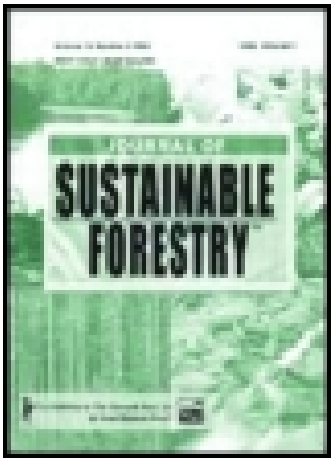

Journal of Sustainable Forestry
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/wjsf20

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Published online: 08 Sep 2009.

To cite this article: Rafael Bernardi De León (2009) Road Development in Podocarpus National Park: An Assessment of Threats and Opportunities, Journal of Sustainable Forestry, 28:6-7, 735-754, DOI: 10.1080/10549810902936607

To link to this article: http://dx.doi.org/10.1080/10549810902936607

Journal of Sustainable Forestry, 28:735–754, 2009

ISSN: 1054-9811 print/1540-756X online
DOI: 10.1080/10549810902936607

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Road Development in Podocarpus National Park: An Assessment of Threats and Opportunities

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Throughout the tropics, processes of ecological degradation, land-use change, deforestation, and frontier expansion have been linked to roads. Roads, and the access they give people, are correlated with the main threats to Podocarpus National Park (PNP). In the PNP region, deforestation and extractive activities are closely associated with roads. Seventy percent of deforested land in a 10-km buffer zone in Zamora-Chinchipe around PNP is within 1 km of a road. Agricultural frontier expansion processes are jeopardizing the success of conservation strategies. However, the development of roads is not an adverse trend from the perspective of all people in the region. Roads provide opportunities for economic development of the region and a means to improve the population's standard of living. Reducing the impact of roads, while securing the interests of all participants, will require participants to (a) integrate large scale road plans in local planning; (b) prioritize and anticipate frontier expansion processes, including those associated with new road developments; (c) increase capacity for participatory patrolling, (d) increase signage; and (e) support participation in road development processes.

KEYWORDS roads, access, agricultural frontier, land use, deforestation, rapid assessment, remote sensing, protected areas, Ecuador, podocarpus

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INTRODUCTION

Roads constitute an archetypical example of the tension between development and environment degradation, as they are necessary for the former and can lead directly to the latter. Achieving a balance between conservation and development goals requires an understanding of the role that roads and access play in land-use dynamics and natural resource extraction. The impacts of roads in protected areas and their buffer zones has been a key issue in the degree of success of protected areas throughout the world (Bass et al., 2004; Cropper, Puri, & Griffiths, 2001; Fearnside, 2002; Strittholt & Dellasala, 2001). In order to bridge conservation and development, it is necessary to avoid undesired effects of roads, and to make sure that the opening of roads is not driven merely by special interests, but reflects the interests of local populations and of different stakeholders in the roads' planning, design, and construction.

This article provides a general analysis of the situation regarding roads and access in Podocarpus National Park (PNP; Figure 1). I look at how roads and access contribute to the threats faced by PNP, and how the positive and negative aspects of roads help and hinder the park from achieving its stated goals (Table 1). I also look at the general trends of road development and land use at the regional and local levels, trying to understand their present and future implications. I briefly present case studies to exemplify the social process that underlies the development of roads. Finally, I make recommendations to reduce problems caused by roads and enhance their positive effects.

METHODS

This study was conducted on a 10-day field trip to southern Ecuador with a group of faculty and students as part of a Rapid Assessment course at the Yale University School of Forestry and Environmental Studies. The trip was preceded by 2 months of preparation, and followed by discussions and analyses. One of our group's objectives was to study Podocarpus National Park, located in the Provinces of Loja and Zamora-Chinchipe, to understand the management policy of the park. We were hosted by The Nature Conservancy (TNC) and Fundación ArcoIris, a local environmental non-governmental organization (NGO) that has had an important role in the history of the park. We visited the park as well as adjacent reserves, and met with more than 30 informants representing more than 15 organizations involved in PNP management efforts.

To further understand the effects of roads, I utilized remote sensing techniques to analyze land cover in the region. I performed an unsupervised classification (all bands) on a Landsat image from 2001 (Figure 2). To

FIGURE 1 Roads and settlements in Podocarpus National Park region. Main Road Axis are proposed highways for international integration. GIS data provided by Fundación Arcoiris.

evaluate accuracy, I performed two different classifications for a total of seven regions, using different sample regions for the "pastures" category, yielding considerable consistency (Table 2). To assess relation of land cover to roads, I created a 10-km buffer around PNP, and calculated total area for

TABLE 1 Goals of PNP (Adapted from Tello et al., 1998). The First Three Goals could be Potentially Threatened by Road Development, While Road Development is a Key Factor in the Achievement of the Last Three Goals. Any Proposed Sustainable Management Should Contribute to a Balanced Achievement of these Goals

Goals of PNP that are potentially threatened by road development
• To preserve a pristine sample of montane and premontane ecosystems
• To maintain Podocarpus forests in a natural state
• To conserve geomorphologic features, vegetation, and soil cover of the upper watersheds of multiple rivers that flow from the mountains
Goals of PNP with potential contribution from road development
• To conserve scenic *páramo* (humid, tropical alpine grasslands) and lake sites for tourism visitation
• To provide opportunities for open-air recreation and environmental education for the region's growing urban populations, particularly of Loja and Zamora
• To support an integrated land-use system compatible with the region, providing opportunities for community development, preservation, and sustained economical use of the area's resources

each land-cover category. Inside this buffer, I then generated 1-km buffers around the roads to compare areas under each category in the Zamora-Chinchipe Region, using a Geographic Information System (GIS) shapefile of roads provided by Fundación ArcoIris (Figure 1).

OVERVIEW: ROADS AND TROPICAL ECOSYSTEMS

Roads are known to cause a series of direct impacts on ecosystems, with habitat fragmentation often considered to be the most important (Spellerberg, 1998). Other effects include physical disturbance, impacts on water, loss of habitat, wildlife mortality on roads, extinction close to the road, habitat change, and wildlife dispersal along roads (including invasive species; Spellerberg). An example in the PNP region is the negative correlation between roads and the habitat of conservation target species such as the spectacled bear (Nogales, Cabrera, Valarezo, Crespo, & Benavides, 2004).

The indirect effects of roads—including frontier expansion, tropical deforestation, and extractive activities—can be more critical than their direct impacts. These effects have been extensively studied in the Amazon region (Fearnside, 2002; Imbernon, 1999; Laurance et al., 2001; Maki, Kalliola, & Vuorinen, 2001; Nepstad et al., 2001; Soares et al., 2004). In PNP, as elsewhere, all activities causing degradation of the park's ecosystem have an "access component" that can determine degradation's spatial location, intensity, and extent: logging, mining, hunting, land conversion (for cattle and agriculture), fires, illegal extraction of plants, and the impacts of infrastructure development. On the other hand, a system of

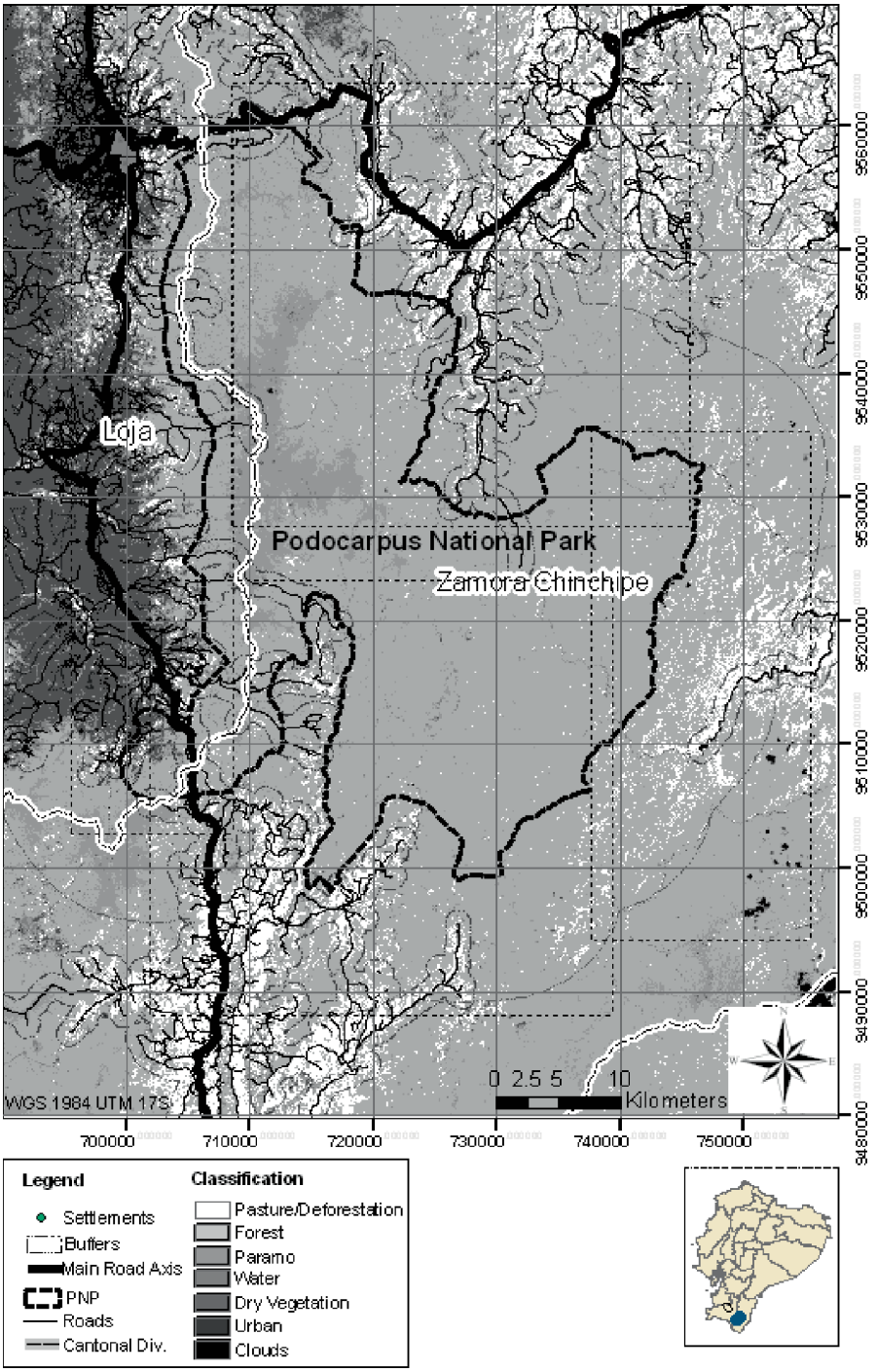

FIGURE 2 Roads and land cover classification of a Landsat TM image (December 3, 2001). Deforestation/pastures are represented in white. Buffers around PNP and roads are shown. Dotted rectangles are general approximations for the E, S, W, N regions.

TABLE 2 User and Producer Accuracies for Two Classification Schemes of a Landsat TM Image (December 3, 2001), in Which Pastures/Deforestation was Classified According to Different Sample Regions. Table Shows Good Agreement Between Classification Schemes

	Pastures	Clouds	Urban	Dry	Water	Paramo	Forest
User accuracy (%)							
Clouds	0.02	99.98	0.00	0.00	0.00	0.00	0.00
Urban	1.69	0.00	98.31	0.00	0.00	0.00	0.00
Dry	5.58	0.00	0.00	94.43	0.00	0.00	0.00
Water	0.00	0.00	0.00	0.00	100.00	0.00	0.00
Paramo	0.63	0.00	0.00	0.00	0.00	99.37	0.00
Forest	1.71	0.00	0.00	0.00	0.00	0.00	98.29
Pastures	95.23	0.00	0.03	0.47	0.00	0.08	4.20
Producer Accuracy (%)							
Clouds	0.00	100.00	0.00	0.00	0.00	0.00	0.00
Urban	0.16	0.00	99.74	0.00	0.00	0.00	0.00
Dry	4.11	0.00	0.00	99.37	0.00	0.00	0.00
Water	0.00	0.00	0.00	0.00	100.00	0.00	0.00
Paramo	0.20	0.00	0.00	0.00	0.00	99.75	0.00
Forest	6.09	0.00	0.00	0.00	0.00	0.00	98.89
Pastures	89.46	0.00	0.26	0.63	0.00	0.25	1.11

good access is fundamental for the economic development of the region by linking producers to markets, generating ecotourism alternatives, allowing for better control of illegal activities, and reducing transport times to services such as health and education. Road density has been correlated both to higher gross domestic product and to land degradation (Wilkie, Shaw, Rotberg, Morelli, & Auzel, 2000).

Agricultural frontier expansion and land conversion are often the result of roads opened by official state policies and economic forces behind extractive activities, including global forces. In Ecuador, frontier expansion is frequently caused by economic booms due to high demand for a resource, after which settlers arrive trying to secure land (Barbier, 2004). This extractive boom pattern might be relevant in the canton of Zamora-Chinchipe, due to a history where colonization has many times advanced in pulses, driven by gold mining industries and governmental plans (Tello, Fiallo, & Naughton-Treves, 1998). One study in Ecuador (Rudel & Horowitz, 1993) shows that even sometimes before a road is built, individuals or organized groups acquire land in expectation of increasing prices and provision of services, thereby driving deforestation. These dynamics of land speculation are similar in the Brazilian Amazon (Fearnside, 2001a, 2001b). Despite recent public pressure and increased awareness of their deleterious effects, roads continue to be problematic. For example, as recent events in Ecuador's Yasuní reserve demonstrate, oil companies still create illegal roads and have not been able to control deforestation and impacts alongside new concession roads, even inside protected areas (Bass et al., 2004).

LEGAL AND INSTITUTIONAL FRAMEWORK

The National Ministry of Public Works is in charge of the construction and maintenance of primary and secondary roads. However, the law of decentralization and social participation of 1997 (*Ley Especial de Descentralización del Estado y de Participación Social, Ley* N° 27, R.O. N° 169, 8-Oct.-1997) transferred the planning, design, construction, and management of side roads within provinces to the Provincial Councils, and of roads within cantons to Municipalities. Road development is regulated by the *Ley de Caminos* (Decreto Supremo 1351, RO/285, 1964). The law and its regulation do not include significant environmental provisions. The law of Environmental Management (*Ley de Gestión Ambiental*, Ley N°37 RO/245, 1999) created the Unified System of Environmental Management (SUMA). Under this law, development of infrastructure that may pose an environmental risk needs to undergo an environmental impact assessment and subsequent approval from the relevant Ministry. In addition, the Law of Forests, Natural Areas and Wildlife (*Ley Forestal y de Conservación de Areas Naturales y de Fauna Silvestre* N° Ley N°74 RO/64, 1981) requires that the patrimony of natural areas must remain unaltered. Any infrastructure construction within such areas must have the authorization of the Ministry of Environment. For roads outside protected areas, the Environmental Impact Assessment is approved by an accredited agency, which cannot be the same one proposing the project. For example, the Ministry of Mines approves roads opened for mine operations, and the Ministry of Public Works approves roads done at the provincial level.

The Ecuadorian government has developed, with support of the Inter-American Development Bank, a Side Roads Program (PCV). This includes the development of participatory road plans (PVP) at the provincial levels. The program seeks to improve road access to smaller communities, increasing their economic opportunities to fight poverty (Ministerial Agreement N°057, R.O. N° 162, 13-Sep-2000). The PVP is intended to decentralize road building, including a series of opportunities for local communities to participate, together with a series of provisions for addressing environmental impacts. While these plans promote participation and greater environmental protection, the delegation of environmental protection functions can be problematic if agencies are not well prepared to apply them correctly. International organizations could provide support for implementations of such plans.

The Law of Environmental Management also requires the Ministry of Environment to generate social, economical, and ecological zoning for each region. The *Ley de Régimen Municipal*, a national law of municipal governance, also requires municipalities to develop land use plans for the cantons. Cantonal and parroquial plans (*parroquias* are the administrative division below *canton*) must also include zoning plans, to be compatible with the management of the productive units, in accordance with the Law of Agrarian

Development (*Ley de Desarrollo Agrario*) and the norms for use of native forests (*Normativa para el Aprovechamiento de los Bosques Nativos*; Becking, 2004). The success of these zoning plans, together with the land titling situation in each region, can be determinant to the land conversion impact by new or improved roads.

TRENDS AND CONDITIONS FOR ROAD DEVELOPMENT

Local development processes need to be situated within the larger context of road planning, looking at the general conditions for the region and then downscaling to the particularities of each local process. In this section, I analyze the national/regional road context, and then provide a more detailed analysis of the trends and conditions that are directly associated with roads and access in PNP and its surroundings.

The National and Regional Context

The development of Ecuador is centered around Quito and Guayaquil. Road access to the south of these urban centers has occurred slowly, due to the rugged Andean topography. To give an idea of the infrastructure in place, it takes at least 12 hours to go by bus from Quito to Podocarpus National Park (647 km). Strategic road plans for Ecuador's international integration include an Andean and an Amazonian axis (Ministry of Public Works, 2002). The Andean Axis includes three main highways or *troncales*: coastal, *sierra*, and Amazon. The sierra component goes through Quito to Loja and continues south, and the Amazon component comes from the north through Zamora, where it connects to the sierra component through Loja. The Amazon axis comes from Puerto Bolivar and reaches Zumba through Loja (Figure 1). These plans include a strengthening of the road to the south from Loja, and no plans of enhancing the road system to the south of Zamora. In addition, long-term improvements are being planned for the Loja-Vilcabamba and Loja-Catacocha sections (Ministry of Public Works, 2002). These roads are part of inter-governmental plans for the region viewed as fundamental for the economic integration of the Amazon and Andean regions. They also include joint plans for road integration between Ecuador and Peru (Ministry of Public Works, 1999). In the broader national context, it would therefore seem appropriate to consider a scenario with heavier traffic in the sections between Loja and Zamora and on the western border of PNP.

The Loja-Zamora road suffers from regular landslides that debilitate transport conditions. In fact, during our assessment, a landslide prevented us from reaching Zamora. These landslides occur in the kame terraces of glacial origin and poor structure, soils that are present in certain slopes in

the region (M. Ashton, personal communication, March 16, 2005). Most occur during the rainy season when rainfall saturates the soil and increases its specific weight, making the slopes more unstable. According to Hernán Lucero, a professor at the Technical University of Loja, increasing the drainage with artificial drains may provide a solution to this problem in some areas, depending on the conditions of natural drainage and the type of failure.

Although slope hydric repairs could be a more effective long-term solution, current economic interests built around regular debris cleaning and post-facto work on slopes could be preventing resolution of these issues. Given the dependence of Zamora on this road, keeping it functional is a fundamental issue for development in the region, and source of potential tensions between road users and authorities.

The Cantón Nangaritza is currently promoting a plan to build a road between Zumba and Zamora-Guayzimi. This plan remains controversial. Even though this road will open the eastern region to new economic activities, it is unlikely that it will be part of the main transport corridors given existing infrastructure and large-scale plans for the region. Therefore, it may not be the best solution to connect the south with the rest of the region.

Considering the poor conditions of many of the roads we traveled through, and the experience with existing roads in the Amazon region in general, it is necessary to make sure that a new road in the PNP area does not follow a pattern of generating access for boom-and-bust extractive activities like mining and logging. Such activities bring in new settlements and set in motion a rapid process of land conversion and deforestation. Without adequate infrastructure in place, once extraction exhausts the resource, the failure to assure the maintenance of the roads and other services in the region reinforces poverty for the settlers and conditions that prevent further economic development. From a regional perspective, a more sound strategy than new road construction would be to work on improving the existing infrastructure, thus reducing travel times to markets.

The recent Programa Podocarpus funded an ecological-economic zoning study by the Centro de Informática Agropecuaria (CINFA), the "Reinaldo Espinosa" herbarium of the Nacional University of Loja, and the Municipality of Nangaritza. This study generated land-use planning proposals for the region that could be used for better planning in anticipation of road opening (Becking, 2004). Such zoning plans, in combination with land property formalization, can help minimize negative impacts of new roads (Bernardi de Leon, 2005).

Roads, Access, and Land Use Around PNP

The classification of land covers for 2001 (Figure 2) shows distribution of land-use types. Areas under pastures or crops (non-forest vegetation) were classified as "pasture." Analyses were done in four generic regions (N, E, S,

and W; Figure 2) based on differences in access and on the divisions used by the Management Plan of 1996 (Ministerio del Ambiente, 2004). Remote sensing analysis is focused on three of these regions in Zamora Chinchipe (N, E, and S) that I consider to be "frontier" areas. These areas have ongoing processes of road opening, deforestation, and forest conversion to agriculture. On the western side most potential lands have already been long since converted, most of the landholders have titles (Tello et al., 1998), and rates of forest conversion are relatively small.

Patterns of deforestation are closely related to roads. Remote sensing analysis showed that the ratio of "pasture" to "forests" was found to be 2.6 times as high within a 1-km distance from roads. Seventy percent of land under pastures or crops in the 10-km buffer in Zamora-Chinchipe was found to be within less than 1 km from the existing roads (total area of road buffers is 38% of total area of the 10-km park buffer; Table 3). These patterns clearly relate land conversion to the opening and penetration of roads, and may be the result of ongoing processes of road expansion.

Accessibility to markets is generally correlated with land conversion (an image of distance to markets can be generated in El Condor Information System, http://www.caf.com/view/index.asp?ms=11&pageMs=14890), although some of the latest road developments have not been included in the map). Accessibility can also provide a general picture of where risks zones for the park may be, if considered for each particular context. For example, in most of the areas to the west of the park, the improvement of roads will most likely improve living conditions of populations and will have a limited environmental impact, given the current intensity of land use in that region. This is generally the case for heavily transited roads. Different situations are happening in the Palanda and Nangaritza cantons, where the improvement of roads can also cause new frontier expansion. I will look at the situation

TABLE 3 Area of Land Under Each Category of the Classification. Table Compares Areas for a 10-km Buffer Around PNP, a 10-km Buffer Around PNP in the Zamora-Chinchipe Province, and a 1-km Buffer Around Existing Roads in this Province

Class region area (km^2)	10-km buffer around PNP	10-km buffer just Zamora	1-km buffer on roads in Zamora
Clouds	0.4	0.3	0.1
Dry	430.4	69.5	49.7
Forest	1449.8	1278.7	355.8
Paramo	107.0	60.6	13.7
Pastures	433.0	347.3	247.5
Urban	55.5	10.7	8.3
Water	0.2	0.2	0.0
Total Area	2476.4	1767.3	674.9
Ratio Forest/Pastures	3.3	3.7	1.4
Pastures as percentage of total area	17.5	19.6	36.7
Pastures in 1-km buffer (as % of area in 10-km buffer in Zamora)	n/a	n/a	69.6

around PNP in four broadly defined regions, which I consider to present different situations.

Western PNP

The western regions have the strongest links to markets and present some threats to the integrity of the park. However, the west is also the most economically active area, with sustained tourism and productive industries. Deforestation in Loja province began during colonial times, but the agricultural frontier had been expanding eastward until it was curtailed in the 1980s with the creation of the park. Four thousand hectares of forest remain in the buffer zone to the west of PNP, and 850 ha inside the western slope of the park are currently under agricultural use (Becking, 2005). Keating (1997) estimates that 3.28% of the forest in this region was lost between 1976 and 1989. Current problems include cattle and agriculture in the limits of the park, forest fires, and uncontrolled tourism.

Case study: the road from cajanuma

In 2004, officials attempted to build a 14-km road from Cajanuma to the El Compadre lakes (Lagunas de El Compadre). The road was a joint project of the Loja Municipality and the Regional Program for Southern Development (*Programa Regional para el Desarrollo del Sur,* PREDESUR), a governmental program, with the approval of the regional office of the Ministry of Environment. As planned, the new route would provide vehicle access to tourists across the montane forest at almost 3000 m to the paramo, at the heads of the watersheds that supply Loja and Zamora. This region is a well-documented ecologically important site (Cisneros, López, Ordóñez, & Guzmán, 2004).

A main trail 2-km long and 2-m wide was opened and vegetation was cleared in adjacent sites (Cisneros et al., 2004). The work was stopped after a campaign by members of the Fundación ArcoIris, who physically blocked the road and presented a demand to the Court of Constitutional Guarantees (*Tribunal de Garantías Constitucionales*). ArcoIris' justification for this action centered on the legality of the project, the lack of an environmental impact assessment, and poor consultation with other stakeholders and local communities. In addition, ArcoIris argued that the project posed a risk to bird populations and tourism would only be possible during 2 months of the year due to wet weather conditions that prevent sightseeing most of the time. The court agreed with ArcoIris and the road was not completed.

This project is a good example of showing how roads are often built for economic objectives by powerful actors acting, legally or not, without considering the many social and ecological effects that new roads may have. The aborted road also shows the vulnerability of the park and

surrounding ecosystems to these types of interventions, and how civil society organizations can affect the outcomes of road building processes.

Southern PNP

Road development in the southern region of PNP is highly problematic, due to land conversion, extractive activities, and conflicting land uses (Becking, 2004). The southwest sector can be accessed through the Yangana-Valladolid road, which cuts across a section of the park, generating problems of fires and wood extraction (Becking, 2004). In addition, a road that was built by the military in Cerro Toledo to install surveillance equipment allows vehicular access from Yangana to the higher parts of southwestern Podocarpus, and trails connect this part to the settlements of Numbala and La Esmeralda, in the inner section of the horseshoe that the park forms to the south.

It was not possible to find out the reasons why the land around La Esmeralda (see Figure 1) was initially excluded from the park, although it possibly involved the Ecuadorian state's lack of funds to buy these lands. Even though it contains pastures for livestock, currently there is no population living inside this region (Becking, 2004). In terms of access, this is one of the more threatened regions of the park, with remaining *Podocarpus* forest, current agricultural activity, and extensive borders that are difficult to control, creating problematic edge effects (Figure 2). In addition, invasions continue in its eastern section.

The southeast part of the park's buffer zone is now an advancing agricultural frontier. Roads are being built in the region toward the eastern Amazon lowlands in proximity to the park. A road is slowly advancing toward the village of Loyola (35 families; Stern, 2002; L. Medina, personal communication, March 14, 2005). According to the director of the Programa Podocarpus, this road has increased the rate of extraction of mahogany (*Swietenia macrophylla*) and other trees (Becking, 2005). Deforestation in this area is expected to wipe out half of the remaining *Podocarpus* in the years to come (Becking, 2004). This road has had no technical planning or environmental impact assessment. The lack of communitarian land-use planning has accelerated wood extraction (Becking, 2004). This goes hand in hand with a process of immigration, as settlers come from the dryer regions of western Loja province to both the highlands and the Amazon Lowlands. Several dozen families are known to have established themselves in these regions of the park in the last decades (Stern, 2005; L. Ordóñez, personal communication, March 15, 2005). These processes pose great risk to the park and its buffer zone, and without appropriate land-use planning will have heavy impacts on the park's connectivity. The slowly unplanned access can generate unmanageable situations in the case of future extractive booms.

The southwest area presents problems of illegal extraction of timber (mainly in Numbala) and other forest products, as well as one example of

collaborative patrolling that suggests how roads can be used to enforce regulations in the region. This patrolling is spearheaded by the Jocotoco Foundation, a bird-conservation organization that owns a 2000-ha reserve next to the park. Working with the police office, Jocotoco has financially supported local police to place road controls to stop the periodic heavy extraction of a palm species (*Ceroxylon parvifrons*) that provides habitat to the endangered golden-plumed parakeet (*Leptosittaca branickii*). The palm is used for local celebrations on Palm Sunday. It appears that this control effort is thus far successful in limiting extraction.

Eastern PNP

During our field trip, the eastern zone of the park area could not be assessed. However, satellite images for the year 2001 (Figure 2) show conversion of forests along the roads that are penetrating the region from the north and the south. This reinforces the need to generate plans to protect this region's connectivity.

Current extraction of timber in Nangaritza is coupled with mining and land speculation (Becking, 2005). Given this situation, the proposed Guayzimi-Zumba "green road," as it has been termed by the Provincial Council of Zamora-Chinchipe, could potentially exacerbate this situation. However, current land-use patterns indicate that a de facto connection of the agricultural frontier of Guayzimi and Zumba could happen in lands claimed by the Shuar community, inside the Nangaritza Protective Forest, contiguous to the park. Such a connection may have potentially important consequences for the ecological connectivity of the microregion. The ecological impact of this connection may depend on several factors, like the quality of the infrastructure, the land-use plans and titling of the lands in the region, and the agricultural and socio-economic drivers of land conversion. For example, Shuar Federation officials have recognized that roads have "advantages and disadvantages" (Rudel & Horowitz, 1993, p. 84). Shuar populations used to have different patterns of land use, with less focus on cattle production than colonists and a wider use of the rainforests (Rudel & Horowitz, p.84). However, Shuar patterns are changing as a result of colonization and the loss of traditional land, and mixed subsistence crops are being substituted for cattle raising (Tello et al., 1998). Landholders inside the Nangaritza Protective Forest (although mostly *mestizos*) use 65% of their land for cattle ranching, and 20% for agriculture (Fundación ArcoIris et al., 2004).

The impact of new roads in this region will thus depend on current formalization processes of land reclaimed and land-use patterns by the Shuar and other local populations. A stripe of land contiguous to PNP to the east is currently a planned Shuar reserve. This reserve continues to the southeast of the park, and could link PNP with the Cerro Plateado-Tres Picachos Ecological Reserve in the Nangaritza Protective Forest (Becking, 2004). To

maintain connectivity in this area under current colonization pressure is crucial for PNP. Unless land-use zoning regulations are able to incorporate current land uses and demands from the communities in their design, their enforcement will be a difficult, if not impossible, task.

Northern PNP

The road to Zamora was opened in the 1950s in the advance of the mining frontier. In the 1980s, the mining settlement of San Luis, inside the park, developed from a concession by the Ministry of Mines (then INEMIN) to the Norwegian-Ecuadorian company Cumbinamasa and the British company Rio Tinto Zinc. A 32-km road was opened and three mining camps were established. Rio Tinto pulled out following pressure by environmental groups, but after the concession was cancelled around 800 small-scale miners settled inside the park (Tello et al., 1998). While an agreement with a mining cooperative and even an army intervention reduced this number to less than 30 today (Becking, 2004), no effort has succeeded in fully removing these settlers.

The access to San Luis through the Jamboe valley is a highly significant threat to the park. Although the permanent mining settlement has been reduced to a few dozen miners (F. Nogales, personal communication, March 16, 2005), roads to San Luis from Zamora and the possibility of reaching PNP's southern region via trails are affecting the park's internal connectivity and providing access for extractive activities. In addition, private landholdings exist inside the park's northern section in Bombuscaro and Curintza (Becking, 2004). These clearings can be detected in the 2001 Landsat image (Figure 2). At the northeastern tip of PNP, around the heads of the Chumbiriatza river, new colonists established their settlement in an area contiguous to PNP and claimed as a Shuar reserve by the Shuar Tayunts Asociation (Becking, 2004).

THE LOCAL DYNAMICS OF ROAD DEVELOPMENT

Analyzing the social process behind the case studies I have mentioned is useful to understand how both road construction and roads' consequences are shaped by the interaction of people and organizations with divergent goals and values.

The mining settlement in San Luis and the aborted road to the Lagunas del Compadre Lakes show similar patterns. Although building a road for tourism may be more sustainable than mining activities, in both cases the processes of road creation obeyed particular sectoral interests that failed to bring participants to agreement on common goals of the proposed access. Both cases resulted in confrontations. In the first, miners had to be expelled by the army, and in the second case ArcoIris led a protest to block the construction of the road.

To clarify and secure the common interest is one of the goals of every effective policy process (Clark, 2002). The case of "collaboratory patrolling" to prevent palm extraction at the Tapichalaca Reserve, supported by Fundación Jocotoco, is an example of how common goals can be reached to achieve a joint solution to shared problems, and transform threats from road access into potentials for ecotourism. However, an explicit definition of common goals is often needed to have a successful inter-organizational coordination. The Jocotoco Foundation is focused almost exclusively on generating habitat that allows for bird watching, and therefore the solutions it supports may not accord with the needs or objectives of other participants. For example, at Bosque del Hanne, another Jocotoco property in the area, fences have been installed around the reserve to prevent cow access, but these fences lack the minimum provisions to allow large mammal movement across them (T. Clark, personal communication, March 12, 2005). At Tapichalaca, local people who harvest the palm will need alternative sources of income, which means that benefits from bird watching should be distributed among local communities. Podocarpus National Park's staff, meanwhile, needs to play a role in patrolling schemes that control access. However, the few rangers do not have proper equipment or uniforms, lack training, and show poor capacity to control access points—a dynamic difficult to understand in a park whose conservation management has indirectly received so much external funding.

Social dynamics get even more complex when we move beyond enforcement to manage common resources and work with the communities around the park. Of all the extractive uses, patterns of land conversion to agricultural activities are the most closely linked to road access. Although other cases throughout the Amazon region show that logging plays a driving role in land conversion by opening roads (Bernardi de Leon, 2005), this does not seem to be the situation inside and around PNP (L. Ordóñez, personal communication, March 17, 2005). Here, extraction of timber proceeds mainly by animal traction and rivers, although the rate of logging will undoubtedly increase in the proximity of roads. The absence of a dynamic of frontier advancement, due to penetration roads being built illegally by loggers or miners, might provide an opportunity to improve the participatory process around local roads built by municipalities and regional councils, and to improve the provisions for roads built by the mining sector.

Land-use change problems seem also to result from a lack of clear policies regarding the lands around PNP. The limits of the park have not yet been clearly defined in many sections. In addition to this, there is incomplete formalization of property ownership and land uses around the park, and no compensation has been offered to people who hold land inside the park. In this situation, new construction of roads will likely result in higher rates of land conversion and deforestation.

RECOMMENDATIONS

Considering the importance of roads and access to every goal of PNP's management (Table 1), it is necessary to look at a broad range of scales and at different social processes. The following recommendations will identify key levels where road-related problems and opportunities could be more effectively addressed. The recommendations place emphasis on incorporating current trends and conditions into critical planning issues around the park for fact-based planning, focus on management actions that could be undertaken by the park's administrators and through cooperative efforts, and address the policy process that maintains current trends. They also focus on the need to prioritize and improve the social process of road planning and construction by establishing and strengthening better mechanisms of participation.

Incorporate Regional Access Plans in the Planning of Local Transport Systems

At the large scale, plans for the region will likely be based on the Loja-Zumba and Loja-Zamora corridors, which will probably be improved over time. Engineering work to prevent landslides and improve the transit on these roads could have positive effects on the park, improving management capability and generating better tourism and development opportunities in its northern area. Their improvement would also grant the communities at the south of the park quicker access to Zamora, which could be a better solution than the proposed new road from Zumba to Zamora-Guayzimi.

Anticipate Frontier Expansion Processes

The park needs to address future threat from the ongoing frontier expansion process in the Zamora-Chinchipe and Nangaritza regions. These processes can disrupt connectivity and isolate the park as they generate encroachment along its limits. The Nangaritza Protective Forest is a step in the right direction, but the success of any plans will likely depend on the result of the Shuar claims of lands and reserves, their patterns of land use, and the government's capacity to solve conflicts with landholders. Frontier expansion is occurring steadily, and the Landsat image (Figure 2) shows a dispersed presence of clearings between Guayzimi and the localities to the south of the park that could be part of a process of closing in the agricultural connection as the frontier advances. This could represent a threat to the park, and needs to be studied in further detail. New roads or extractive booms could drastically accelerate this process.

Reducing these risks will require: (a) defining the park's limits, (b) giving individual property titles and delimiting further reserves, (c) generating specific

land-use plans and zoning in agreement with communities and municipalities, (d) improving participation in road development processes, and (e) working to manage land-use practices in the region (see Leahy, this volume). In addition, added funding to control activities in the frontier areas of PNP should be foreseen.

Considerations for the Guayzimi-Zumba Project

Although pressures by sectoral groups to open new roads can be strong, they can also generate undesired colonization and long-term problems in the region. Assuring a road's maintenance is just as important as building the road, especially when it is not part of main transportation axes. If the decision to build a new road between Guayzimi and Zumba is made, it is critical to consider the long-term goals and effects of a new road in Nangaritza prior to its planning—a process that needs to involve the indigenous Shuar and Saraguro communities, settlers, NGOs, and other participants.

Control and Management Through Roads

Participatory patrolling of roads and access can be a way to enhance current control capacity of the park's management unit. This, however, needs to be articulated with the activities of park rangers, who should act as supervisors or partners of any other actors in charge of patrolling. Currently, park rangers do not have proper equipment and training to effectively do this task. Successful participatory patrolling will require simultaneously greater control by the park's management unit, and greater flexibility in its ability to generate joint projects with police and other participants.

Identify Threats and Priorities of Access

A constant categorization of the present and possible threats regarding different access points is needed to assure efficient patrolling and to identify main and new threats. This could be developed by the park's management unit in cooperation with NGOs or other organizations, using remote sensing, road survey methods, and basic statistics of access for illegal activities.

Signage

At the microscale, I would recommend the installation of clear signs indicating park limits on the roads that go through PNP. Current public visibility of the park is very low, especially in the north and the southeast. Signs could create a sense of authority, educate people about the park, and increase awareness of the park's presence on the most transited road in the Canton of Zamora.

Increase Participation in the Road-Building Process

A potential way to bridge the gap between negative and positive aspects of roads is to establish a truly participatory road-building decision process. For example, the lack of participation by the Ministry of Environment in decisions regarding road construction around PNP is perceived as a weakness in the latest management plan (Ministerio del Ambiente, 2004). Current regulation can provide an opportunity to improve participation, but regulation is not enough. Incorporating communities and stakeholders in decision-making processes needs constant work, not only in the planning but also in the design and implementation phases. Opportunities for participation should be identified at the national, regional, and municipal level, so that road-opening plans do not collide with current participatory efforts underway, such as the Regional Environmental Action Plan (*Plan de Acción Ambiental Regional*, PAAR).

Support Participation in Road Planning

As an overall recommendation, roads need to be incorporated into the priorities of conservation programs. Funds from cooperation agencies and NGOs should be directly allocated to improve public participation in the processes of road planning, and to generate environmental impact assessments. Improvement of existing roads should require serious consideration also, especially for "penetration" roads in frontier areas. The participation of a broad social base, working with provincial councils and municipalities during the design and development of road plans, could help find "common goals" that provide economic and social benefits while conserving the region's natural ecological value.

CONCLUSIONS

Loja and Zamora-Chinchipe broadly characterize two access situations for PNP. Zamora-Chinchipe is now an expanding agricultural frontier, while in Loja land conversion processes have been stabilized. Land cover analysis in a 10-km buffer of PNP in Zamora-Chinchipe show that pastures or crops amounted to 17.5% of the area, with 70% of them within 1-km of existing roads. Access to the park is easy in Loja. Although this can facilitate some illicit activities, it also means greater opportunities for management and control, and makes possible activities like ecotourism and research. Current controlling capacity of the park, however, remains very poor. Even though participatory patrolling can enhance this capacity, it cannot substitute control by park rangers. The access situation in Zamora-Chinchipe is more difficult to control. In addition to extractive activities, probably the greatest current threat to the park is in the expansion of populations in the south (Loyola) and the Zumba-Guayzumi connection. This expansion has the potential to generate

further colonization in PNP's eastern section, which could surround the park in an agricultural landscape, seriously jeopardizing its ecological value. The need to anticipate frontier expansion and define strategies to cope with it is pressing. Additionally, the current municipal and regional road planning should consider the possible impacts of road opening and road improving as well as their benefits, and include the Ministry of Environment and local communities in the process. Finally, road opening and improvement decisions need to be articulated with current management plans for the broader region.

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