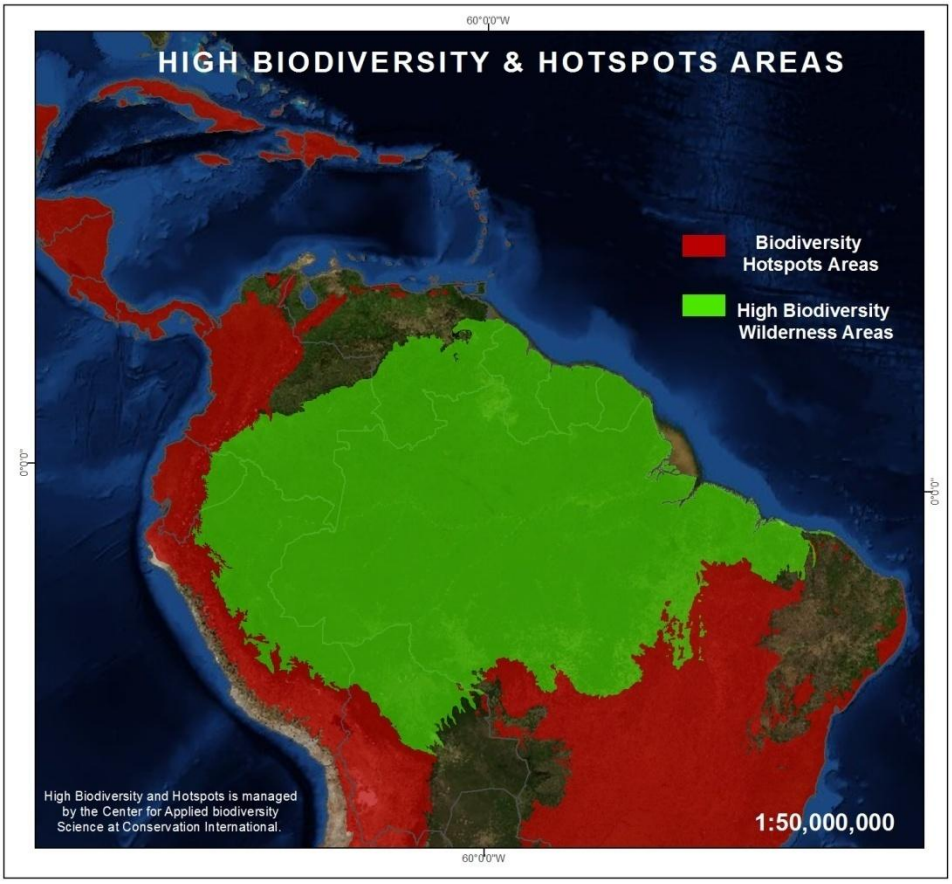

Figure 14. Biodiversity map in Latin America.

[2] Clements, James F. (2000). Birds of the World: a Checklist. Cornell University Press.

Conclusions

In Peru, Terra-i monitored habitat loss every 16 days from the 1st of January 2004 until the 10th of June 2011 and detected a cumulative loss of habitat during the 7.5 years analysed of 350,894 hectares nationwide, equivalent to an annual rate of 46,786 ha/year. The highest rates of deforestation were detected in the departments located in the Amazon, including Amazonas, Loreto, Madre de Dios, San Martin and Ucayali. The main deforestation driver, according to a study by the Peruvian Ministry of the Environment, is agricultural expansion (MINAM Peru 2009). This same study notes that Amazon soil is not viable for agriculture. When soil fertility inevitably starts to decrease, settlers must move to another place to start again with the same method.

It should be noted that deforestation by shifting cultivation and livestock is directly related to the accessibility of forested lands. Therefore, the road can be considered as an enabler that eases access to remote areas and therefore has a considerable negative impact within its area of influence (between 0 km and 50 km from the road). The construction of roads should therefore always be undertaken within development plans protocols that take strategic conservation areas into consideration. Furthermore, strong environmental and agricultural policies should be in place and enforced by local and regional authorities. Such practices can considerably reduce negative environmental impacts associated to road infrastructure development. Otherwise, road projects can be the catalysts that start a complex process of degradation and desertification (Universidad del Pacifico, 2003).

The road impact analysis shows that the buffer zone of 10 km around the road is the most impacted area. For Section 1 (Patia-Tarapoto) which crosses the departments of Piura, Lambayeque, Cajamarca, Amazonas and San Martin an average annual loss rate of 2,464 hectares was measured between 2004 and 2011. Section 2 (Tingo Maria – Tarapoto) lost 1,148 hectares/year and Section 3 (Tingo Maria-Cruzeiro) lost 1,623 hectares year.

In the Peruvian Amazon, deforestation increases alongside road construction and on the edge of rivers due to human settlement and the subsequent shift in land use to cultivation. From the Terra-i data, one can see that the construction of roads close to or through protected areas has the consequences of increasing the deforestation pressure, threatening the conservation of plant and animal species, and compromising the provision of key ecosystem services.

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