



# **ROAD IMPACT ON HABITAT LOSS**

**PANAMA SECTION OF  
PAN-AMERICAN HIGHWAY  
1992 to 2010**



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# Acknowledgements

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# Executive Summary

The following document presents a study of the environmental impact generated by the construction and development of the Pan-American Highway located at the eastern end of Panama in the Darien and Panama provinces. The Pan-American Highway in Panama crosses the Panama Canal and ends at Yaviza, at the edge of the Darien Gap.

The length of the section analyzed is approximately 262 kilometers. More than 10 protected areas with important ecological functions are located within a 30 km buffer zone around the road: Soberania National Park, Camino de Cruces National Park, Chagres National Park, Tapagra Hydrological Protection Zone, Nargana Wildlife Area, Bahía of Panama Wetland, Isla Maje Hydrologic Reserve, Serrania del Darien Hydrologic Reserve, Alto Darien Forest Protection, Filo del Tallo Hydrologic Reserve, Canglón Forest Reserve, Chepigana Forest Reserve, and Darien National Park.

The Darien Gap Rainforest has been described as a "laboratory of biodiversity," and a critical bridge for the exchange of plant and animal species between North and South America. The average rainfall and genetic diversity there are among the world's highest ((PANAM) 2003).

This document presents a detailed analysis of land use change in Panama using satellite images from the years 1992 to 2010, with an emphasis on the area of influence of the Pan-American Highway. We found that between 1992 and 2000 there was an alarming loss of 7% of the total national forest cover. This deforestation is localized mostly in the provinces of Panama and Darien, less than 30km from the Pan-American Highway.

Analysis of land use change in Panama was based on Landsat satellite imagery for 1992 to 2000 and the Terra-i system for 2004 to 2010. As Terra-i is based on vegetation index data, it cannot identify the causes of vegetation change. Therefore, all information on deforestation drivers in this report is derived from secondary sources. The impact of the Pan-American Highway construction was evident mainly in the area of direct influence – between 0 and 10 km from the road – between the years 1992 and 2000. This zone saw the national historic greatest loss of habitat with a cumulative loss of 77,930 hectares, an area equivalent to 32% of the 10 km buffer around the road. It is also evident that habitat loss decreases in proportion with the distance of the analyzed buffer from the road.

# Area of Study

The Pan-American Highway is located in the Darien province in Panama at the eastern end of the country. Its length is approximately 262 kilometers.

More than 10 protected areas with important ecological functions are located in a 30 km buffer zone around the road: Soberania National Park, Camino de Cruces National Park, Chagres National Park, Tapagra Hidrological Protection Zone, Nargana Wildlife Area, Bahía of Panama Wetland, Isla Maje Hydrologic Reserve, Serrania del Darien Hydrologic Reserve, Alto Darien Forest Protection, Filo del Tallo Hydrologic Reserve, Canglón Forest Reserve, Chepigana Forest Reserve, and Darien National Park.

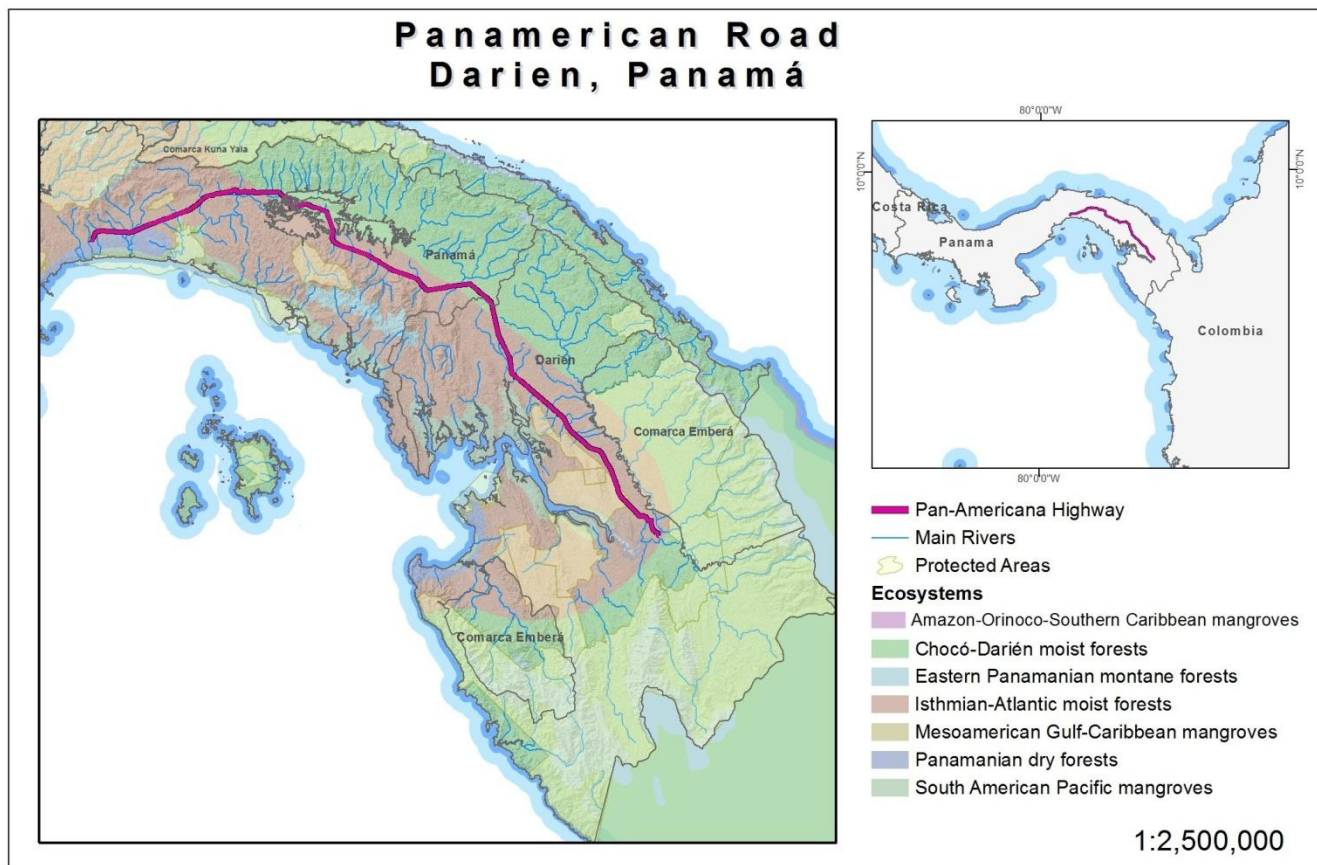


Figure 1. Study Area: Darien Province, Panama

# Habitat Change Monitoring

## Habitat Loss 1992-2000 using ANAM dataset

The Terra-i monitoring system has only been operational since 2004, hence it could not be used to analyze the road construction that took place before that date. Therefore, to detect the change in the ecosystem during the construction and development of the Pan-American Highway a dataset of land cover produced by the Forestry Information System Project of the National Environmental Authority (ANAM) was used. The ANAM is an autonomous governmental entity specializing in natural resource and environmental management. It ensures compliance and enforcement of regulations and national environmental policy by leading, facilitating, overseeing and guiding environmental management for sustainable development.

To create a map of forest cover for 1992 we used the ANAM land cover dataset and reclassified it using GIS software and the data from Table 1.

Table 1. Classes from the land cover map for 1992 produced by ANAM.

Category	Area (Ha)	Classification
Mangrove	169,105	Forest
Disturbed forest	640,821	No Forest
Agriculture	1,455,581	No Forest
Primary successional forest	905,748	No Forest
Other use	1,010	No Forest
Other use	32,602	No Forest
Homogenous orey forest	3,624	Forest
Subsistence agriculture	629,586	No Forest
Flooded forest	45,016	Forest
Mature forest	3,336,280	Forest
Flooded low vegetation	21,052	No Forest
Homogenous cativo	8,774	Forest
Inland waterways	5,605	No Forest
Dunes	6,355	No Forest
Mixed cativo	31,983	Forest
Secondary forest	69,646	Forest



Figure 2. Forest cover map for 1992 generated with dataset from ANAM's Forestry Information System project, Panama. Spatial resolution: 25m

The forest cover map for 2000 was created using similarly reclassified data from the 2000 Land Cover Map of the Republic of Panama generated by ANAM's Forestry Information System Project. The ANAM map is a compilation of satellite images inventoried at different institutions and NGOs, including ANAM, the Panama Canal Authority (ACP), and the National Association for the Conservation of Nature (ANCON). Updated satellite images were acquired for the summers of 2000 to 2001, giving priority to those with low cloud percentage (from 5% to 10%) and with all bands available (seven bands for LANDSAT TM5, eight bands for Landsat TM7, resolution of 25m x 25m per pixel (650 m<sup>2</sup> interpretable)). Finally, administrative and topological data were digitalized and updated based on satellite images as



this information, mainly in the eastern area, did not match the georeferenced images used as basis for the study.



Figure 3. Forest cover map for 2000 generated with the dataset from ANAM's Forestry Information System project, Panama. Spatial resolution: 25m.

Table 2. Classes from the land cover map for 2000 produced by ANAM.

Categories	Area (Ha)	Clasificación
Mature forest	3,002,246	Bosque
Subsistence agriculture	815,687	No Bosque
Disturbed forest	915,857	No Bosque
Primary successional forest	1,142,746	No Bosque
Mangrove	163,455	Bosque
Agricultural	1,067,677	No Bosque
Other use	58,790	No Bosque
Water	5,773	No Bosque
Flooded forest	36,912	Bosque
Secondary forest	70,387	Bosque
Low vegetation	32,876	No Bosque
Homogenous orey forest	3,638	Bosque
Mixed cativo	30,832	Bosque
Homogenous cativo	9,340	Bosque
Dunes	2,058	No Bosque
Planted forest	3,112	No Bosque

These two maps were then compared in order to generate a map showing the trends in forest cover change over the 8 year period between 1992 and 2000. Between those years there was an alarming loss of 7% of total nation-wide forest cover. This deforestation was mainly located in the provinces of Panama and Darien, at less than 30 km from the Pan-American road.

Table 3. Deforestation and reforestation in Panama detected between 1992 and 2000.

Province	Reforestation	Unchanged	Deforestation
Bocas del Toro	269	447,506	10,560
Coclé	16,063	455,067	22,184
Veraguas	10,182	1,009,150	31,000
Herrera	2,806	226,514	4,104
Los Santos	10,199	365,040	3,490
Comarca Embera	9,358	410,762	13,417
Darién	25,650	991,651	169,140
Colón	12,875	401,533	37,740
Panamá	38,612	964,142	109,731
Comarca Kuna Yala	880	231,119	1,894
Comarca Ngobe Buglé	5,937	588,351	86,156
Chiriquí	20,852	614,238	7,893
<b>Total Country</b>	<b>153,683</b>	<b>6,705,072</b>	<b>497,306</b>

The Darien province lost about 14% of its forest cover between 1992 and 2000, while the Panama province lost 10%.

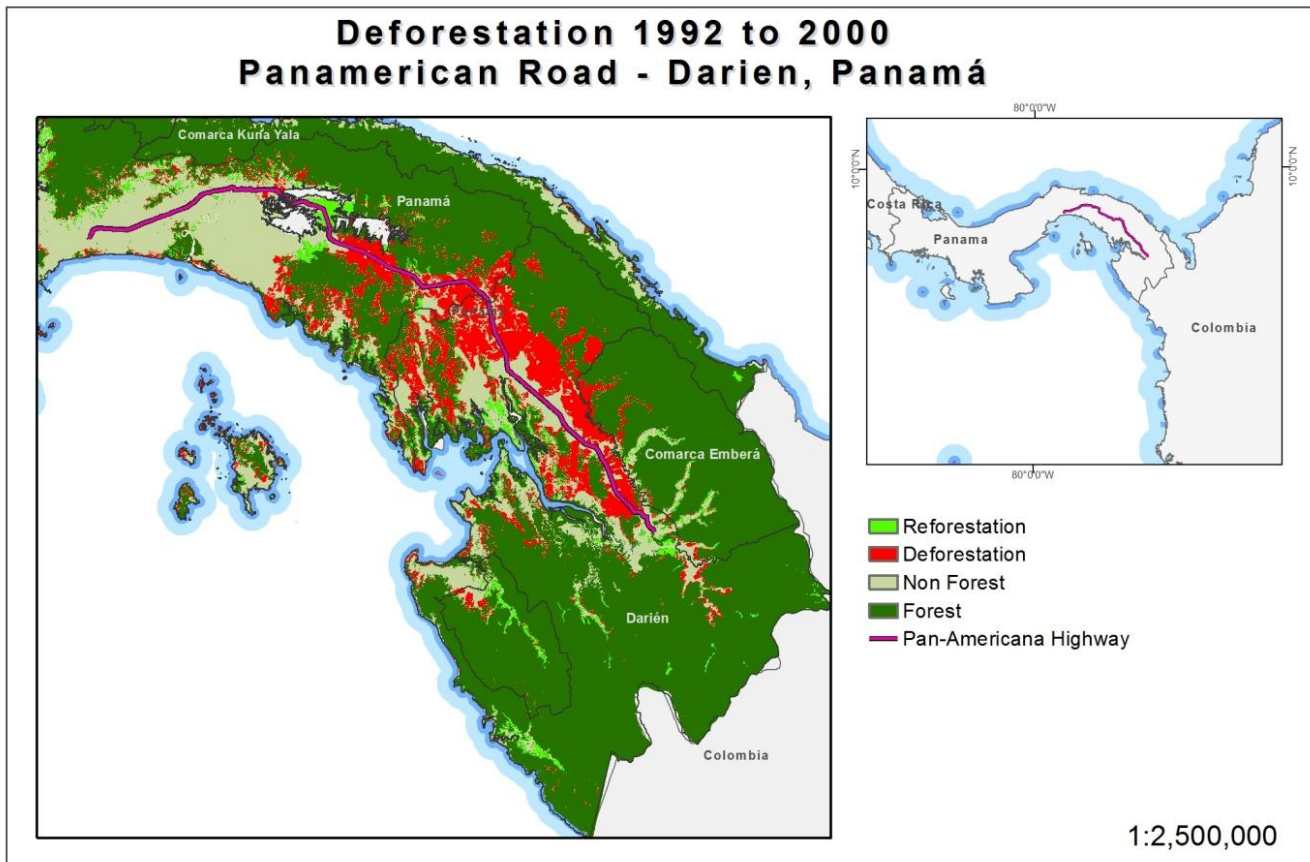


Figure 4 . Deforestation map 1992 to 2000, generated with dataset from ANAM's Forestry Information System project, Panama. Spatial resolution: 25m

# Habitat Loss 2004 to 2010 using Terra-i

As no dataset of land cover for Panama was found with quality and spatial resolution equal to the 25 m resolution land cover maps that exist for the years 1992 and 2000, we were not able to analyze the land cover changes for the years 2001 to 2003. However, it was possible to use Terra-i data to detect forest cover loss from 2004 to 2010.

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 behavior in a time-series of vegetation change. 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.

As shown in the following table, in the Darien province Terra-i detected a cumulative loss of 5,000 hectares between the years 2004 and 2010. Due to bad image quality (high cloud cover), only 53% of the territory was analyzed. In the Panama province, Terra-i detected 12,513 hectares of lost forest cover in the 60% of area that was analyzed.

Table 4. Habitat loss in Darien and Panama between 2004 y 2010 using Terra-i

Province	Area	%NoData	2004	2005	2006	2007	2008	2009	2010	Accum.	Rate
Comarca Embera	433613	51%	81	31	56	13	31	106	356	675	96
Darien	1202213	47%	269	306	344	556	1,206	1,069	1,250	5,000	714
Panama	1125288	40%	944	1,238	1,094	1,331	4,044	2,606	1,256	12,513	1,788

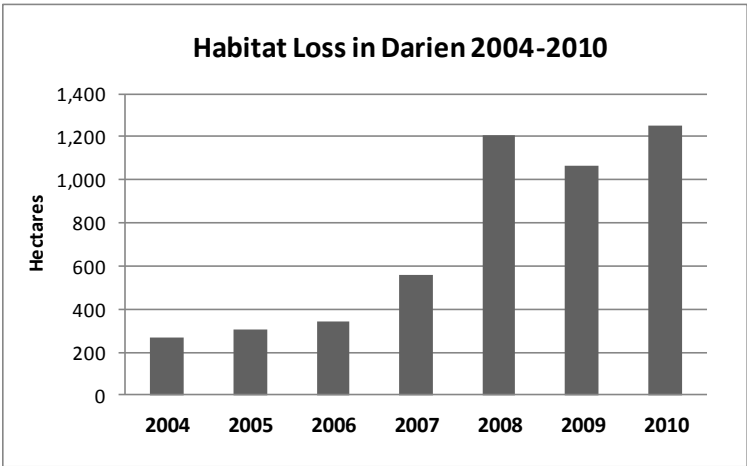


Figure 5. Habitat loss in Darien, 2004 to 2010.

In the Darien province there has been a recent sharp increase in habitat loss, from 556 hectares in 2007 to an average of 1,175 hectares in the years 2008, 2009 and 2010.



## Deforestation 2004 to 2010 Panamerican Road - Darien, Panamá

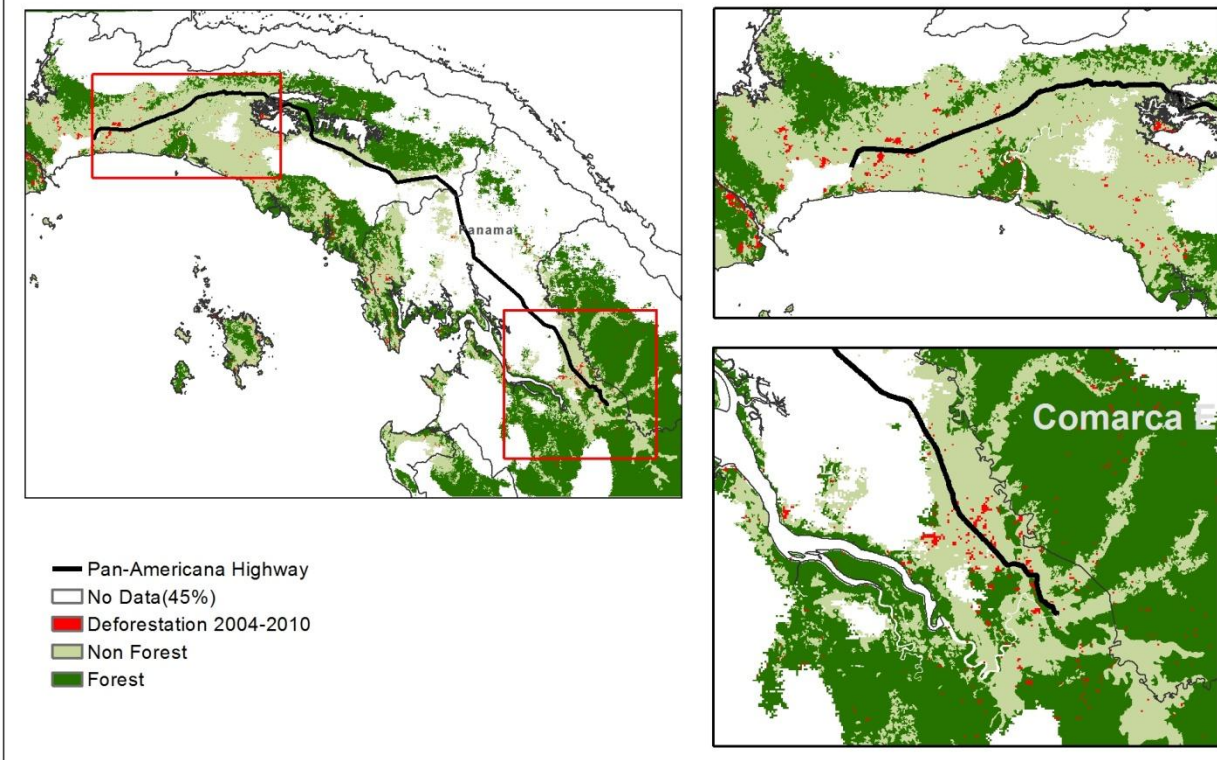


Figure 6. Habitat loss detected by Terra-i between 2004 and 2010.

In the province of Darien 169,140 hectares were lost from 1992 to 2000 and 5,000 from 2004 to 2010. The province of Panama lost 109,731 hectares from 1992 to 2000 and 12,513 hectares from 2004 to 2010.

Table 5. Hectares of habitat loss, 1992-2000 and 2004-2010.

	Land Cover Maps (25m)	Terra-i Detection (250m)
	1992-2000	2004-2010
<b>Darién</b>	169,140	5,000
<b>Panama</b>	109,731	12,513

## Road Impact

Using the 1992-2000 deforestation map generated from the ANAM data and the 2004-2010 satellite data and habitat loss maps generated with Terra-i we conducted an impact analysis in the area of influence of the Pan-American Highway.

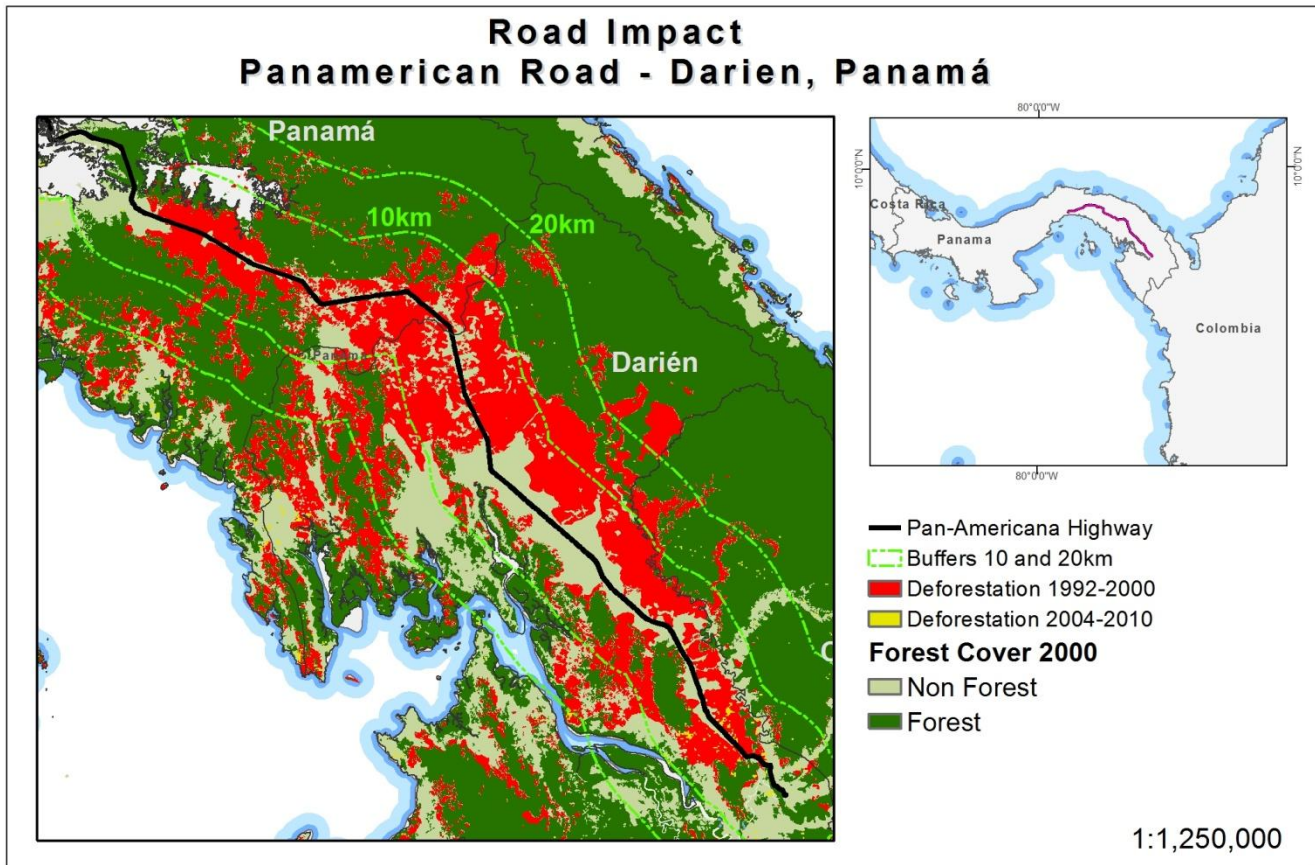


Figure 7. Impact analysis in areas of influence of the Pan-American Highway.

As shown in Figure 7, the highest historic loss of habitat in Panama (77,930 hectares, or the equivalent of 32% of the 10 km buffer zone around the analyzed road) occurs near the segment of the Pan-American Highway in the province of Darien, from the years 1992 to 2000. Table 6 and Figure 8 show that the habitat loss decreases in proportion with the distance of the buffer from the road. In the most remote buffer zone (40-50km) the impact falls sharply to 9,310 hectares.

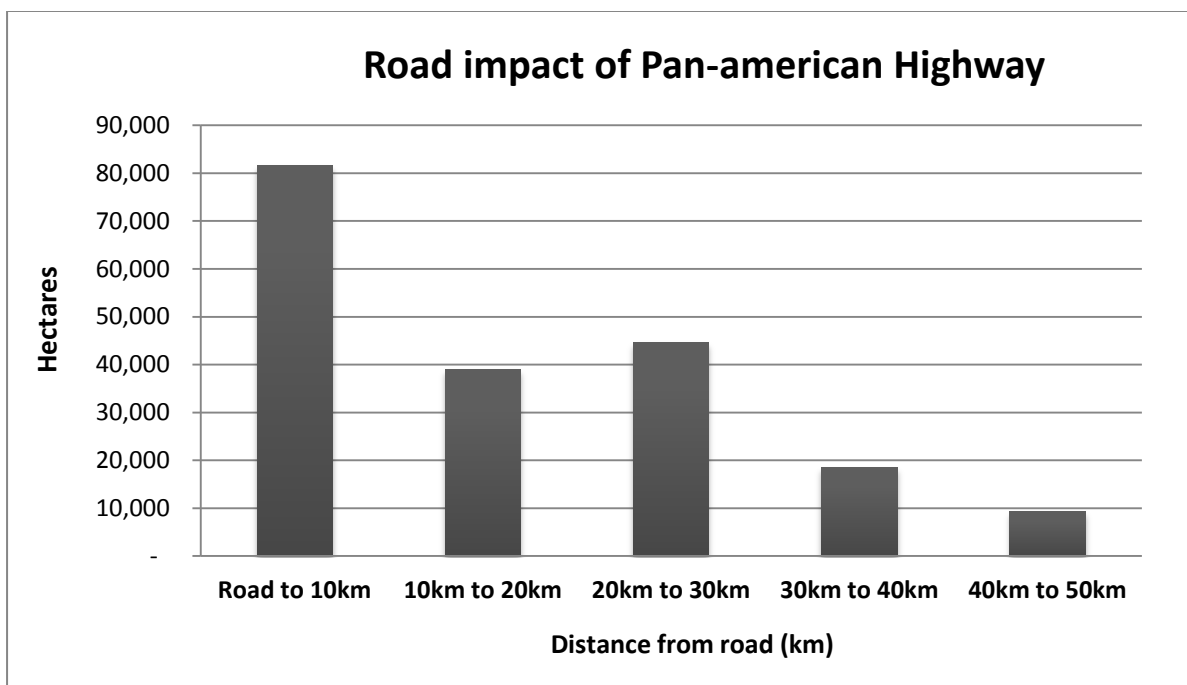


Figure 8. Impact analysis in areas of influence of the Pan-American Highway 10, 20, 30, 40 and 50km from the road.

Table 6. Deforestation and reforestation 10, 20, 30, 40 and 50km from the road.

Buffers	Area	1992-2000	2004-2010	Total loss	%Loss
<b>Road to 10km</b>	253,546	77,930	3,675	81,605	32%
<b>10km to 20km</b>	260,711	37,391	1,606	38,997	15%
<b>20km to 30km</b>	539,159	39,849	4,700	44,549	8%
<b>30km to 40km</b>	497,927	16,051	2,531	18,583	4%
<b>40km to 50km</b>	380,294	7,466	1,844	9,310	2%
<b>Road to 50km</b>	<b>2,450,696</b>	<b>272,150</b>	<b>18,231</b>	<b>290,381</b>	<b>12%</b>

The highway construction process disrupts ecosystem functions, causing biodiversity loss and deforestation. This disruption will only be exacerbated by the traffic that will eventually use the highway. Also a threat is the huge number of settlers seeking free land in the Darien Gap region. Both Panama and Colombia have serious land distribution challenges which will drive the landless poor (and short-term land speculators) into the Darien Gap. The Highway will provide a main artery into the region from which new access roads will spring ((PANAM) 2003).

## 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 the map, carbon stocks are concentrated mainly in the south-east of the country in protected areas, principally Darien National Park and protected mature forests located in the provincial boundary between the Kuna Yala and Panama province.

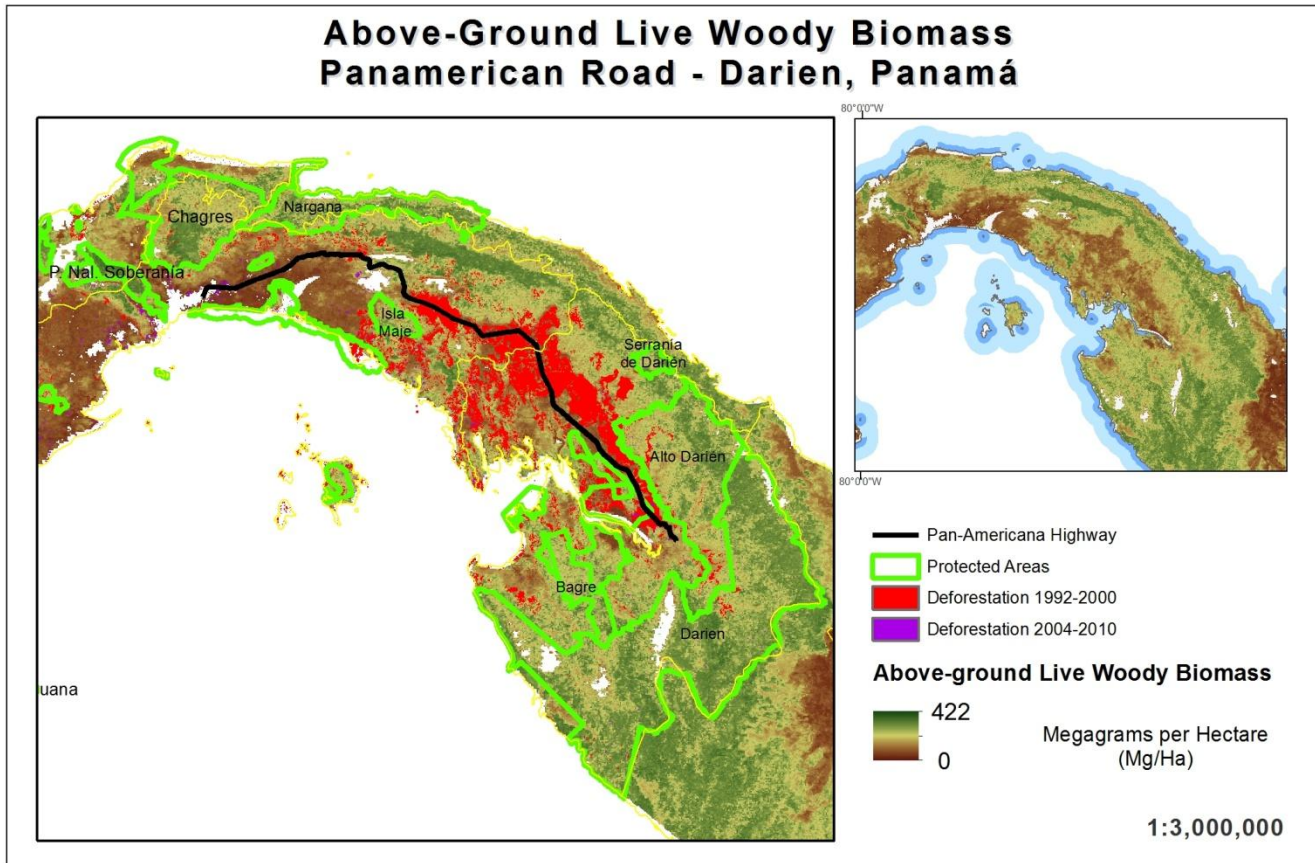


Figure 9. Above-ground live woody biomass in Panama.



Furthermore, Panama is a world biodiversity hotspot. To qualify as a hotspot, a region must meet two strict criteria: it must contain at least 1,500 species (or greater than 0.5% of total world species) of endemic vascular plants, and it has to have lost at least 70% of its primary vegetation. The Mesoamerican Hotspot encompasses all subtropical and tropical ecosystems from central Mexico to the Panama Canal. It is a region with a significant reservoir of biodiversity that is under threat from humans.

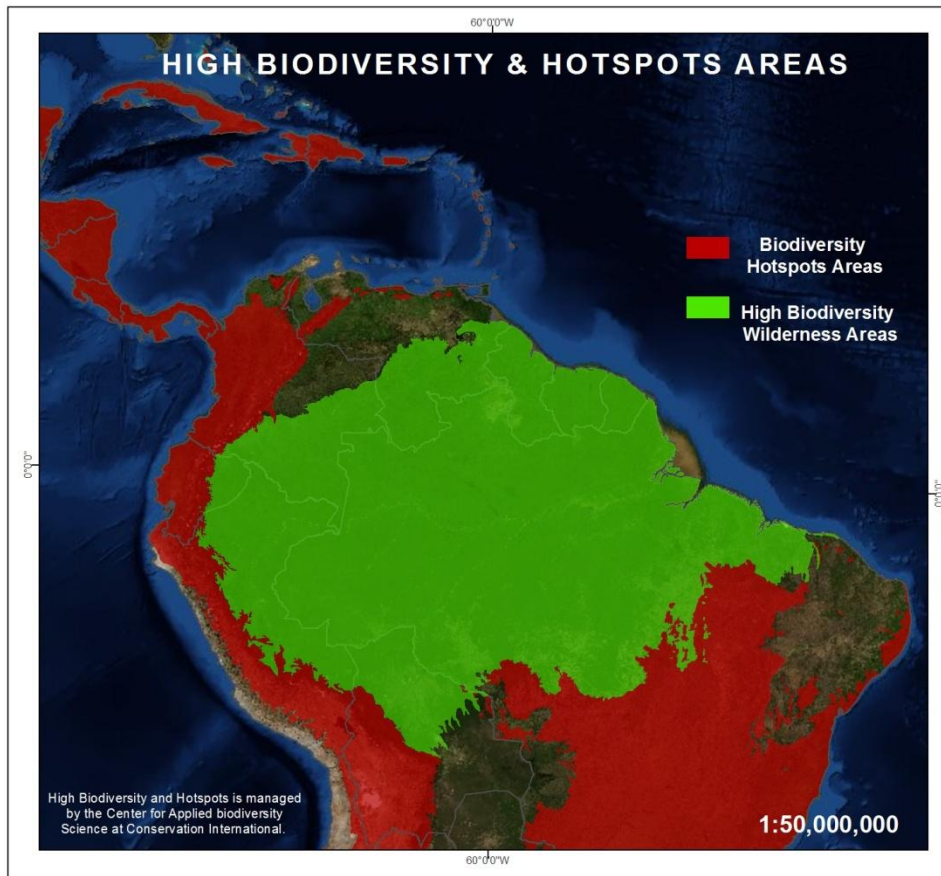


Figure 10. Biodiversity map of Latin America.

# Conclusions

Between 1992 and 2000 there was an alarming loss of 7% of the total national forest cover in Panama, equivalent to 497,306 hectares. This deforestation is localized mostly in the provinces of Panama and Darien, less than 30 km from the Pan-American Highway. The impact of the Pan-American Highway construction mainly occurred in the area of influence, from 0 to 10 km from the road, between the years 1992 and 2000. This area logged the national historic greatest loss of habitat with a cumulative area of 77,930 hectares, or the equivalent of 32% of the 10 km buffer around the analyzed road. The habitat loss clearly decreases in proportion with the distance of the analyzed buffer from the road. Such high rates of conversion around the analyzed road show that it enables ease of access to remote areas and therefore has a considerable negative impact within its area of influence (from 0 to 50 km from the road). The construction of roads should therefore always be undertaken in the context of development plans that consider strategic areas of conservation. Furthermore, there should be strong environmental and agricultural policies in place which are enforced by local and regional authorities. These two strategies could considerably reduce the negative environmental impacts associated with road infrastructure development.

The current carbon stocks of Panama are concentrated mainly in the south-east of the country in protected areas: Darien National Park and the protected High Forest National Park located in the provincial boundary between the region of Kuna Yala and Panama Province. This fact is particularly alarming as imagery of land use change over the past 17 years shows that the greatest loss of ecosystems occurred in the provinces of Darien and Panama, where there are a total of 290,034 and 261,329 deforested hectares respectively. The Darien province lost 24% of its forests, and the Panama province 23%. Most of this deforestation occurred in mixed cativo forest due to cropland expansion. These areas are therefore considered biodiversity hotspots due to the high number of endemic species combined with high threat levels from human origins.

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