Economic Analysis of Three Road Investments through Western Panama´s Barú Volcano National Park and Surrounding Areas

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Executive Summary

Three road investments have been proposed in the vicinity of the Barú Volcano National Park in the province of Chiriquí: (1) a one-lane road from Cerro Punta to Boquete, via the Park; (2) the so-called "southern route" from Cuesta de Piedra to Boquete via Palmira; and (3) paving the access roads as far as the guard stations at the Park's Eastern and Western entrances (see figure 2). This paper provides an economic analysis of the proposals, conducted by Conservation Strategy Fund (CSF) and The Nature Conservancy (TNC) between February and April, 2003. We employed the "Roads Economic Decision Model," developed by the World Bank in 1999. The research was jointly funded by the Nature Conservancy and Conservation International (CI).

Cerro Punta-Boquete: The Cerro Punta-Boquete road is economically infeasible and would represent a net loss to the Panamanian economy, even before considering environmental costs. Our base case envisions 250 vehicles per day, traffic equal to around 25 percent of that on the main two-lane paved roads linking Cerro Punta and Boquete to the Inter-American Highway. This scenario yields a net loss of $808,000 to the national economy in the first 20 years of operations. In order for the road's benefits to be at least equal to its costs (yielding a net present value of zero), an average of 364 daily vehicles would be needed in the first year, over 500 per day by its tenth year of operation and 657 in twenty years. Large hourly, daily and monthly variations would occur, meaning that maximum traffic would be significantly higher than the average. These levels of traffic are incompatible with the road's "ecological" concept, which is to allow motorized transportation to the zone without degrading the ecosystem or harming its species, and without precluding peaceful contemplation of nature. This volume of traffic will also make the road dangerous, slow, or both, due to its 4.5-meter width.

The figures above exclude environmental concerns. A careful Environmental Impact Assessment is needed as a basis for making accurate estimates of environmental costs. In order to understand which environmental impacts have the greatest potential costs, we calculated the economic losses associated with given percentage reductions in potentially affected sectors (see Table 1). Of those quantified, impacts on hydroelectric production and tourism are the only ones likely to prove significant. Indeed, hydroelectricity production declines of less than three percent would cancel out any potential benefits of the road. Because of the volcano's uniqueness and location within a biologically rich region, we expect that the ecological losses could be the largest single cost of the project, but it would take a careful contingent valuation study (a survey method used to estimate values of non-market environmental values) to quantify those costs.

Table 1 – External Costs	
Values potentially impacted	Annual Costs
Water for irrigation	10% decline = $3,035 to $41,207
Water for hydroelectricity	10% decline = $2,200,000
Tourism	10% net decline = $270,000
Park management	Additional costs = $54,000
Biodiversity	Not Quantified

Southern Route: The "southern route" is not a clear alternative for traffic between Boquete and Cerro Punta because it is much longer, although it does cut 40 kilometers from the current route via David. Its value as a transportation investment rests on the substantial number of potential beneficiaries and the significant possibilities for economic development between the road's endpoints. The traffic required to justify it, 490 vehicles per day initially, represents a plausible and environmentally sustainable figure. Environmental damage would be limited because most of the route is already deforested.

Park Access Roads: Paving the already constructed roads to the National Environment Authority (ANAM) stations would make it easier to visit Barú Volcano National Park, but it is not clear that there is enough demand, or management capacity, to justify doing so. According to ANAM records, average daily visitors to the park total around ten people, though the true number of current visitors is probably higher than records suggest, as not every visitor is registered. Visitation would need to increase dramatically to justify the paving project, which requires 232 vehicles per day.

Conclusions: Of these three investment options, the southern route is the most attractive economically, and also best in environmental and equity terms. If improving the entire southern route is judged too expensive, strategic investments in selected sections and river crossings could still significantly improve transportation and spur development. Building the northern Cerro Punta-Boquete route, the so-called "eco-road," would most likely result in a large net loss for the Panamanian economy. It is also clear that the volume of traffic necessary to justify the investment and maintenance costs of the "eco-road" is far beyond the amount of traffic which is compatible with ecotourism or environmental conservation activities.

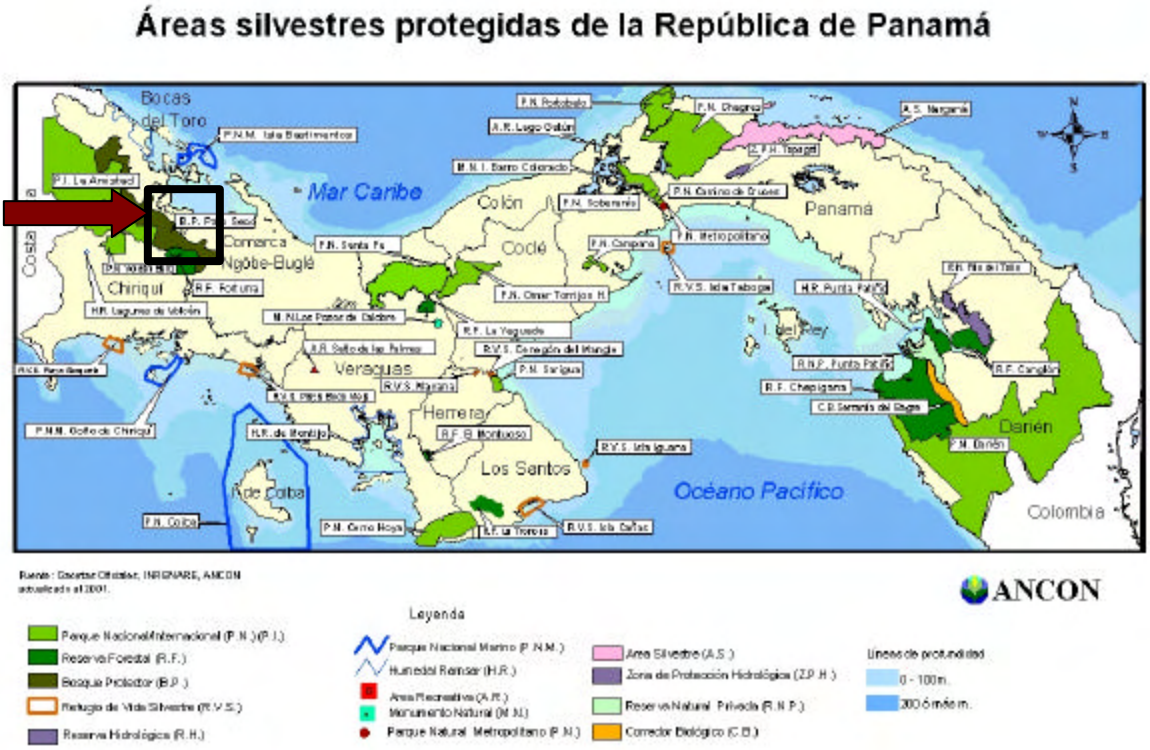

Figure 1: Location of study area in western Panama

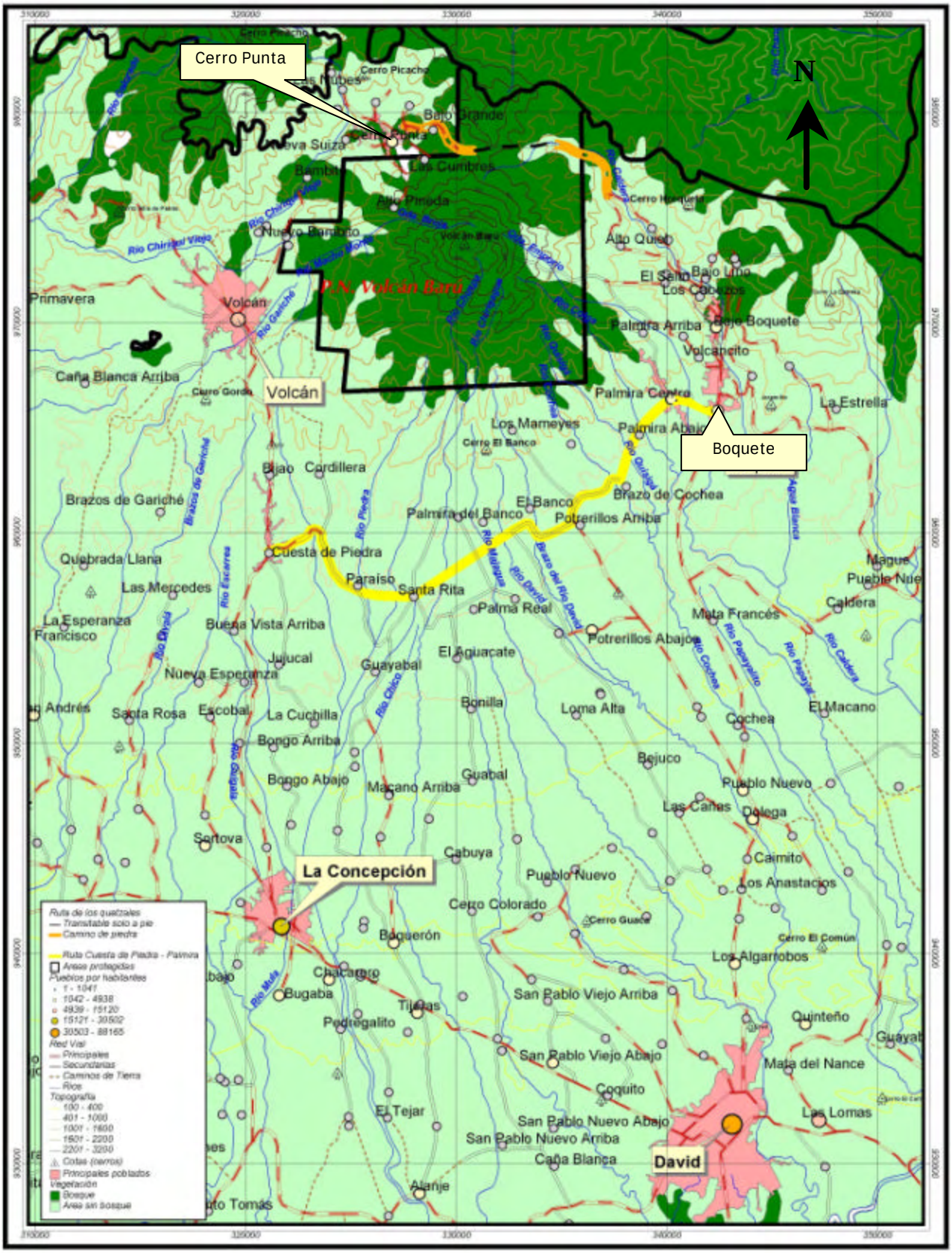

Figure 2: The three road projects considered in the cost benefit analysis. The Cerro Punta – Boquete eco-road includes the orange and intermittent lines indicated in the northern section of the Barú Volcano National Park (P.N. Volcán Barú), the "Southern Route" from Cuesta de Piedra to Palmira is indicated by the yellow line south of the park, and the access roads to the park from Cerro Punta and Boquete are indicated by the orange lines approaching the northern part of the park from the west and east respectively. Forest cover is indicated by the dark green areas.

Foreword

In December 2002 the Panamanian Government authorized the construction of the Cerro Punta-Boquete road project; in fact, this was the third time that it has been promoted in the last 30 years. This project, which goes through the Barú Volcano National Park, was rejected on the first two occasions, because of concerns regarding natural disasters (flooding) and hydroelectric electricity generation. During this third instance the project has once again caused great controversy in Chiriquí and in Panama City because of it environmental, economic and social consequences.

In addition to being part of TNC´s prioritized conservation areas, the Barú Volcano National Park is part of the UNESCO Man and the Biosphere site called PILA. TNC is working through a bi-national, Costa Rica – Panama, conservation program for the La Amistad site which includes, among others, the Barú Volcano National Park and the area which will be impacted by the "Cerro Punta– Boquete eco-road." As we have significant investments projected for the area in the next 3 years, we are finishing a conservation area plan for the site. It is of vital importance for us to understand the details involved with this road project, in order to modify our regional plans accordingly and ensure that our contribution to the area is employed effectively. In addition, as a group who supports protected area management in the entire country, TNC is always willing to collaborate with the Panamanian Environmental Authority (ANAM) and the Panamanian Government on the plans that they develop within these areas, as long as they are consistent with our mission and values.

In order to help provide relevant and complimentary information for the debate concerning the Cerro Punta- Boquete road construction project promoted by the government, TNC-Panama has worked with John Reid from Conservation Strategy Fund (CSF) on an economic analysis of this road project in Chiriquí, and two alternative road investments in the region proposed by groups in the area.

This analysis utilized an economic valuation model for road projects designed by the world bank called "Roads Economic Decision Model," and was funded by TNC and Conservation International (CI). The costs and benefits of the road were examined, with and without consideration of environmental costs. We also evaluated the economic viability of two alternate road investments in the region: a road from Cuesta de Piedra to Palmira (The Southern Route), and paving the access roads to the Park from Boquete and Cerro Punta.

The results of this study were presented in Panama Wednesday April 9, 2003 in an open forum, including participation from the press and a panel of distinguished economists who had an opportunity to offer their opinions of the analysis. These outstanding Panamanian economists supported the analysis and its conclusions unconditionally. The results were also presented in David, Chiriquí Province, on April 7, 2003 in the Chamber of Commerce, Industry and Agriculture of Chiriquí.

TNC- Panama is pleased to present the results of this study, entitled "Economic Analysis of Three Road Investments Through Western Panama's Barú Volcano National Park and Surrounding Areas." We hope that this effort will be useful to interested parties as an additional element in the evaluation of the eco-road project.

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I. Introduction

This economic analysis of the proposed road from Cerro Punta to Boquete in the province of Chiriquí was conducted by Conservation Strategy Fund between February and April of 2003, in partnership with The Nature Conservancy (TNC) Panama. The analysis was funded by TNC, and Conservation International (CI). The purpose of the study is to provide information on the costs and benefits of building this road, called the "*camino ecológico*" (eco-road) by the government, as well as two road investment alternatives in the same region.

The Cerro Punta-Boquete link has been promoted on various occasions. Construction actually began twice in recent decades, in the mid 1970's and again 1992. In both instances the Panamanian government halted the road over environmental concerns and possible flood damage that might be sustained by adjacent communities. A fresh effort began in late 2002 and has continued into the current year. Supporters of the road affirm that it will have important economic benefits. They say the region's tourism economy will flourish once the area is open to motor vehicles and lodges can be built for visitors not willing, or physically capable, of hiking the route. They also envision increases in real estate values, particularly along the route itself. Another purported benefit is enabling Cerro Punta and Boquete farmers to consolidate their production and reap economies of scale in exporting. A further benefit they anticipate is that the road will serve as an emergency escape route from Boquete and Cerro Punta in the event that roads to the Panamerican Highway should be blocked (Group interview with road supporters, Boquete Lions Club, February 24, 2003).

A variety of environmental concerns have driven opposition to the project over the years. Concern over flooding and the watershed's hydroelectricity production goes back to the 1970's. By 1992, opposition was more multifaceted, with protection of biodiversity in Barú Volcano National Park (VBNP) and the La Amistad International Park (commonly known by its Spanish acronym, PILA) surfacing as a major issue. Today, the ecological connection between Barú Volcano and Amistad is a major issue. The forest the road would traverse is perhaps the best nesting habitat in Panama for the resplendent quetzal, an icon of Central American nature and a major tourist attraction.

In this analysis, we measure the costs and benefits of two alternative transportation investments in the region, the Cerro Punta-Boquete road and a proposed road from Cuesta de Piedra to Palmira, which has been dubbed the "southern route" from Cerro Punta to Boquete. We also briefly examine the economics of simply paving the existing access roads to the guard stations operated by the National Environment Authority (ANAM) at the western and eastern entrances to the Barú Volcano National Park. These roads are also segments in the northern Cerro Punta-Boquete plan.

II. The Region

Economy

Cerro Punta and Boquete can be broadly characterized as agricultural communities with fast-growing tourism sectors and a trend toward becoming retirement centers for Europeans and North Americans. Tourism and retirement homes are more common in Boquete than in Cerro Punta. Both are significant producers of vegetables, notably onions, potatoes, strawberries, cabbage, lettuce and tomatoes. Boquete's leading crop is coffee. The district had 10 million of the province's 28 million mature plants as of the 2000 agricultural census (Contraloria General de la República, 2003), and produced 114,037 quintals – more than half the provincial output. The crop was worth an estimated $7.4 million.

Cerro Punta has 7 lodging establishments with 97 rooms, 58 of which pertain to the Bambito Hotel (48) and Forest Resort (10). Boquete's hotel sector is more developed, with 18 establishments, totalling 158 rooms (IPAT 2003). Boquete has around 17 restaurants (Gutierrez 2003). The occupancy rate for the province was 29.3 percent for 2001 (IPAT 2003). Hotel prices vary widely, from around $20 per night to nearly $200 per night. If average double-occupancy accommodation is in the range of $50 per night, the two towns reap on the order of $1.36 million per year in lodging. This figure can confidently be at least doubled to account for food, souvenirs, guide services, transportation and other spending, meaning that tourism brings a minimum of $2.7 million in annual income. This figure leaves out the economic contributions of Panamanian and foreign visitors who own their own homes in Boquete and Cerro Punta.

Demographics

As of the 2000 census, the whole district of Boquete had a population of 16,943, while Cerro Punta, part of the Bugaba district, had a population of 6,860 (*Contraloria General de la República 2003*). As noted above, Boquete in particular has a growing population of foreign retirees. Boquete district household income was $317 per month, slightly above the Chiriquí provincial average of $302 and below the national average of $380. The Boquete figure does not reveal the fact that within the district there is wide variation and some clearly wealthy enclaves, with incomes as high as Santa Lucia's $1,538. Cerro Punta's average monthly income was $285.

Road infrastructure and traffic: Cerro Punta and Boquete are served by two-lane paved roads from the Pan-American Highway. Both towns have small networks of paved roads to some of the surrounding communities. Traffic on the main access roads averages approximately 1000 vehicles per day according to MOP's regional Chiriquí office (Ing. Luís Fanovich, personal communication, February 25, 2003). An informal Sunday count of traffic revealed that the majority of vehicles using paved roads are pickup trucks or similar utility vehicles, followed by cars (See Table 2). Weekday traffic showed similar shares, though the number of cars declined significantly and trucks increased, a shift that is to be expected.

Table 2 – Concepción-Cerro Punta Sunday traffic composition	
Pickup/utility	60%
Car	24%
Small truck	6%
Small bus	7%
Medium truck	2%
Large truck	2%

III. Methodology

To better understand the terrain and proposed road projects, we made field visits that included a tour of the entire Cerro Punta-Boquete route and a tour of the southern route between Cuesta de Piedra and Palmira. We traveled the southern route segments between El Paraíso and Santa Rita and between Brazo Cochea and Palmira Abajo on foot. Interviews were conducted with a variety of people in Cerro Punta, Boquete, David, and Panama City (Please see interview list in Annex 2).

Cost-Benefit Analysis: We conducted a cost-benefit analysis of three possible road investments in the environs of the Barú Volcano National Park: The Cerro Punta-Boquete road, the Cuesta de Piedra-Palmira "southern route," and paving of access road leading to the parks entrances. For all three roads we calculated levels of use that would be required to justify their capital investments and maintenance costs. For the Cerro Punta-Boquete road, we also constructed a base case scenario, calculated the road's net present value[1], and performed a risk analysis to determine the road's likelihood of economic viability.

Costs include the construction and maintenance of the road projects. There are also environmental costs associated with any project of this kind, and we quantify these where possible, without calculating the scale of potential environmental impacts.

Benefits are composed of the savings in travel costs and time on the part of road users, as well as increased transportation activity spurred by the upgraded infrastructure. We aggregate the benefits accruing to all sectors of the economy in our benefits calculation. In other words, the benefits to agriculture, tourism, commerce and all other sectors are added together to determine the road's total benefits. These benefits are compared to the road's construction and maintenance costs to determine whether the investment represents a net gain or loss for the Panamanian economy.

[1] Net present value (NPV) is the standard criterion for determining economic viability. A net present value greater than zero indicates that benefits from a project exceed its costs, after adjusting values for the point in time when they occur.

Benefits were calculated using the *Roads Economic Decision* model, developed by the World Bank (Modeling assumptions are presented in Annex 1). This model aggregates benefits of four different types:

Normal traffic represents vehicles using the road before the road is improved. For example, in the "camino ecológico" case the only normal traffic is that which currently uses the access roads to the park.

Diverted traffic is made up of vehicles that now take an alternative route and would switch to the new road once built. In the "camino ecológico" case, diverted traffic now travels between Cerro Punta and Boquete via David, the provincial capital of Chiriquí. Our interviews in both towns suggested that there is very little traffic between the two towns, with the notable exception of transportation for tourists who travel on foot and then return to the town from which they started by taxi or bus. The overwhelming majority of vehicles on the region's paved roads travel between David and a variety of outlying settlements. Nonetheless, our calculations assume that a small proportion of the area's traffic consists of Cerro Punta-Boquete travelers who would switch to the new road if it were built.

Generated traffic represents latent demand that translates into new users once the road is improved, in other words, people who will begin to travel between Cerro Punta and Boquete once the road opens, but do not now use the David route because of the high cost. This figure is exceedingly difficult to estimate, so we have tested a range of values in the benefits equation.

Induced traffic results from local economic development caused by the road, and is in addition to generated traffic, which is demand on the part of the existing economy. In the event that tourism is the main use of the area along the road, we assume that most induced traffic would be in the form of private cars and utility vehicles, as well as some small buses.

These aggregated benefits accumulate over a twenty-year time horizon and are weighed against the construction and maintenance costs over the same period to give us a net present value using the following formula:

$$NPV = \sum_{t=0}^{n} \frac{(B-C)_t}{(1+r)^t}$$

t = time, in years from the present
n = the analysis time horizon, 20 years in this case
B = benefits
C = costs
r = the real discount rate, which expresses the real inter-temporal preferences of Panamanian society, plus an element of risk (which raises the rate).

Distributional analysis: A project's net present value indicates whether benefits are greater than costs, but does not reveal who receives the benefits and who pays costs. The distribution of costs and benefits is important as a matter of policy and we will examine it briefly for the Cerro Punta-Boquete road and the "southern route."

Externalities: The term "externalities" refers to costs and benefits experienced by people not involved with a particular project. To determine whether a road investment is good for the economy as a whole we need to count these external impacts because they represent real changes in people's well-being. In the short time we had to conduct this study, it was impossible to thoroughly study these costs and benefits, so we will segment our analysis. First, we examine the economic viability of the road projects without counting externalities. Then we look at the value of some external impacts that are most readily quantifiable and relevant to people in the region, and show the impact they would have on the NPV calculation.

IV. Results

"*Camino ecológico*" Cerro Punta-Boquete

The northern route, or "*camino ecológico,*" is defined as an environmentally sensitive road by several characteristics, according to Constructora Urbana, S.A. (CUSA 2002), the firm tasked with design and construction of the 15.5-kilometer project.

1. It would be a one-lane road, just 4.5 meters wide, presumably to minimize impacts on vegetation the route would traverse and create a smaller barrier for wildlife than would a normal two-lane rural highway (which is usually 10 meters wide with 7 meters for the lanes and three meters for the shoulders).
2. CUSA would minimize the trees cut down for the right of way.
3. The road would include three parking areas, three meters by 40 meters each, for motorists to stop and appreciate their surroundings.
4. A weight limit of 10 tons would be imposed, barring large buses and trucks.
5. Rustic wooden informational signs would be posted.

In addition, ANAM Director Ing. Ricardo Anguizola suggests that the road may have a toll, a participatory co-management scheme and perhaps traffic lights at either end to enable controls on the direction and volume of traffic (Personal communication, February 26, 2003). In other respects the road would resemble other low-volume, one-lane paved segments elsewhere in the region. It would have a gravel base with a 0.08 asphalt surface.

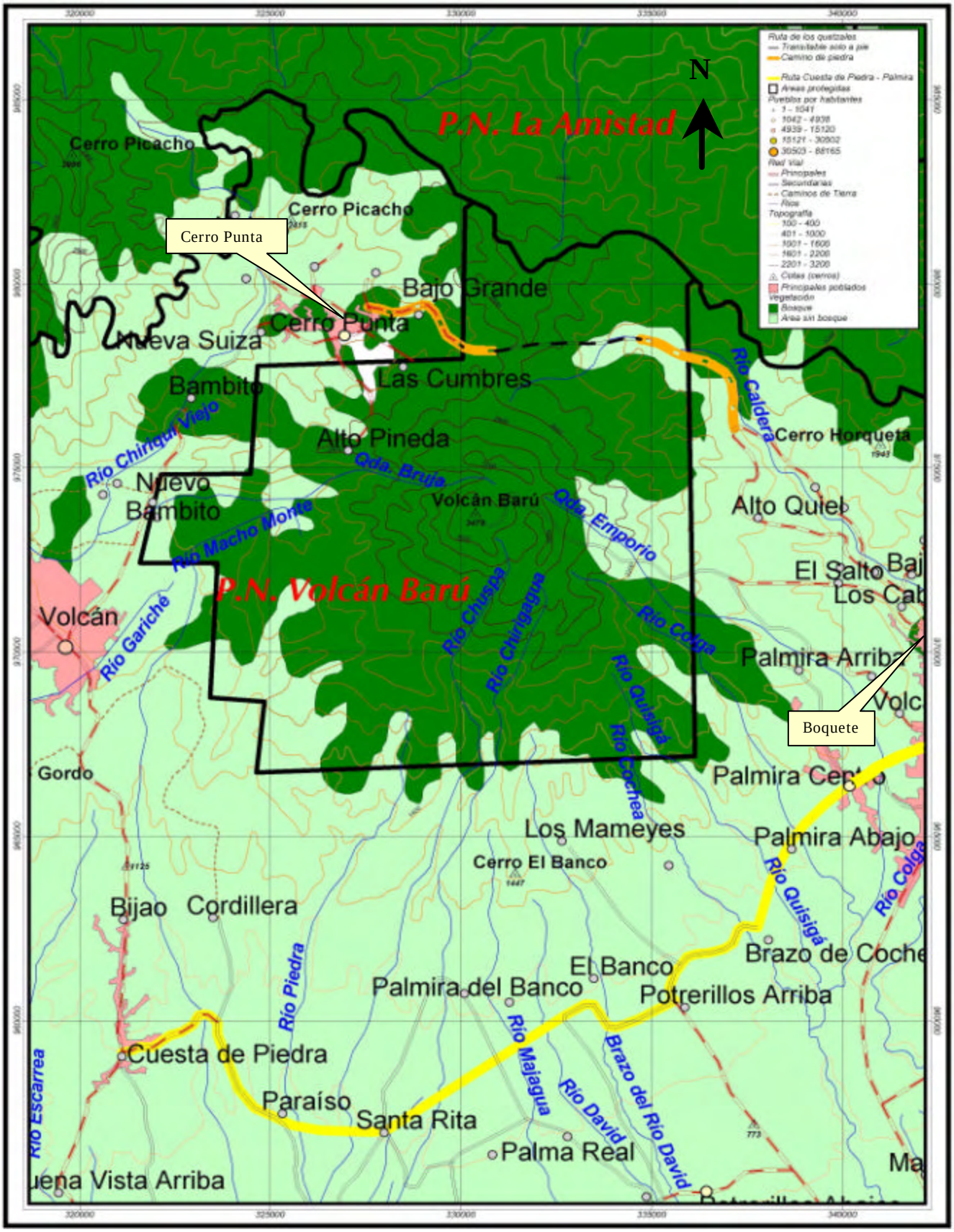
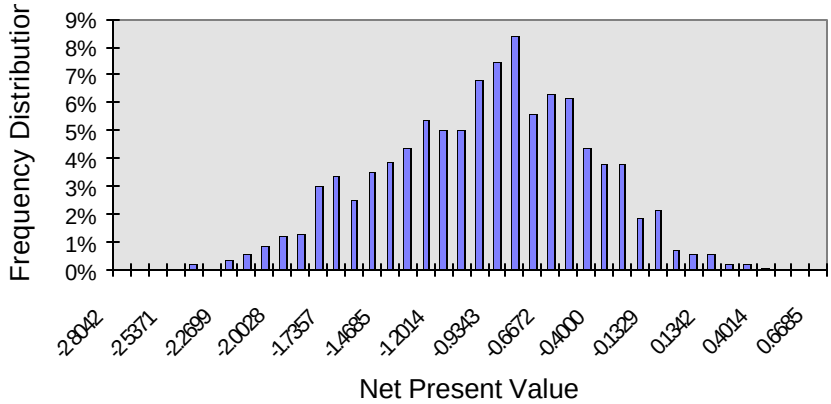


Figure 3: The "eco-road" through the Barú Volcano National Park's northern sector is indicated by the orange and intermittent line above. The southern route is indicated by the yellow line running from Cuesta de Piedra to Palmira. Forest cover is indicated by the dark green areas.

In our base scenario, which uses 250 cars per day growing at 3% annually, the northern route yields a net present value (NPV) of negative $808,000 in a 20 year period, before considering any of its potential environmental impacts.

Figure 4 - Cerro Punta Boquete Economic Risk Analysis



According to our risk analysis, the probability that the NPV is greater than zero, which is the fundamental criterion for economic feasibility, is only two percent. The risk of project failure is therefore 98 percent under these conditions. In the risk analysis, we varied projected traffic, road condition (with and without the project) and construction cost. We tested 1,000 scenarios, using values both above and below the mean values that produced the NPV reported above. Figure 1 shows the distribution of the 1000 NPV results. Two percent of the results, those at the extreme right of the figure, were positive.

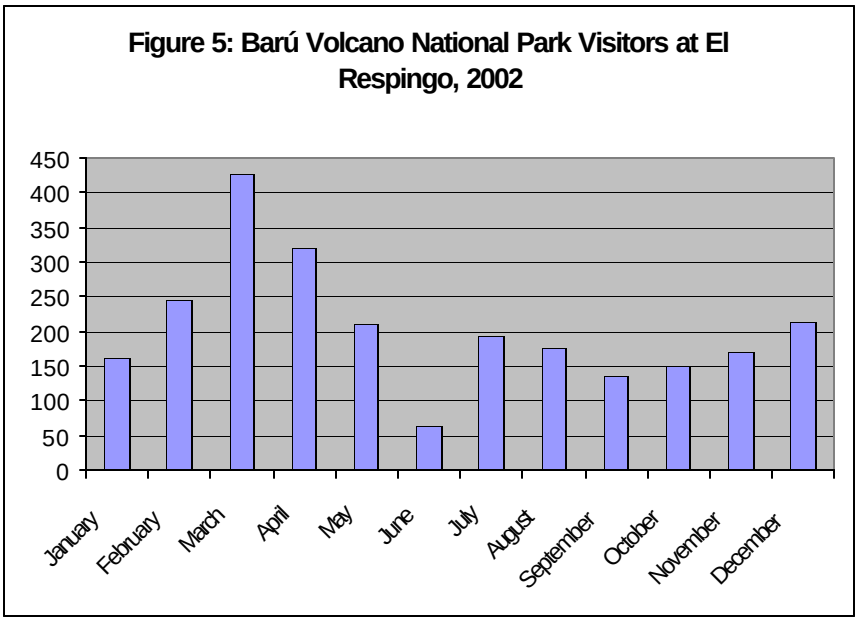
Box 1 - How many cars would you meet?

Practically speaking, the one-lane design of the "camino ecológico" only works if vehicles meet infrequently.

MOP Chiriquí suggests that cars could be spaced every 100 meters in both directions. With this much traffic, each motorist would have 300 head-on meetings with other cars during his 15-kilometer tour, or one car every four seconds, assuming an average speed of 45 km/hour. The nearly 500 cars per day needed within a decade to justify the project would imply meeting 32 vehicles, or one every 37 seconds, *on average*. During peak hours, the number would be much higher.

Average daily traffic necessary to make the route economically viable is approximately 364 in the first year after construction. Note that this is an *average* figure and that maximum traffic needed to produce this figure would easily exceed 500 vehicles per day, due to the seasonal nature of tourism and variations between weekdays and weekends. Also consider that traffic is not evenly distributed throughout the day, but has inevitable peaks. During these peaks the combined 24-car capacity of the parking areas would be overwhelmed if indeed the road succeeds in drawing tourists. Further, this scenario requires three-percent annual traffic growth, so that in twenty years the "camino ecológico" would have an average of 657 vehicles per day. Finally, all the vehicles except cars would have noisy diesel engines. This level of traffic is not only unlikely, but also incompatible with the one-lane design, as well as the area's ecotourism and environmental conservation goals, particularly

considering the fact that maximum traffic will occur in the dry season (January-April), precisely when quetzals are nesting.



Willingness to pay: Another way of measuring the economic feasibility of roads is to determine their users' willingness to pay for them, and compare that demand to the actual cost. These figures show the tolls that would have to be collected at different levels of traffic in order to pay for the road, assuming a 10-percent real discount rate and a 20-year amortization. Compare these figures to Panama City's *Corredor Sur*, where the 20-kilometer trip from Paitilla to the airport costs $2.75. A Cerro Punta resident making five round-trips in a month, at $6 each way would spend a staggering 20 percent of his monthly income on tolls.

Table 3 – Tolls required to pay for the Cerro-Punta Boquete road				
Average Daily Traffic	100	200	300	500
Toll required to pay for road	$18	$9	$6	$4

Assumptions

The base case scenario assumes average daily traffic of 250 vehicles per day, or about a quarter of current traffic on the region's main two-lane highways. The composition of vehicles is assumed to be similar to that on the Cerro Punta-Concepción road, with all vehicles over 10 tons (a limit proposed by MOP) eliminated and a greater share of small cars and buses, which would be used for tourism purposes. Interviews in Cerro Punta and Boquete suggest there is extremely limited traffic specifically between the two towns. We assume that around three percent of cars, pickups, utility vehicles, small buses and light trucks on the paved roads to the Pan-American Highway are now traveling that route and would be diverted to the "camino ecológico." This is probably

an overestimate. In this scenario the average normal traffic is limited to around 10 vehicles per day since around half of the route does not yet exist, but we assume generated traffic of around 120 vehicles per day in the first year, and traffic induced by new economic activity of around 90 vehicles per day in the first year after construction. Traffic is projected to grow at an annual rate of three percent per year throughout the whole 20-year period. Other assumptions are listed in Annex 1.

Construction costs for Cerro Punta-Boquete were taken from the January 29, 2003, Cabinet Resolution 10, authorizing a contract in the amount of $4.6 million between the Government of Panama and CUSA. Estimated maintenance costs of $100,000 per year were provided by the regional Chiriquí office of the Ministry of Public Works (Ing. Luis Fanovich, personal communication), and also reported on the MOP website (http://www.mop.gob.pa/). Though we have no reason to question the construction cost figure, it is important to note that costs for paved roads in difficult terrain and areas of high rainfall can run significantly higher, topping $1 million per kilometer, which was the construction cost average for the road recently built by CUSA along the coast of Bocas del Toro (Personal communication, Lic. Graciela Palacios, February 26, 2003).

Distribution of Costs and Benefits

As noted above, "distribution" refers to the distribution of gains and losses experienced by different sectors of society. Generally, a project has favorable distributional impacts when it results in a more equitable allocation of wealth in a society. In the case of the Cerro Punta-Boquete proposal, property owners adjacent to the road would benefit as their property values rose. Road supporters estimate that there are 20 property owners within two kilometers of the route (Graciano Cruz, personal communication, February 24, 2003).[2] During our site visit we identified no more than five properties crossed by the middle portion of the route where there is currently no road cut. Taxpayers would foot the bill: given that the project would cost $4.6 Million, and that in Panama there are approximately 702,000 tax paying citizens (Anonymous source, personal communication, MEF, May, 2003), the price would be around $6.55 per person.
Beyond that, the distribution of benefits and costs is less clear. Tourists who prefer to access the area of the Quetzal Trail by car, or who are physically unable to hike it, would benefit. At the same time, the Quetzal Trail itself will be destroyed by the road, because its most important sections are crisscrossed by the proposed route. The 93 members of the Boquete irrigation association would see greater risk to their water supply, and the probabilities of floods in the Caldera River would increase. These consequences would result from the inevitable deforestation from the road cut, and development of tourist facilities. Deforestation increases surface runoff and decreases water retention within the soil profile. Current tourism entrepreneurs could lose market share if property owners along the new road succeed in developing new lodgings.

Finally, road supporters have underscored the benefits of an emergency route to David and a shorter alternative from David to Cerro Punta, two benefits that would be broadly, and therefore equitably, distributed. We have no data on the frequency with

[2] During our tour of the area, a local guide identified just four properties covering most of the area where a new road would have to be cut.

which the main roads become impassible, but note that the high rainfall and mountainous terrain of the Cerro Punta-Boquete route make it quite likely that any weather-induced emergency that blocks the main roads will block it also. As a Cerro Punta-David short-cut, it saves around 17 kilometers. However, slow travel on the "camino ecológico" would lower average speeds sufficiently (65 kmh v. 80 kmh on the current route) that travel time would be about the same. Vehicle operation cost savings would be $3.74 for a pickup, less the amount of the toll.

In summary, this road would elevate incomes of a relatively small group of people already above average in terms of their economic status. There is no clear positive impact on lower-income people.

Externalities

Water for hydroelectricity: As we noted above, there is a long history of opposition to this road on the grounds that it could damage the Caldera River watershed and adversely affect the quality and quantity of water available downstream. As with most other impacts, actual risk to energy production can only be gauged based on an environmental impact assessment that includes a thorough study of the watershed. Here, we merely calculate the scale of economic risk, should impacts take place. Production at the Estrella-Los Valles complex, managed by AES-Panama, averages 440 gigawatt-hours per year, worth approximately $22 million dollars at a price of $50/MWh, a figure that reflects the spot market for wholesale power (Ing. Peñalosa and Ing. Evaristo Alvarez, April 2, 2003. Also Ente Regulador de Servicios Públicos 2003). A ten percent decline in production would therefore cost $2.2 million per year in energy assuming $50/MWh. This calculation ignores any impacts on the 120-MW Está plant, under construction below the Caldera's confluence with the Chiriquí River. The está plant is also an AES-Panama project

An interview with Ing. José Victoria, Environmental Specialist with AES-Panama, suggests that the company is less concerned than electricity officials have been in the past regarding this road's impacts on their operations. Victoria contends that the Caldera's watershed already produces substantial sediment and organic waste from coffee production. He observed that the company recently installed a dredge to keep La Estrella's small reservoir clear, and that further deforestation was unlikely to elevate costs or decrease production. Even so, Ing. Victoria suggested that in his opinion the road should *only* be built if a tunnel is used to pass under the most sensitive areas, a measure he estimates would double the cost.

Water for irrigation: The watercourse most affected by the road would be the Caldera River. In 2000, a $7.3-million irrigation project began drawing water from the Caldera through a 26-inch aquaduct. The system serves 93 Boquete area users with an estimated 2000 total farm employees. Around 270 hectares are irrigated by the system, with summer onions the predominant crop. Total capacity is estimated at 636 hectares. The system is not extensively used in the rainy season. Users pay a $25 registration fee, a $100 per year water rights fee, and $0.015 per cubic meter ($m^3$) of water (Máximo Montenegro, personal communications, February 25, 2003 and March 17, 2003).

Irrigation association president Máximo Montenegro voices concern over organic material clogging the aqueduct intake if the road is built. Thorough hydrological studies are needed to gauge the potential impact of the road on the irrigation system. All we can state at this point is that every 10 percent reduction in water availability imposes a maximum potential cost of $3,035 on the irrigation association. Impacts of this magnitude are not large enough to make a significant difference in the overall economic viability of the road project. However, water is heavily subsidized. Payments only cover a tiny fraction of the capital cost, and the water's actual value is very likely much higher than its price.

Table 4 – Water use and variable payments by Boquete Irrigation Association members.		
Aqueduct capacity	350	liters/second
% of capacity currently used in dry season	40	%
Estimated annual use (5.5 months per year)	2,023,560,000	liters
Maximum potential annual use	2,023,560	m^3
Annual variable payments, whole association	$30,353	
Annual average variable payment per user (n=93)	$326.38	

The price of urban water supply in Panama is been between $0.18 - $0.28 per m^3, according to data on recent years from the *Ente Regulador de los Servicios Públicos* (Ente Regulador 2003). At these values, a ten percent loss in Boquete irrigation supply would be worth between $26,490 and $41,207. These figures represent an upper bound for the water's value, since urban users' willingness to pay is usually greater than water's marginal product in agriculture.

Tourism: It is very difficult to project the net affect that the road might have on the region's tourism industry. We know that the industry is second to agriculture and growing in importance, but the change that would be brought about by the Cerro Punta-Boquete road is a matter of intense debate. Proponents of the road argue that new tourist lodges and newly developed trails, all inside the Barú Volcano National Park, would increase tourism activity and draw elderly – and wealthy – foreign tourists. Opponents contend that the Quetzal Trail is one of the top, if not *the* top local attraction, and that the tourism economy will decline if the trail is destroyed.

Our approach was to incorporate tourism growth within our road model and assume robust growth along the road's path, with economic spillover to businesses in the two towns. This assumption favors the road and may well be overly optimistic. If road opponents are correct, even a slight decline in the tourism sector would have a high cost. A ten percent drop in visitation – on the part, for example, of hikers and birdwatchers – would imply at least a $270,000 annual cost to Cerro Punta and Boquete. The only way to predict the outcome with more certainty would be to conduct a careful survey of visitors' relative preference for the region with and without the road.

Park management: In 2003, ANAM will spend $9,600 on the VBNP park director and $7,400 on two park guards. This level of staffing is inadequate at present and would

certainly need to increase with motorized access to the Park's northern flank. The 1992 Ministry of Public Works (MOP) mitigation plan for the road (MOP 1992) calls for a staff of eight, not including supervisors. Bringing the number of guards up to 10 would impose an additional $33,600 in salary costs. Assuming two additional Toyota pickups, driven an average of 20,000 kilometers per year, at an average cost of $0.26 per kilometer, incremental vehicle costs would total $10,400 per year. We conservatively add another $10,000 for other costs, including maintenance of new infrastructure, materials, equipment, uniforms, etc. The Park budget would have to increase by $54,000, effectively tripling it's current level of funding.

Table 5 – Mesoamerican biodiversity hotspot's rank among 25 global hotspots in terms of species richness.

	Number	Rank
Birds		
Endemic	251	3
Total	1,193	2
Mammals		
Endemic	210	1
Total	521	2
Reptile		
Endemic	391	2
Total	685	1
Amphibian		
Endemic	307	2
Total	460	2
All species		
Endemic	1,159	2
Total	2,859	2

Source: This table is from Shapiro (2001)

Biodiversity loss: The Caldera River valley can be seen as a biodiversity hotspot within a hotspot – the Talamanca range – which is also within a larger hotspot – the Mesoamerican hotspot (as defined by Conservation International). This area connects the Barú Volcano National Park's ecosystems to La Amistad International Park, which covers part of the Talamanca range and is the largest contiguous forest area in Central America. Amistad and its environs have over 880 species of birds, 217 species of mammals, 207 species of reptiles, and 155 species of amphibians (CI, 2001). The Mesoamerican biodiversity hotspot, in which Amistad is embedded, ranks high in species richness (see Table 5) because within this relatively small tropical area there is great variation in altitude, micro-climate and landscape. Further, it is a point of encounter between species assemblages of North and South America.

The right-hand column in Table 5 shows Mesoamerica's rank among the 25 biodiversity hotspots on the planet. Focusing in closer,
we have Barú Volcano National Park, created by Executive Decree on June 24, 1976. It includes 14,322 hectares of highlands, approximately 6,000 of which remain forested (Lider Sucre, personal communication, February 26, 2003). The Park is currently part of the PILA Biosphere Reserve, which is also a TNC conservation action area. At 3,472 meters above sea level, Barú Volcano is the highest point in Panama, and one of the highest peaks in Central America. This park has 6 of the 12 Holdridge Life Zones identified in Panama, including very moist montaine forest, which is only found in this park in Panama. Barú Volcano is also home to large extensions of cloud forest. The park is currently connected to the rest of the PILA site on its northern boundary, where the proposed "eco-road" would pass. The proposed road would follow a hiking trail called the Quetzal Trail, established in the 1920's and named for the large population of quetzals in the cloud forest it traverses. Many important species frequent the park,

including puma, tapir, jaguar and harpy eagle. The 56 species of endemic birds who only reside in the Panamanian and Costa Rican highland PILA region would also be adversely affected by the fragmentation of this landscape. Included in this group of endemic birds are several species which are particularly vulnerable, such as the yellow-billed cotinga (*Caropdectes antoniae)*, which is endangered according to the World Conservation Union. Other species susceptible to extinction include the bare necked umbrella bird (*Cephalopterus glabricollis)*, the yellow-green finch (*Pselliophorus luteoviridis)*, and the glow-throated hummingbird (*Selasphorus ardens*) (Shapiro 2001). The road would make Barú Volcano an ecological island, cut off from the rest of the PILA site.

Shapiro's (2001) analysis of the entire Panamanian portion of the PILA and environs classified the valleys occupied by Cerro Punta and Boquete at the top conservation priorities in all of Western Panama. Her criteria were biodiversity and degree of threat, combined in a matrix. In fact, the 25 top-ranked communities for conservation action were all near Barú Volcano, either in Cerro Punta, Boquete or Volcán. The area where the Quetzal Trail now passes, though high in biodiversity, did not rate quite as high a conservation priority, precisely *because* the perceived threat was low due to the absence of roads and human population. The portions just outside the protected area did rate as high priorities.

Very few roads have been built in tropical forests without provoking deforestation. Costa Rica's San José-Guápiles is a notable exception and shows the conditions that are necessary to harmonize roads and nature. The government expanded the Braulio Carillo National Park many years before the road opened, the land was duly acquired by the government, and adequately guarded by the National Park Service. Barú Volcano does not meet the conditions of public ownership nor adequate protection, and has lost much of its forest cover since its creation in 1976.

Pfaff (1997) showed that in the Brazilian Amazon paved roads were the single most important factor determining deforestation and the Brazilian space agency has since shown that 90 percent of deforestation has taken place within 100 kilometers of paved roads (Alves 1999). This is a remarkable figure given the size of the Amazon Basin and the importance of river transportation there. Cropper et al. (1997) showed that roads and population pressure were the main factors leading to forest loss in Thailand between 1976 and 1989. In Cameroon and the Democratic Republic of Congo, Mamingi et al. (1996) showed that transport access is more important than climate, soils, or distance to markets in determining deforestation.

These analyses simply confirm the obvious – that roads are associated with deforestation. The amount depends on local conditions such as soils, slope, climate and degree of government intervention to stop forest loss. Importantly, the studies cited all focus on the forest lost as an indirect result of roads. In the Cerro Punta-Boquete case, the area is small and sensitive enough that direct impacts, usually not a leading concern, could be substantial.

The effect of deforestation in this area would be especially acute because the road would cut off the Barú Volcano National Park's forests from the much larger contiguous forest

in the PILA Biosphere reserve, fragmenting what was once a large expanse of habitat forest and turning the park into an island of natural habitat. One immediate effect of forest fragmentation is the increase in the amount of forest edge habitat. Forest edges are characterized by relatively dry conditions with increased light, fire and wind exposure compared to non-edge parts of a forest. Increasing forest edges usually favors widespread generalist species at the expense of less common primary forest species, including predators.

Forest fragmentation unleashes a process called "trophic cascades." This is a process by which the elimination of predators causes major perturbation of local species composition, and thus diversity loss. The flooding of river valleys for hydroelectric projects and for the Panama Canal have provided opportunities to examine what happens to a tropical ecosystem when forests are isolated, and trophic cascades ensue. Top predator species are removed from an ecosystem, allowing a few prey species to become hyperabundant, which inflicts unprecedented pressure on local resources and other species(Terborgh, 2001). On Barro Colorado Island (BCI) in Panama, loss of top predators was associated with the extinction of 45 species of birds between 1920´s and the early 1970´s (Willis, 1974).

Another ecological dynamic of fragmentation is that described by MacArthur and Wilson in their theory of island biogeography (MacArthur and Wilson, 1967). They observed decreased biodiversity on small distant islands and higher levels of biodiversity on nearby large islands. MacArthur and Wilson posited that levels of diversity found on different sized islands depend on rates of species immigration and extinction, which are functions of each island's size (which determines extinction rate) and proximity to sources of immigration (which determines immigration rate). In other words, an island of any given size will have a lower equilibrium number of species when it is far from species sources (in this case the PILA), as compared to an island of the same size that is closer to source populations. The theory also dictates that at any given distance from a source of species, larger islands will reach equilibrium with higher levels of species diversity than smaller islands.

Ecologists have found that, fragmented forests manifest similar ecological dynamics as islands. In the case of the Barú Volcano National Park, the gap created by the road and subsequent activities will decrease immigration from PILA. The road will immediately reduce the area that species can count on as contiguous habitat, thereby increasing the extinction rate. Among the species at greatest risk are the 115 endangered and endemic mammals, reptiles, butterflies and birds currently residing or expected to inhabit the Barú Volcano National Park according to the Directory of Important Bird Areas in Panama (Angher, 2003. See Annex 3). Several of the park's resident bird species are globally threatened, including the red-fronted parrotlet (*Touit costaricensis)*, three-wattled bellbird (*Procnias tricarunculata*) and bare necked umbrellabird (*Cephalopterus glabricollis)*, as well as the near-threatened crested eagle (*Morphnus guianensis*), black guan (*Chamaepetes unicolor*) and resplendent quetzal (*Pharomachrus mocinno)* (Angher, 2003).

The only way to place a value on the biodiversity of the Quetzal Trail area is to conduct a careful contingent valuation study, a method of analyzing the importance people place

on values not directly traded in markets. Such an analysis is beyond the scope of this study. However, in the context of all the possible external costs we have examined, the biological impacts of this road could well be the most severe. There are three reasons for this conclusion. First, biodiversity losses are irreversible and inevitable. Road advocates have stated that the route need not result in forest loss, and that, in fact, landowners have staunchly defended the forest within their properties. However, a site visit to the zone showed that deforestation had advanced inside the park boundaries, precisely where the gravel access road is present. If the "camino ecológico" were not accompanied by deforestation, it would be a very rare case indeed, particularly given the minimal effective control the government exercises over unexpropriated land within the park.

Second, the resources lost are unique. Water loss that reduces irrigation and/or hydroelectricity can be partly mitigated by substituting inputs, switching crops or exploiting other energy sources. Loss in tourism value can be ameliorated up to a point by development of alternative attractions. Substitutes represent second choices and resorting to them involves an economic cost, but the loss is greater when a resource – a species or ecosystem – without substitutes is sacrificed.

Third, there are technical solutions to some of the potential environmental costs. These might include more dredging, increasing reservoir size and more regular cleaning of the aqueduct intake, for example. There are no similar short-term interventions that can minimize the biological impacts of habitat loss. Efforts to relocate species in the path of development projects have been uniformly unsuccessful (See Ledec, 1999).

Table 6 – Selected Potential External Costs

Values impacted	Potential Costs
Water for hydroelectricity	10% decline = $2,200,000
Tourism	10% net decline = $270,000
Water for irrigation	10% decline = $3,035 to $41,207
Park management (8 more staff, 2 more vehicles)	Additional $$ in costs = $54,000
Biodiversity	N/A
Total annual quantified costs	$2,527,035 to $2,565,207 + biodiversity
Present value over 20 years at 10% discount rate	$21,054,340 to $21,379,320

Table 6 summarizes the external costs that would result from a ten percent decline in irrigation water, hydroelectric production and tourism, along with a rough doubling of Barú Volcano National Park's costs. The table is meant to be illustrative of the magnitude of potential costs, not to represent point estimates of costs, because such precise predictions need to be done as part of a careful environmental impact assessment and no such assessment has been done. Further, we repeat that, in all of our modeling

on the road's benefits, we assume that the tourism sector expands rather than shrinking. Over a third of traffic would represent tourism activity specifically generated by the road within its area of influence. The table merely shows the gross cost of each ten percent contraction should it turn out that the road actually damages these resources.

Despite the inherent uncertainty in these calculations, the table does bring two points into focus. First, the largest potential impacts are on electricity production, the tourism sector and biodiversity. These impacts should be examined with great care in the Environmental Impact Assessment. Second, these figures show that it is quite plausible that the present value of environmental impacts is several times greater than the entire road investment. For the investment to be considered economically viable its *internal net benefits* would have to exceed external costs. Adding the as-yet unquantified biodiversity costs to the equation, chances dwindle even further that this investment would benefit Panama's economy.

Southern Route

Economic feasibility

The "southern route" is a road connecting Cuesta de Piedra with Boquete, skirting Barú Volcano to the south, rather than to the north. This option would follow some existing asphalt, gravel and dirt roads, as well as developing several new road segments. It would require around 12 new bridges, several of them quite substantial. This route is does not serve exactly the same purposes as the Cerro-Punta Boquete road. It would be only around 40 kilometers shorter than the existing route via David, while the northern connection between the two towns would save around 90 kilometers. On the other hand, there are communities between the road's endpoints, which is not the case of the Cerro Punta-Boquete Road. As of the 2000 census, these communities (Cuesta de Piedra, Cordillera, Paraiso, Santa Rita, El Aguacate, Palma Real, Rovira Arriba, Potrerrillos Arriba, Potrerrillos Abajo, Brazo Cochea, and Palmira) represent 9,443 potential beneficiaries. The total number of beneficiaries is higher if we adopt a somewhat wider zone of influence used by IRHE in 1993. They estimate 10,823 beneficiaries as of 1990. The true number is probably between 10,000 and 15,000.

Rich volcanic soils and reasonably good water supply and quality make this sector a promising area for agricultural development (IRHE 1993). The region is still dominated by cattle raising, with pasture the predominant land use. Table 6 shows the areas of pasture in "southern route" for which the 2000 Agricultural Census contains data.

Table 7 – Pasture and cattle in selected "southern route" communities		
	Hectares	Head
Cordillera	2,727	2,673
Paraiso	1,464	1,343
Potrerillos	955	1,147
Potrerillos Abajo	1,188	1,967
Rovira	683	1,260
Total	7,017	8,390
Source: Contraloria General de la República, 2002		

The province of Chiriquí leads the country in milk production operations and the Bugaba district, on the western end of the southern route, is the province's leader by a wide margin. The higher-elevation farms in this area have a natural advantage in that they can use European or mixed breed cattle (*Bos taurus taurus x Bos taurus indicus)*, which do not thrive as well in hot, humid lower elevations, and are prolific milk producers. Nonetheless, precarious road access puts farmers at a fatal disadvantage in getting their highly perishable product to market. A good road, therefore, could be expected to stimulate milk production. The 1993 IRHE study contends that bringing down transport costs could also unleash a boom of agricultural development because inputs would become cheaper and production could be delivered to market quickly, a critical consideration for fruits and vegetables.
Currently, large scale fruit production is limited to the *Cítricos de Chiriquí, S.A.* holdings west of Santa Rita. The true competitiveness of this operation is unclear because it has been in and out of bankruptcy and government ownership over the years.

Tourism is nearly nonexistent in this zone at present. It lacks the charm, coffee plantations and forest that draw visitors to Boquete. However, some of the rivers (Bregue, Piedra, Chuspa and Quisigá, for example) have distinct potential for recreation if access is improved.

The main technical challenge posed by this route is crossing six sizeable rivers and a similar number of smaller tributaries. Much of the route is flat or rolling terrain where construction and maintenance costs will be low. The landscape is cut, sometimes deeply, by a series of rivers running perpendicular to the route. Bridges, and the accesses to them substantially elevate costs.

We examined two alternative cost estimates for this route. The first is an estimate by the Chiriquí regional office of the Ministry of Public Works, dated February 17 of this year. The second is an estimate developed in the mid 1980's by the same ministry's *Dirección de Proyectos Especiales.* The former project assumes a paved road from Cuesta de Piedra to the highway just south of Boquete. The latter project ends up in Palmira Centro, omitting rehabilitation of the 7 kilometers of pavement linking Palmira to the Boquete-David road. In our analysis we add this segment in, using the cost estimated by MOP this year.

A third assessment was done in 1992 by the firm Geoconsult, and recommended building a "third order" road and omitting the Potrerillos Arriba-Palmira section. This omission makes some sense, given that there already a fast paved connection from

Potrerillos Arriba to Dolega on the Boquete-David road and it is questionable whether the Palmira link would divert significant traffic from that route.

After adding $120,000 for repairing 6 kilometers of paved road and adjusting the 1980's estimate for inflation (1987-2003 at 2.5 percent/year), its cost is $11.8 million, compared to $14.2 million estimated by MOP this year. The unit costs are $266,656 and $321,728 per kilometer, respectively. (CUSA's contract for the Cerro Punta-Boquete road implies a cost of $298,022 per kilometer).

The benefits, as always, depend on the number of beneficiaries and how much they use the road. We estimate that as of the 2000 census, there were at least 9,443 people living within the "southern route's" area of influence, between (and including) Cuesta de Piedra and Palmira. That figure excludes people in the rest of the Boquete district (which includes Palmira), in Volcán (10,188) and in Cerro Punta (6,860), who might use either road. The figure simply reflects beneficiaries along the southern route, for whom there are no counterparts on the northern route.
If the new MOP estimate of $14.2 million is correct, traffic needed to justify the road would be around 491 vehicles per day. The $11.8 million road would require 373 vehicles per day. As we noted above, traffic on the paved Concepción-Cerro Punta and David-Boquete roads is around 1,000 vehicles per day. The figures needed to justify the "southern route" represent large increases over current traffic. While more investigation of actual transport demand is needed to determine whether the entire route is justified at this point, the costs are for a two-lane paved road, which can actually accommodate hundreds, and even thousands, of vehicles per day, which the "camino ecológico" cannot. Second, the economic development potential in between the road's endpoints is substantial, in contrast to the wilderness of Barú Volcano National Park that the "camino ecológico" would traverse. Third, the southern route does not imply major environmental costs, since the region is mostly deforested and not part of a protected area.

Distributional issues

All of the communities served by the southern route have average incomes below the national average of $380 per month and all but one were below the Chiriquí average of $302, the Boquete district average of $317, and the Cerro Punta average of $285. Therefore, this road would be more likely than the northern route to improve equity. Further, as noted above, there are many more direct beneficiaries along the road's right-of-way than is the case with the northern route.

Table 8 – Average household income in 2000

Community	Average monthly income
Cordillera	$220
Paraiso	$170
Potrerillos Arriba	$205
Potrerillos Abajo	$324

Table 8 – Average household income in 2000	
Community	Average monthly income
Santa Rita	$208
Rovira	$217
Palma Real	$150
Aguacate	$236
Brazo de Cochea	$92
Source: Contraloria General de la República (2002)	

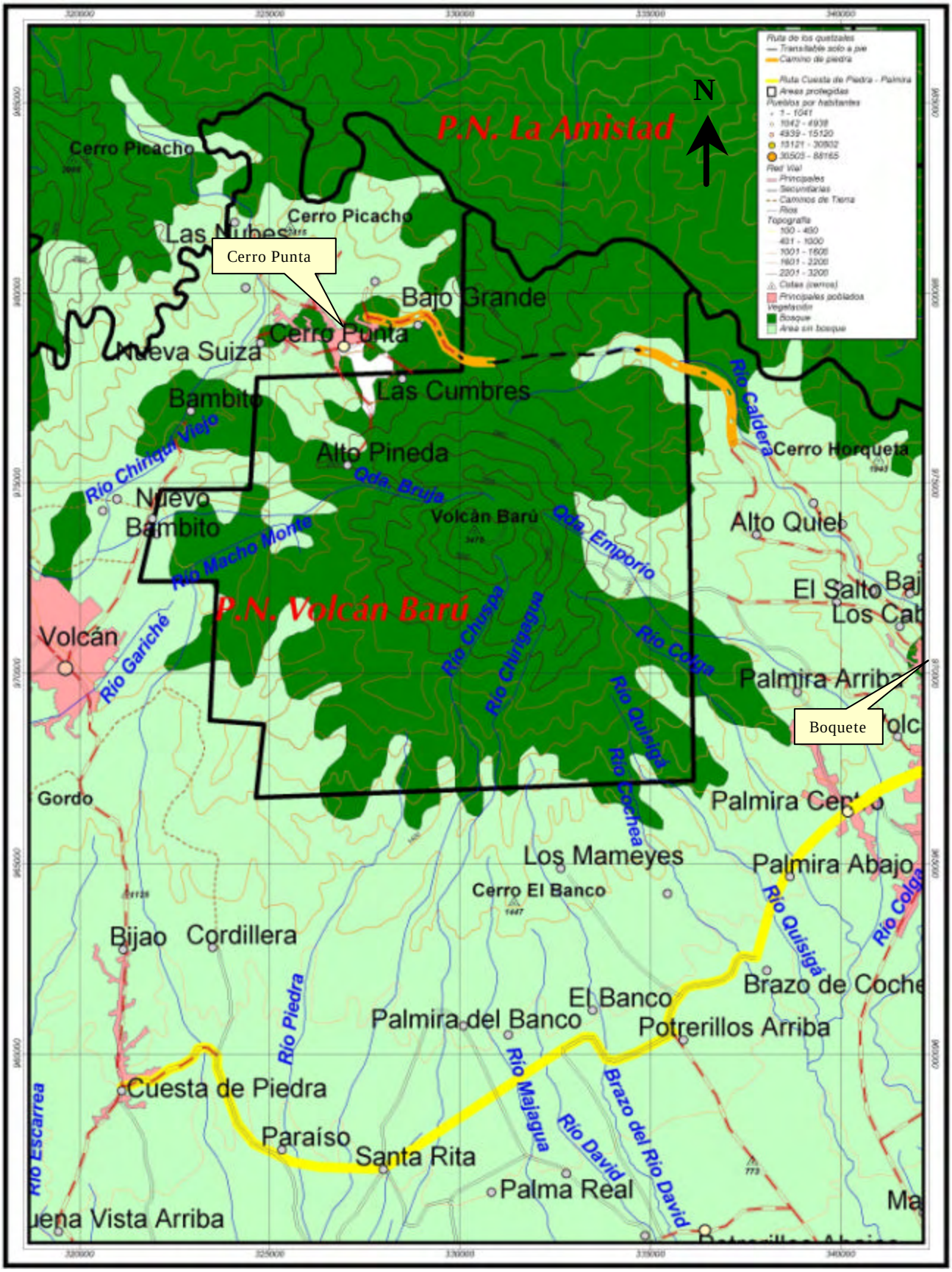


Figure 6: Access roads to the park's eastern and western entrances are indicated by the orange lines flanking the northern section of Barú Volcano National Park. Dark green areas indicate forest cover.

Economic feasibility

An additional option is the paving of the access roads to the guard stations at el Respingo and Bajo Mono (see figure 6). Six or seven kilometers of new pavement are needed to achieve this goal. We assume unit costs of around $150,000 per kilometer and unit maintenance costs equal to those cited by MOP-Chiriquí for the whole route. Traffic needed equals 232 vehicles per day. If we assume that 50 vehicles are driven by local residents and the remaining 172 by park visitors, and that each tourist vehicle carries an average of 3 people, 516 people would visit the park on the average day. For the entire year 2002, 2,467 visitors registered at the park's El Respingo entrance. An interview with the guard at the Alto La Chilena entrance suggested that visitors

entering on that side equal around 50 percent of El Respingo visitors, so the total may currently be in the range of 3,600 annually, or 10 per day. Increasing from 10 to more than 516 daily visitors immediately is both unlikely and problematic without more infrastructure, trails and staff. This number of visitors would fill nearly the total combined capacity of Cerro Punta and Boquete lodgings. There is substantial capacity in Volcán (122 rooms) for overflow, but Boquete and Cerro Punta capacity would undoubtedly need to grow to meet peak demand if park visitation rises to that degree.

Nonetheless, if park infrastructure is developed, it is likely that it could attract and accommodate several hundred visitors per day in the long run. An average entry fee of $2 would generate enough - $376,680 - to cover incremental costs. Above, we put these costs at around $54,000 with a road going all the way through the park.

V. Conclusions and Recommendations

The road proposed from Cerro-Punta to Boquete would almost certainly cause a net loss to Panama's economy, as well as provoking environmental damage in the Barú Volcano National Park and the La Amistad International Park. The project is marked by a fundamental contradiction: It is an apparent compromise between a traditional road and a scenic footpath. This is an interesting concept and certainly the notion of reconciling environmental protection with economic development is worthy, but this design achieves neither. Planners have two realistic options. One is to redesign the road as a traditional rural route, with two lanes and minimal traffic restrictions. The road will require high volumes of traffic to achieve economic viability (unlikely given current demand projections) and will certainly be more practical than the one-lane design, although it would clearly preclude ecotourism activities in the area. It will also be more likely to result in deforestation, hunting and opening of feeder roads, not to mention direct impacts associated with earth moving. Alternatively, improvements in that sector of the Barú Volcano National Park can be limited to upgrades to the footpath and perhaps development of additional hiking trails.

The "southern route" makes sense as an attempt to spur economic development in the volcanic soils to the south of Barú Volcano. Certain sections of the project are expensive due to steep river valleys that need to be traversed. Without better projections of demand for this route it is hard to make definitive statements on its

economic feasibility. Nonetheless, the levels of traffic needed to justify it are not inconceivable and not incompatible with environmental protection.

If planners do not build the whole southern route now, one option would be to make some selective investments to remove the most significant bottlenecks, leaving heavier investments for later. These bottlenecks are the crossings and approaches to the Bregue, Piedra and Chuspa rivers. A 40-50 meter bridge at the site of the current suspension bridge on the Bregue river (or the 100-meter span downstream, as recommended by MOP), a new bridge on the Rio Piedra, and completion of the in-progress bridge on the Chuspa river would integrate the entire zone between Cuesta de Piedra and Potrerillos Arriba, which is connected to Dolega and thence to David already by a paved road. The surface could be upgraded to a higher quality gravel standard or to pavement. Pavement and concrete drainage ditches make sense for the steep approaches to the bridges.

Taking for granted the costs in the 2003 MOP-Chiriquí estimate (which is generous), building the needed bridges and paving from Cuesta de Piedra to Potrerillos Arriba would cost just under $8 million at the most.

Paving the access routes to the Barú Volcano National Park would give access to cars, small buses and other two-wheel drive vehicles. Such a project could have negative impacts in the still-forested approach from Cerro Punta while spurring economic activity in the immediate vicinity of the park on both sides. These scenarios require careful study in an environmental impact assessment and should be evaluated in light of the park's soon-to-be completed management plan and real management capabilities.

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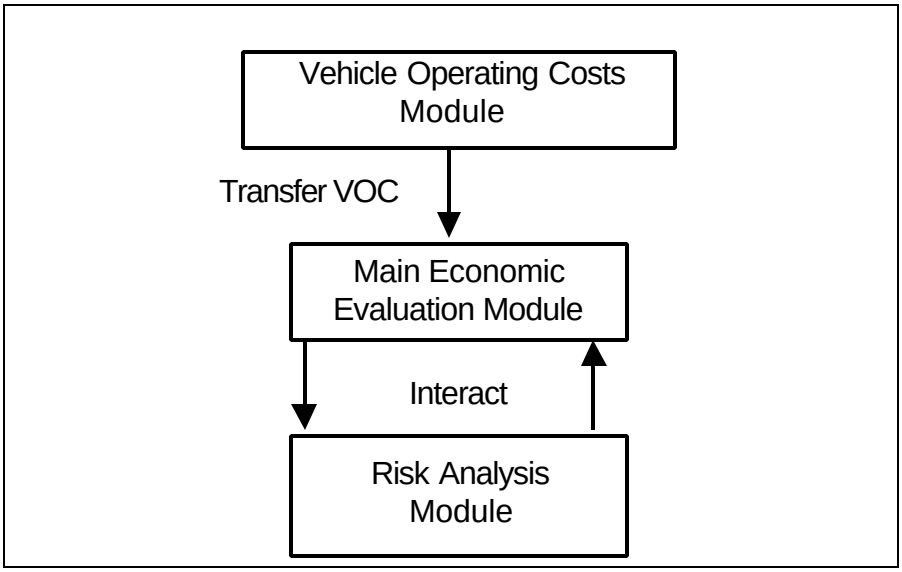
Annex 1: The Model and Assumptions

The Roads Economic Decision model, developed by the World Bank in 1999, performs an economic evaluation of road investments options using the consumer surplus approach. This approach measures the reduction of vehicle operating costs and time costs, computed from relationships relating vehicle operating costs and speeds to road roughness. The consumer surplus approach isolates the transportation savings to various sectors of the current economy, and adds to them transportation benefits of economic expansion resulting from the road improvement. The model is customized to the characteristics and needs of low-volume roads, including substantial uncertainty of model inputs such as future traffic and the condition of unpaved roads. The model deals with a portion of uncertainly with a basic risk analysis based on triangular distributions for the main inputs.



The foundation of the model is a Vehicle Operating Costs (VOC) module, in which per-kilometer costs are calculated for a particular country and region based on the cost of inputs, terrain and road conditions. VOCs are calculated as a function of road roughness in a cubic polynomial equation for which the coefficients are determined by the variables mentioned above. For Example:

Some of the key assumptions not stated in the text include the following:

Discount rate: 10 percent per year.
Time horizon: 20 years.
Periodic reconstruction costs: None beyond maintenance expenses.
Factor for conversion of financial to economic prices: 0.9.
IRI before paving: 14. IRI after paving: 3.5.

Terrain assumptions:

Terrain Type	Rise & Fall (m/km)	Horizontal Curvature (deg/km)
Flat	10.0	50.0
Rolling	20.0	150.0
Mountainous	50.0	300.0

Main inputs to vehicle operating costs:

Unit Costs	Car	Pickup	Small Bus	Medium Bus	Large Bus	Light Truck	Medium Truck	Heavy Truck
New Vehicle Cost ($/vehicle)	15000	18000	45000	65000	75000	18000	21000	60000
Fuel Cost ($/liter)	0.62	0.51	0.51	0.51	0.51	0.51	0.51	0.51
Lubricant Cost ($/liter)	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95
New Tire Cost ($/tire)	45.00	75.00	100.00	150.00	287.00	77.00	170.00	255.00
Interest Rate (%)	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0

Utilization	Car	Pickup	Small Bus	Medium Bus	Large Bus	Light Truck	Medium Truck	Heavy Truck
Kilometers driven per year (km)	18000	35000	80000	80000	80000	50000	50000	70000
Hours driven per year (hr)	500	1100	2000	2000	2000	1300	1800	2000

Service Life	Car	Pickup	Small Bus	Medium Bus	Large Bus	Light Truck	Medium Truck	Heavy Truck
Service life (years)	10	9	9	9	9	9	10	10

Gross Vehicle Weight	Car	Pickup	Small Bus	Medium Bus	Large Bus	Light Truck	Medium Truck	Heavy Truck
Gross vehicle weight (tons)	1.2	2.0	3.0	6.0	11.0	6.0	12.0	20.0

Annex 2: Interview List

Name	Organization
Gladys Beatriz Rodríguez Rodrigo Marciaq	Fundación para Vida, Salud, Ambiente y Paz de Boquete (FUNDAVISAP)
David Samudio Jorge Pittí Damaris Sánchez Victoriano Ríos	Fundación para el Desarrollo Integral de Cerro Punta (FUNDICEP)
Edidio Bonilla Clafira Muñoz de Bonilla Ezequiel Miranda Elba Landau Carlos Catengel Nicomedes Gonzáles	Comité pro- Carretera Cuesta de Piedra, Santa Rita, Palmira, Boquete
Graciano Cruz Oracio Capiero Roberto Jaramillo Eduardo Landero Oldemar Le Sucre Gonzalo Rojas	Comité Cívico de Boqueteños, Northern Route Promoters
Maximo Montenegro	President, Boquete Irrigation Association
José Victoria Rigel Moscote Evaristo Álvarez	AES Corporation (Hydroelectric)
Demetrio Miranda	University of Panama
Nixa de Ríos	Instituto de Enseñanza Superior- OTEIMA
Luís Fanovich	Ministry of Public Works - Chiriquí
Enzo Polo Cheva	Enzo Eduardo Polo Cheva
Ricardo Anguizola	General Administrator, National Environment Authority
Graciela Palacios	Environmental Coordinator, Constructora Urbana S.A. (CUSA)
Líder Sucre	Executive Director, Asociación Nacional para la Conservación de la Naturaleza (ANCON)
Charlotte Elton Rafael Spalding	Centro de Estudio y Acción Social Panameña (CEASPA)
Jessica Young	Sociedad Audubon de Panamá
Ariel Rodríguez	Centro de Recursos Bióticos de la Universidad de Panamá
Anonymous source	Ministerio de Economía y Finanzas (MEF)

Annex 3: Lists of 115 endangered and endemic mammal, reptile, butterfly and bird species currently residing or expected to inhabit the Barú Volcano National Park according to the Directory of Important Bird Areas in Panama (Angher, 2003)

Threatened and endemic fauna found or expected in Barú Volcano National Park: Mammals:

Blackish Small-eared Shrew, Talamancan Small-eared Shrew, Talamancan Yellow-shouldered Bat, Montane Squirrel, Chiriquí Pocket Gopher, Sprightly Pygmy Rice Rat, Underwood's Water Mouse, Chiriquí Singing Mouse, Chiriquí Harvest Mouse, Naked-footed Deer Mouse, Dice's Rabbit, Mexican Porcupine, Cacomistle, Olingo, Ocelot, Margay, Jaguarundi, Puma and Jaguar.

Amphibians and reptiles:

Frogs and toads: Atelopus Chiriquíensis, A. varius, B. peripatetes, Dendrobates speciosus, Hyla debilis, Hyla pseudopuma, H. rivularis, H. tica, H. zeteki, Phyllomedusa lemur, Ptychohyla legleri, Eleutherodactylus fleischmanni, E. melanostictus, E. monnichorum, E. noblei and Rana vibricaria, the salamanders Bolitoglossa marmorea and B. nigrescens;

Lizards: Mesaspis monticola, Anolis aquaticus, A. kemptoni, A. microtus, A. vociferans and A. woodi, **Snakes:** Geophis championi, Hydromorphus dunni, Rhadinaea calligaster, R. godmani and Urotheca pachyura.

Talamanca endemic butterflies:

Lienix cinerascens, L. viridifascia and Epiphile grandis

Threatened and Endemic Bird Species found or expected in Barú Volcano National Park:

		Threatened	
		Globally	**Nationally**
Nothocercus bonapartei	Highland Tinamou		† †
Accipiter bicolor	Bicolored Hawk		†
Morphnus guianensis	Crested Eagle	#	† †
Spizastur melanoleucus	Black-and-white Hawk-Eagle		† †
Chamaepetes unicolor	Black Guan	#	†
Crax rubra	Great Curassow	#	† †
Odontophorus leucolaemus	Black-breasted Wood-Quail		†
Columba subvinacea	Ruddy Pigeon		†
Claravis mondetoura	Maroon-chested Ground-Dove		†
Geotrygon chiriquensis	Chiriquí Quail-Dove		†
Geotrygon costaricensis	Buff-fronted Quail-Dove		†

		Threatened	
		Globally	**Nationally**
Pyrrhura hoffmanni	Sulphur-winged Parakeet		†
Bolborhynchus lineola	Barred Parakeet		†
Touit costaricensis	Red-fronted Parrotlet	†	†
Otus clarkii	Bare-shanked Screech-Owl		†
Aegolius ridgwayi	Unspotted Saw-whet Owl		†
Caprimulgus saturatus	Dusky Nightjar		†
Panterpe insignis	Fiery-throated Hummingbird		† †
Elvira chionura	White-tailed Emerald*		† †
Lampornis castaneoventris	White-throated Mountain-Gem		† †
Philodice bryantae	Magenta-throated Woodstar		† †
Selasphorus flammula	Volcano Hummingbird		† †
Selasphorus scintilla	Scintillant Hummingbird		† †
Pharomachrus mocinno	Resplendent Quetzal	#	† †
Semnornis frantzii	Prong-billed Barbet		†
Pteroglossus frantzii	Fiery-billed Aracari		† †
Margarornis rubiginosus	Ruddy Treerunner		†
Thripadectes rufobrunneus	Streak-breasted Treehunter		†
Sclerurus albigularis	Gray-throated Leaftosser		†
Scytalopus argentifrons	Silvery-fronted Tapaculo		†
Phyllomyias zeledoni	White-fronted Tyrannulet		†
Contopus lugubris	Dark Pewee		†
Contopus ochraceus	Ochraceous Pewee		†
Empidonax atriceps	Black-capped Flycatcher		†
Myiodynastes hemichrysus	Golden-bellied Flycatcher		†
Pachyramphus albogriseus	Black-and-white Becard		†
Cephalopterus glabricollis	Bare-necked Umbrellabird	†	† †
Procnias tricarunculata	Three-wattled Bellbird	†	†
Cyanolyca argentigula	Silvery-throated Jay		†

		Threatened	
		Globally	**Nationally**
Cistothorus platensis	Sedge Wren		† †
Troglodytes ochraceus	Ochraceous Wren		†
Thryorchilus browni	Timberline Wren		†
Myadestes melanops	Black-faced Solitaire		†
Myadestes melanops	Black-billed Nightingale-Thrush		†
Turdus nigrescens	Sooty Thrush		†
Phainoptila melanoxantha	Black-and-yellow Silky-Flycatcher		†
Ptilogonys caudatus	Long-tailed Silky-Flycatcher		†
Vireo carmioli	Yellow-winged Vireo		†
Parula gutturalis	Flame-throated Warbler		†
Myioborus torquatus	Collared Redstart		†
Basileuterus melanogenys	Black-cheeked Warbler		†
Zeledonia coronata	Wrenthrush		†
Tangara dowii	Spangle-cheeked Tanager		†
Chlorophonia callophrys	Golden-browed Chlorophonia		†
Euphonia anneae	Tawny-capped Euphonia*		†
Chlorospingus pileatus	Sooty-capped Bush-Tanager		†
Pheucticus tibialis	Black-thighed Grosbeak		†
Lysurus crassirotris	Sooty-faced Finch		†
Pselliophorus tibialis	Yellow-thighed Finch		†
Pezopetes capitalis	Large-footed Finch		†
Acanthidops bairdii	Peg-billed Finch		† †
Diglossa plumbea	Slaty Flowerpiercer		†
Junco vulcani	Volcano Junco		†

† † † = Critically Endangered
† † = Endangered
† = Vulnerable
# = Near Threatened
* = Unconfirmed records, but the species are expected to exist based on its geographic distribution and habitat requirements.