CHAPTER 7 Avoiding the End of the Amazon

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CHAPTER 7

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The future of the Amazon will depend in large part on the educational opportunity provided to its residents; payments for carbon storage could be used to invest in health and educational services (© Hermes Justiniano/ Bolivianature.com)

The two most serious threats to the conservation of the Amazon's biodiversity are climate change and deforestation, both of which will be greatly stimulated by IIRSA and PPA investments. Deforestation and forest degradation are fully underway along the margins of the Amazon. IIRSA and related initiatives will lead to the further fragmentation of the Amazon, accelerate forest degradation in the Andes, and complete the conversion of the Cerrado savannas to cropland.

Without a radical change in the nature of modern development, efforts by governments, financial institutions, and civil societies to limit the degradation will be unsuccessful. Regional and global markets will continue to dominate the dynamic on the agricultural front, and standard remedies for slowing or limiting deforestation will have little chance of success. Although sustainable development has been promoted as a philosophical framework to reconcile development and conservation, it has, in practice, only ameliorated the most egregious aspects of development and has had no substantive impact on slowing the rate of tropical deforestation (Figure 7.1).

Figure 7.1. The Amazon needs a new development paradigm in which natural resources are transformed into goods and services that are competitive in global markets; for example, this experimental fish farm in Bolivia relies on the region's abundant surface water, native herbivorous fish, and locally produced soy and corn (© Pep Barba/Estación Piscícola Mausa).

Under the best of circumstances, protected areas and indigenous reserves will be consolidated to function as biological reserves. However, it is unlikely that more than 30–40 percent of the land surface in the Amazon will be set aside for this purpose. In addition, indigenous and extractive reserves will face increased degradation unless the so-called sustainable forestry model is significantly modified or communities choose to opt out of that exploitation alternative. Outside of the protected area and indigenous reserve systems, the landscape will be subject to the inevitable forces of the market.

Policies to slow deforestation on privately held land over the past 20 years have depended on improving "governance," but unfortunately, these have been largely—if not entirely—ineffective. The two most common approaches have been 1) to invest in land use planning studies that promote forest management, and 2) to promulgate regulations that require landholders to retain a specified amount of their land in natural habitat.[88] Deforestation, however, continues at near-record levels, and Brazil's recent report that the annual rate of deforestation has fallen is probably a short-term phenomenon caused by weak international commodity markets rather than the success of government policies to suppress land use change. Landowners routinely ignore requirements to maintain a certain percentage of a property in forest cover. Similarly, regulations that prohibit land clearing along water courses and on steep slopes to create environmental easements are either ignored or unknown. Despite limited success to improve forest management most timber originates from the agricultural frontier where forest landscapes are cleared of their timber resources before the land is converted to crops or pastures. Some analysts are hopeful that the current trend to decentralize administrative responsibility to regional and municipal governments will decrease deforestation. They believe that local governments will be more effective at convincing land holders to conserve forest, limit the use of fire, and avoid the overexploitation of terrestrial and aquatic ecosystems (Nepstad *et al.* 2002). Although improving local government is a laudable goal, it is unlikely that private landholders will react differently to overriding market conditions, or that local governments will be less corrupt or any more attuned to environmental issues than national governments (Fearnside 2003).

Landholders will always act to maximize their own economic benefits, and no amount of regulation will successfully alter that behavior. Landholders will also probably dominate local government and its policies. In the developed world, the right of the landowner to manage private property is considered a foundation of a free market economy and a basic element of human nature. It is unreasonable to expect Amazonian landowners, most of whom come from this cultural tradition, to believe or behave differently, regardless of legal systems that seek to control the exploitation of the natural resources in the national interest.

If markets are destined to prevail and statutory land use regulations prove ineffective, then alternative approaches for saving the Amazon must be developed and implemented that recognize the predominance of the market, or society must accept the fact that most of this forest will eventually be degraded. One approach is to recognize the predominance of markets and to manipulate them through regulatory mechanisms that have been effective in other regions of the world. Almost all markets are regulated to some degree, to avoid extreme situations that are characterized as an abuse of the marketplace. As recent history has shown, unregulated land and commodity markets will eventually lead to the complete deforestation of the Amazon, which can logically and appropriately be considered an abuse of the marketplace.

Market regulations take many forms, but the most effective are those based on financial incentives that motivate individuals to choose voluntarily what is in their short-term economic interest. In North America, Europe, and Japan, subsidies and tax incentives guide land use and promote certain production activities. Agriculture is the most obvious example of how subsidies maintain a land use that would not otherwise be economically competitive. Countries with agricultural subsidies argue that they are necessary to ensure traditional activities, essential to their economy, and provide social welfare to an important sector of the population. This argument applies equally well for the conservation of the Amazon forest ecosystem. Brazil and the Andean countries have recognized that the conservation of the Amazon is a strategic priority. Combine this with the even greater strategic priority for economic growth to improve the social welfare of their populations, and it fully justifies the use of direct and indirect subsidies to ensure investments and activities that promote economic growth while simultaneously conserving the Amazon ecosystem.

The challenge is to find a source of revenue large enough to finance the requisite subsidies. Equally important is to identify economic models that produce goods and services while also avoiding deforestation. Fortunately, the growing recognition

[88] The Forest Code of Brazil establishes this value at 80 percent in the Amazon and 20 percent in the Cerrado.

that ecosystem services have real market value is creating an opportunity to finance this new development paradigm. Key policy options must be elucidated and selected over the next decade to generate the revenues and to ensure a framework that delivers the right economic incentives to the individuals who live and work in the Amazon.

Below are some recommendations for policies and mechanisms that would provide a new development paradigm for the Amazon. This list is by no means exhaustive or particularly novel, but it identifies opportunities for reducing deforestation while addressing the major impediments to sustainable development in the Amazon, Cerrado, and Andes.

RAISING THE MONEY: MONETIZING ECOSYSTEM SERVICES

There is now worldwide concern over global warming and awareness that the conservation of tropical forests can partially mitigate this threat. Given this context, a framework for the transfer of funds from developed nations to developing countries with threatened tropical ecosystems can serve as one source of revenue for conservation and subsidize development that is truly sustainable. The bulk of this revenue would come from carbon credits, which will eventually be implemented under reformed rules of the United Nations Framework Convention on Climate Change (UNFCCC 2006).

- Carbon credits would be earned by reducing emissions from deforestation and forest degradation (REDD according to UNFCCC terminology). For example, lowering the annual deforestation rate in the Amazon basin by 5 percent would generate approximately $650 million in the first year of a multiyear commitment; amounts would multiply dramatically as avoided emissions increased over 30-year commitment periods (see Appendix, Table A.3).
- For countries with currently high levels of deforestation, reductions would be calculated on the basis of historical deforestation; other countries would negotiate a different compensation package so as not to be penalized for past (or recent) low levels of deforestation.
- The issue of leakage— the displacement of existing emissions to other regions rather than actual reductions— would be managed by setting deforestation reduction targets at the national level. Consequently, shifts in land use within a country would cancel each other out or, more optimistically, add up.
- Reforestation and afforestation projects need to be greatly increased in developing countries to restore ecosystem function on previously degraded landscape. Current rules within the Clean Development Mechanism (CDM) have not fostered carbon sequestration in many countries because of implementation and certification burdens. Many of these measures were imposed to address concerns that carbon credits derived from reforestation projects might perversely stimulate the drivers of deforestation. The past decade has demonstrated, however, that this is not the case, and reforestation projects in the developing world have subsequently lagged.
- National commitments to reduce emissions from deforestation (RED) and sequester carbon (CDM) within the confines of the UNFCCC could be complemented by individual projects financed via voluntary markets with a less stringent certification process than the UNFCCC, especially when these bring strong benefits for biodiversity conservation and human welfare. Voluntary certifications could be fortified by adhering to the standards outlined in the Convention on Biological Diversity and the Millennium Development Goals.
- Carbon credit compensation schemes should be designed and managed by the governments of sovereign states as part of their national strategy to reduce carbon emissions. Some countries may adopt market mechanisms, whereas others may choose to create compensation funds that are replenished from both the private and public sectors.[89]
- In recognition of the fact that their agricultural production and hydropower depend partially on the Amazon, the Southern Cone countries of Argentina, Paraguay, and Uruguay join Brazil in making payments for ecosystem services according to the percentage of water each Mercosur nation receives from the Amazon and its degree of economic development.

A FAIR EXCHANGE: ECOSYSTEM SERVICES FOR SOCIAL SERVICES

Frontier populations rank education and health care as their two most important needs; thus, direct economic subsidies that link forest conservation to social services would create a powerful local constituency for conservation. To reduce deforestation, each nation must involve the actors responsible for deforestation and monitor the efficacy of the program on an annual basis. Although the administration of economic subsidies will vary among countries, resources and benefits must flow to local communities, regardless of the mechanism selected. Because local governments are usually responsible for providing essential social services, they are logical candidates for administering these programs (see below).

- Transfer payments to local governments for carbon credits and other ecosystem services should be dedicated to improving education and health care.
- Payments for ecosystem services would not be entitlements. Positive incentives in the form of increased budgets could be used to reward communities for going beyond commitments, while communities that fail to meet commitments would face budget reductions.
- A similar mechanism to reduce forest fires could generate additional carbon-based revenues. A reduction in fire would benefit forest management, local health, and contribute to more robust rainfall regimes.

89 Brazil has proposed that transfer payments be made as part of development assistance programs, whereas the Alliance for Rainforest Nations has proposed that market-based systems be used to govern the transfers.

QUID PRO QUO

Although ecosystem services can provide an important new source of national revenue, individual nations may need additional incentives to enter into ecosystem services agreements. In particular, Brazil and the Andean nations may be resistant to participate in mechanisms that seem to limit their sovereignty over the natural resources of the Amazon. To make participation politically palatable, compensation systems related to ecosystem services could also relate to other national priorities such as commerce and international security.

- Agricultural subsidies in Europe and North America are a major point of contention in world trade talks. Brazil is a leader among developing countries in contending that agricultural subsidies must be reduced if commerce in industrial goods and services is to be liberalized. Shifting subsidies from domestic agriculture to forest conservation via reduced emissions from deforestation would limit agricultural expansion in the Amazon and indirectly protect European and North American farmers.[90] Brazil would open its markets to industrial goods and services, while developed countries would open their markets to food and biofuels from Brazil.
- Global climate change represents a real and present threat to the planet's security—one that the collapse of the Amazon ecosystem would dramatically exacerbate.[91] Although the United Nations Security Council has not traditionally addressed environmental security, an increase in climate-related natural disasters has highlighted the vulnerability of the planet. Recognizing the importance of the Amazon to global security would provide additional weight to Brazil's petition for a permanent seat on the Security Council.
- In the Manaus Free Trade Zone, international companies have demonstrated a willingness to invest in an Amazonian urban center when offered tax advantages and lower tariffs. This could be used as a model for manufacturing and commercial centers in other regional cities, providing an alternative to development based solely on natural resource exploitation. Any such initiative must also include incentives for technology transfer so that these centers evolve past the initial assembly line (masquilladora) stage of development.

SUBSIDIZING ALTERNATIVE PRODUCTION SYSTEMS

The inhabitants of the Amazon need and deserve increased economic opportunity. Revenues generated by the monetization of ecosystem services could subsidize production systems that both stimulate economic growth and remain compatible with forest conservation. A number of systemic constraints to economic growth exist in the region. The most important is the insecurity of land tenure, followed by poor transportation systems, the absence of affordable credit, and a lack of reliable energy supplies. Current development models provide no adequate solutions for any of these impediments and tend to promote deforestation. The following alternative models conserve ecosystem services and could replace the existing models if markets are effectively regulated and are accompanied by subsidies to counterbalance existing market forces.

People by Air and Cargo by Water

As an alternative to highways that degrade and fragment the Amazon, the countries of the region could adopt a bimodal transportation model that uses airlines and river barges. This system could complement a limited highway network envisioned by IIRSA, but would erase the need for other projects promoted by national and state transportation ministries.[92] As part of a modified IIRSA investment program, it would provide cost-effective alternatives for transporting people and commodities.

- Airline and barge companies could be supported indirectly by tax abatements, as well as subsidized fuel prices and below-market interest rates for capital investments. Services to remote areas could be directly subsidized by cash payments to ensure reliable and regular services.
- Air service could promote regional integration by offering cross-border flights without routing through capital cities or large regional hubs.
- A greatly expanded air service would benefit the tourism industry by opening up remote areas, which would have the added benefit of reducing the environmental impact on areas with high tourist loads.
- A subsidized river transport service would provide a cost-effective solution for moving bulk commodities (i.e., timber, grain, minerals, and biofuels).

Land Tenure for Conservation

Reformed land tenure systems are central to stopping deforestation. People seeking land tenure are one of the principal causes of deforestation because the current titling process rewards land tenants who deforest lands and it castigates those who do not. The goal would be to maintain a forest matrix by subsidizing land use models that follow the 80:20 (forest:cultivated land) rule stipulated by the Brazilian Forest Code.[93] Both governmental regulations and market-based economic incentives are needed to ensure that intensive production systems are linked to forest conservation.

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90 Subsidies in Europe and North America fluctuate between $50 to $75 billion annually. The proposed payments for carbon sequestration services represent only 1 percent of this total.

91 The U.S. military recently recognized global climate change as an important national security threat (MAB 2007).

92 All of the Andean countries have different versions of a piedmont highway that would transect various national parks, whereas Brazil plans a second Transamazonian highway (BR-210), known as Perimetral Norte, that would parallel the Amazon river approximately 8 degrees north of the equator.

93 Even the most optimistic land use change scenarios predict that at least 20 percent of the Amazon will be converted to intensive or semi-intensive production systems over the next century, with pessimistic scenarios forecasting up to 50 percent deforestation. Thus, a land use model in which 20 percent of the landscape is deforested but linked to the conservation of 80 percent would result in reduced deforestation.

- Enterprises that agree to a contractually binding ratio of 80:20 in perpetuity would enjoy an expedited titling process.[94]
- The state would distribute land by commercial transactions rather than land grants, and the terms of the mortgage would stipulate the 80:20 land use ratio.
- In heavily deforested landscapes, access to low-interest credit and expedited land titles would be offered to enterprises that agree to plant trees to meet the 80:20 land use rule.
- Enterprises that agree to the 80:20 land use rule would have access to low-interest loans to implement high-intensity production models (see next section).
- Compliance with the 80:20 land use rule would be monitored with remote sensing technology and with land registries managed by local and national governments. Failure to comply would lead to an immediate revocation of credit and the reversion of land to the state.

Economic Growth and Job Creation

Intensive production needs to predominate on landscapes that have been converted to agriculture, livestock, or tree plantations.[95] This production must ensure long-term sustainability and be diversified to ensure economic stability in fluctuating international commodity markets. Subsidized credit, transportation, and energy are paramount and should be considered as legitimate components of Amazonian production models; however, producers must provide commercially attractive goods and services that are competitive in real markets.

- A diversified tourist industry could focus on ecotourism, but it would also include sport fishing, cultural tourism, adventure leisure activities (water skiing and scuba diving), and luxury cruise lines.
- The tourist industry should be democratized by involving local communities as shareholders in new enterprises. Subsidized credit can be given to enterprises that enlist local communities as shareholders.
- Fish farming should be promoted as the primary production system in the Amazon.[96] Water is the region's most abundant and valuable resource and should form the foundation for its economic growth. Fish farming is the most efficient method of converting vegetable matter to animal protein and can be organized into small units managed by families.[97] It can also be a key component in a production chain that links the granaries of Mato Grosso and Santa Cruz with overseas markets.[98]
- Tree plantations in previously deforested regions will sequester carbon while also creating an economic resource over the medium term. Subsidies in the form of low-interest loans, technical support, and direct payments can be used to reforest landscapes.
- Mineral and hydrocarbon exploitation will continue to be important sources of revenue for national economies.[99] Royalty revenues from these activities should be used to secure additional resources from deforestation avoidance initiatives; for example, hydrocarbons are often produced within protected areas, so a portion of the royalties could be used to finance the management of the protected area. This would link fossil fuel production to positive actions that will reduce greenhouse gas emissions.
- Nonresource-dependent economic models need to be created to diversify the region's economy; the example of Manaus as a free trade zone that developed a high-tech industry should be duplicated in other Amazonian urban centers.

Innovation in Energy

Economic growth requires energy. The remoteness of the Amazon increases the cost of traditional fossil fuels, creating both challenges and opportunities. Clean energy should be the paradigm for production systems that are subsidized by ecosystem services payments, and the Amazon can create opportunities for strategic partnerships in the research, development, and commercialization of alternative energy.

- Solar power will be the most competitive option for most remote localities with moderate energy needs; investments in this technology could be subsidized by ecosystem service payments.
- Tax abatements, tariff preferences, and direct subsidies should be provided to multinational corporations that establish solar panel manufacturing facilities in Amazonian urban centers.
- Because water is the Amazon's most important natural resource, hydroelectric power will be an important component of the energy model. The potential for hydroelectric power in the Amazon is enormous, but facilities should not be constructed on the major tributaries of the

[94] Ten percent of the Amazon is equivalent to about 25,000 km^2. At an average productivity of $500 per hectare (based on low soybean yields and low prices in Bolivia), this would generate $1.2 billion in annual revenues for the region. The potential from biofuels will be several times higher than this figure.

[95] In some parts of the humid tropics, only 5 percent of deforested lands are under production, while the other 95 percent is left as secondary forest fallow.

[96] Fish farming, or aquaculture, is now the fastest growing form of food production in the world. Since 1990, it has increased at a rate of 10 percent per year. If this trend continues, within a decade, more seafood will come from farms than from the wild.

[97] Yields of 3,682 kg/ha have been obtained in fisheries of commercial *Colossoma macropomum* (tambaqui), a frugivorous species that is fed a commercial diet in stocked ponds; 10,000 ha of ponds would produce 35,000 metric tons of fish per year, matching the total wild harvest of all species in Loreto, Peru in 1994 (Peralta & Teichert-Coddington 1989).

[98] This production model would need to incorporate guidelines to avoid or minimize potentially negative environmental impacts, such as the conversion of wetlands, the introduction of exotic species, and the pollution of fresh water from the inappropriate treatment of wastewater and effluents from fish ponds.

[99] Neither mines nor hydrocarbon concessions should have trouble meeting the 80:20 rule if local populations collaborate by not invading concessions.

Amazon (e.g., Madeira and Xingu) in order to limit the impact of dams on aquatic ecosystems.
- Biofuel crops, including African oil palm to produce biodiesel and elephant grass to produce cellulosic alcohol, will probably be the most successful agricultural enterprise in the Amazon. Locally produced biodiesel could provide an economically competitive source of fuel for the barge industry.
- Although the cultivation of biofuel crops probably poses the largest single future threat to the Amazon, this threat can be mitigated by requiring the 80:20 land use model and—most importantly—subsidizing biofuel production on previously deforested, degraded landscapes.
- Propane and butane (i.e., liquefied petroleum gas—LPG) are usually abundant in natural gas fields and provide an energy-rich, clean, and portable fuel source. Although LPG is separated out at refineries and sold as subsidized fuel to urban populations, small gas plants can be built in the Amazon, and LPG can become one of several energy options.
- Fossil fuels for the airline industry will have to be subsidized to support the people-by-air cargo-by-water transportation model; however, technological innovation should eventually allow for the conversion of vegetable oils to produce kerosene and aviation fuel.

HARNESSING THE POWER OF LOCAL GOVERNMENT

Statutory regulations have been ineffective because they have been isolated from market mechanisms. Similarly, economic incentives will be insufficient to change the development dynamic in the Amazon if they are implemented in a lax regulatory environment. Subsidies are easily abused, and strong institutions are required to ensure that market forces operate as intended. Thus, all the subsidies and market mechanisms proposed here are linked to regulatory requirements, particularly the 80:20 land use rule that offers one of the few realistic options to limit deforestation. Most laws and regulations are initiated at the national level, but municipal and regional governments have an important and growing role in enforcement. The conservation of the Amazon will depend on a large extent on the capacity of local governments to fulfill their role as public institutions.

- Land title registries must be a priority investment across the Amazon region. Questionable land tenure is a source of violence and corruption in frontier areas. Local governments must create and maintain rural and urban land registers as the foundation for long-term growth and good government. Land tenure would be the basis for local taxes, and access to credit would be granted on the basis of the patrimonial value of land.
- Independent watchdog agencies must be established to monitor deforestation, and municipal governments will need remote sensing and geographic information system (GIS) capacity to enforce bans on deforestation and fires. In Brazil, this capacity exists at the national level and has recently been decentralized in Mato Grosso[100]; however, no such coordinated effort exists in any of the Andean countries.
- Regional universities will need an infusion of investment to support revitalized educational and health systems. Resources channeled to state universities should be linked to governance reforms and support expanded research programs linked to extension and focusing on rural development.[101]
- University-based research will help subsidize and improve intensive production systems, particularly to discover novel uses for the biological and genetic resources of the Amazon and Andes.

DESIGNING CONSERVATION LANDSCAPES

In addition to conserving large blocks of the Amazon within an expanded protected area system, it will also be necessary to design and implement "conservation corridors" in strategic areas where transportation corridors are considered requisite for the physical and economic integration of the region. A conservation corridor is a landscape that is designed to promote biodiversity conservation. It consists of protected areas strategically situated within a matrix of different land use types so that species can move and exchange genetic resources. As IIRSA highways are constructed and deforestation belts expand over time, and as global warming brings about shifts in the environmental gradients that control species distribution, the importance of habitat connectivity will become ever more important.

- Large blocks of forest must be conserved to minimize the impact of edge effects and to provide sufficient area for the survival of rare species.
- The western Amazon should receive special consideration because it is the most biologically diverse region and has enjoyed the most stable climate over millennia.
- Although much of the landscape outside of protected areas will eventually become "production forests," these should be established with timber harvest cycles of approximately 100 years to maintain the essential characteristics of forest wilderness.
- Incentives must be developed for communities to conserve forest landscapes adjacent to highways so that wildlife can migrate across these barriers.[102]
- The connectivity between the piedmont and the montane ecosystems of the Tropical Andes Hotspot must be main-

[100] The System for Environmental Licensing in Rural Properties uses remote sensing technology provided by the national space agency (INPE) to monitor deforestation in approximately real time and compares that information with land tenure data acquired through a licensing program.

[101] Brazil has adopted a relatively efficient governance structure for its public university, but Andean countries cling to an outdated, highly politicized model in which students and faculty choose university authorities via an electoral process. This model tends to reward teaching while penalizing research and extension.

[102] The recently published environmental management plan for the BR-163 transportation corridor between Cuiabá and Santarém incorporates a Jamanxim National Park that literally straddles the highway (Plano BR-163).

Text Box 7

Protected Areas: Enough Is Enough—or Not Nearly Enough?

The 1990s witnessed the creation of many protected areas throughout the Amazon, with the goal to designate approximately 20 percent of the total surface of each country as some type of protected area, with different levels of natural resource use (IUCN 1994). At the same time, indigenous peoples began to gain the titles for their traditional lands, acquiring about 20 percent of the region, which many conservationists hope will function as surrogate protected areas.

Brazil is still actively expanding its protected area system under a range of categories with flexible development options. Slightly more than 70 percent of Amapá and almost half the area of Pará, Acre, and Roraima states have been incorporated into some form of conservation unit, including indigenous areas and productive forest reserves. Peru has likewise set aside almost half (45 percent) of its Madre de Dios Province, and Colombia has essentially ceded almost all of its lowland Amazon region to indigenous groups (see Figure 5.3 and Tables A.5 to A.7). However, the basin-wide total is still a long way from 50 percent, and even if 50 percent is eventually set aside, the eventual deforestation and degradation of the remaining half is far from an attractive proposition

Many people, particularly in the private sector and the prodevelopment ministries, believe that "enough is enough" and fear that more protected areas will make large regions unavailable for mining, hydrocarbons, and timber. However, conservationists argue that what has been set aside is "not nearly enough," particularly because parallel efforts to slow forest degradation and deforestation have failed (see Figure 2.1).

These apparently opposed positions will eventually be resolved via democratic processes. It is hoped that both groups will realize that there can be common ground: that a protected area may have multiple uses, that mining and hydrocarbon production do not necessarily have to lead to widespread deforestation, and that logging might be truly sustainable. One hopes, too, that people will see conservation as an investment in the planet's future. Once the natural ecosystem is permanently altered, there is no turning back. If a mistake is to be made, it would only seem prudent to err on the side of caution and be generous with future generations when deciding "how much is enough?"

tained (or restored) to ensure that lowland species can migrate into the foothills in response to climate change.

- River Corridors should be another priority because they incorporate moist valley bottoms that will be resilient to future drought, and they protect both terrestrial and aquatic ecosystems. The southern Amazon tributaries (e.g., Xingu, Madeira) will also function as latitudinal corridors.
- Topographic features that would offer refuge to lowland species migrating in response to global change should be identified as priority areas for protection; this highlights the importance of the hills, ridges, and valleys of the Brazilian and Guayana Shield regions.

CONCLUSIONS

The Amazon Wilderness Area is facing inexorable changes resulting from economic development and environmental degradation, processes that have already transformed the Cerrado into a vast agroindustrial estate. The tropical forests of the Andes have been subject to a long history of degradation, but in the past this settlement has been characterized by isolation, with small circumscribed regions linked to a single urban area in the highlands; IIRSA proposed to integrate the isolated regions of the Andean piedmont and link them with national, regional, and global markets. IIRSA, the PPA, and other public and private initiatives will amplify the impacts of human migration, agricultural expansion, timber extraction, mining, hydrocarbon production, and climate change. The existing paradigm of sustainable development has failed to arrest deforestation and forest degradation. Unfortunately, traditional development is largely incompatible with conservation because it cannot produce the economic incentives to promote the long-term preservation of natural forest habitat. Efforts to use community-based initiatives to slow deforestation have failed—and will continue to fail—because the ever-expanding Amazon frontier is populated with individuals who make decisions on the basis of their economic interests for the short term. Even the most amenable production systems, such as the current model of sustainable forestry, will lead to the eventual degradation of forest ecosystems and conversion to tree plantations.

The traditional solution of creating protected areas will likely be an integral but insufficient solution because it will encompass only 20–30 percent of the landscape, and these protected areas will become increasingly isolated in a matrix of degraded forest and anthropogenic landscapes. Indigenous lands and extractive reserves offer an important complement to protected areas, but these may be co-opted into the current forest management model unless communities have a more attractive economic alternative. Even if indigenous lands are preserved intact and the protected area system is expanded, they will not exceed 50 percent of the total land surface of the Amazon, even in the most optimistic scenario. That explicitly leaves the remaining 50 percent exposed to the forces of international commodity markets and the search for personal wealth that characterizes modern society.

The Amazon requires a new development paradigm unique to its special characteristics and global importance. This new paradigm must ensure its inhabitants a dignified level of prosperity while making important contributions to the economies of the nations that are custodians of the Amazon. If the Amazon forest is a global asset worth preserving, then it is only reasonable that the custodians be paid for their efforts.

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APPENDIX

Tables A.1 through A.4 provide simple models that estimate the value of the carbon stored in Amazonian forests (Table A.1), the value of the carbon released each year via deforestation (Table A.2), the potential value of a 5 percent reduction in deforestation in the eight countries of the greater Amazon Wilderness Area compared against the documented baseline deforestation rates (Table A.3), and the potential value of a 5 percent reduction in deforestation for four Andean countries when compared to a Business as Usual Scenario (Table A.4). Tables A.5 through A.7 provide statistics on protected areas and indigenous lands.

Table A.1. A model estimating the economic value of the Amazon forest based on the carbon stored in its biomass; forest cover estimates are derived from published and on-line studies using satellite images; the value of 125 metric tons of carbon per hectare is a conservative estimate derived from plot-based biomass studies (Baker *et al.* 2004); the market value of a metric ton of carbon ($10) is near the current value quoted on the Chicago Climate Exchange for carbon financial instruments.

	Forest cover (×1,000 ha)	Carbon @125 t/ha (×1,000 t)	Gt C	Gt CO_2	Value of Standing Forest @ $10/t CO_2 ($ billion)
Bolivia[1]	46,070	5,758,750	5.8	21.1	211
Brazil[2]	336,873	42,109,109	42.1	154.5	1,545
Colombia[3]	57,117	7,139,606	7.1	26.2	262
Ecuador[3]	11,764	1,470,438	1.5	5.4	54
Peru[3]	71,335	8,916,825	8.9	32.7	327
Venezuela[3]	42,164	5,270,494	5.3	19.3	193
Guyana[4]	15,104	1,888,000	1.9	6.9	69
Suriname[4]	14,776	1,847,000	1.8	6.8	68
French Guiana[4]	13,000	1,625,000	1.6	6.0	60
Total	608,202	76,025,221	76.0	279	2,790

1. Killeen *et al.* 2007b.
2. Derived from published reports of total forest cover for the Brazilian Amazon (Btito-Carreres *et al.* 2005, PRODES 2007).
3. Unpublished results of a deforestation study of the Andean countries recently completed by Conservation International (Harper *et al.* 2007).
4. FAO 2005.

Table A.2. A model estimating the economic value of the Amazon forest based on the carbon released each year into the atmosphere from deforestation. Cover estimates are derived from published and online studies using satellite images; the value of 125 metric tons of carbon per hectare is a conservative estimate derived from plot-based biomass studies conducted in the Amazon (Baker *et al.* 2004); the price of a metric ton of carbon ($10) is near the current value quoted on the Chicago Climate Exchange for carbon financial instruments.

Amazon Countries	Forest Cover 1990 (×1,000 ha)	Forest Cover 2000 (×1,000 ha)	Forest Cover 2005 (×1,000 ha)	Annual Rate of Deforestation (×1,000 ha yr^{-1})	Carbon Emissions@ 125 t/ha (×1,000 t)	CO_2 Emissions (×1,000 t)	Value of Emissions @ \$10/t CO_2 (\$ million)
Bolivia[1]	48,355	46,862	46,070	240	30,001	110,105	1,101
Brazil[2]	364,922	348,129	336,873	2,250	281,250	1,032,188	10,322
Colombia[3]	59,282	57,839	57,117	144	18,044	66,221	662
Ecuador[3]	12,333	11,953	11,764	38	4,748	17,423	174
Peru[3]	72,511	71,727	71,335	78	9,800	35,966	360
Venezuela[3]	43,258	42,529	42,164	73	9,119	33,466	335
Guyana[4]	15,104	15,104	15,104	-	-	-	-
Suriname[4]	14,776	14,776	14,776	-	-	-	-
French Guiana[4]	13,000	13,000	13,000	-	-	-	-
Total	643,540	621,919	608,202				
Annual rates				2,824	352,961	1,295,369	
						Annual Total	12,954
						30-Year Total	388,611
						Net Present Value for 30 Year Total	134,325

Andean Countries	Forest Cover 1990 (×1,000 ha)	Forest Cover 2000 (×1,000 ha)	Forest Cover 2005 (×1,000 ha)	Annual Rate of Deforestation (×1,000 ha yr^{-1})	Carbon Emissions @ 125 t/ha (×1,000 t)	CO_2 Emissions (×1,000 t)	Value of Emissions @ \$10/t CO_2 (\$ million)
Bolivia[1]	48,355	46,862	46,070	240	30,000	110,100	1,101
Colombia[3]	59,282	57,839	57,117	144	18,000	66,060	661
Ecuador[3]	12,333	11,953	11,764	38	4,748	17,423	174
Peru[3]	72,511	71,727	71,335	78	9,800	35,966	360
Total	192,481	188,381	186,285				
Annual rates				500	62,548	229,549	
						Annual Total	2,295
						30-Year Total	68,865
						Net Present Value for 30-Year Total	23,803

1. Killeen *et al.* 2007b.
2. Derived from published reports of total forest cover for the Brazilian Amazon (Btito-Carreres *et al.* 2005, PRODES 2007).
3. Unpublished results of a deforestation study of the Andean countries recently completed by Conservation International (Harper *et al.* 2007).
4. FAO 2005.

Table A.3. A model estimating the economic value of a Sustainable Scenario where Amazonian countries agree to reduce the annual rate of deforestation by 5 percent every year for 30 years. The Baseline Scenario is based on estimates of deforestation derived from published and online studies using satellite images (see Table A2). The value of 125 metric tons of carbon per hectare is a conservative estimate derived from plot-based biomass studies conducted in the Amazon (Baker *et al.*, 2004); the price of a metric ton of carbon ($10) is near the current value quoted on the Chicago Climate Exchange for carbon financial instruments.

Year	Baseline Scenario Forest Cover (1,000 ha)	Baseline Scenario Deforestation Rate (1,000 ha yr^{-1})	Sustainable Scenario Deforestation Rate (1,000 ha yr^{-1})	Sustainable Scenario Forest Cover (1,000 ha)	Difference in Deforestation between Scenarios (1,000 ha)	Total Accumulated Carbon Offset 125 t/ha (x1,000 t)	Total CO_2 Emissions (×1,000 t)	Total Accumulated Value @ $10/t CO_2 (×$1,000)	Annual Payment @ $10/t CO_2 (x$1,000)	Total Accumulated Value at NPV @ $10/t CO_2 (x$1,000)	Annual Payment at NPV @ $10/t CO_2 (x$1000)
2007	608,202										
2008	605,378	2,824	2,683	605,519	141	17,648	64,768	647,684	647,684	647,684	647,684
2009	602,554	2,824	2,548	602,971	416	52,062	191,067	1,910,669	1,262,984	1,632,593	984,908
2010	599,731	2,824	2,421	600,550	819	102,403	375,819	3,758,188	1,847,519	3,020,661	1,388,069
2011	596,907	2,824	2,300	598,250	1,343	167,875	616,102	6,161,016	2,402,828	4,661,825	1,641,164
2012	594,083	2,824	2,185	596,065	1,982	247,722	909,139	9,091,386	2,930,371	6,481,354	1,819,530
2013	591,260	2,824	2,076	593,989	2,730	341,224	1,252,292	12,522,922	3,431,536	8,418,367	1,937,013
2014	588,436	2,824	1,972	592,018	3,582	447,699	1,643,057	16,430,566	3,907,644	10,423,606	2,005,239
2015	585,612	2,824	1,873	590,144	4,532	566,499	2,079,051	20,790,512	4,359,946	12,457,553	2,033,947
2016	582,789	2,824	1,780	588,365	5,576	697,007	2,558,014	25,580,145	4,789,633	14,488,825	2,031,272
2017	579,965	2,824	1,691	586,674	6,709	838,637	3,077,798	30,777,980	5,197,835	16,492,815	2,003,991
2018	577,141	2,824	1,606	585,068	7,927	990,834	3,636,361	36,363,608	5,585,628	18,450,544	1,957,728
2019	574,317	2,824	1,526	583,542	9,225	1,153,069	4,231,764	42,317,638	5,954,031	20,347,682	1,897,138
2020	571,494	2,824	1,450	582,093	10,599	1,324,841	4,862,165	48,621,652	6,304,013	22,173,730	1,826,048
2021	568,670	2,824	1,377	580,715	12,045	1,505,672	5,525,815	55,258,149	6,636,497	23,921,327	1,747,597
2022	565,846	2,824	1,308	579,407	13,561	1,695,109	6,221,051	62,210,505	6,952,356	25,585,666	1,664,339
2023	563,023	2,824	1,243	578,164	15,142	1,892,723	6,946,293	69,462,928	7,252,423	27,164,004	1,578,339
2024	560,199	2,824	1,181	576,984	16,785	2,098,104	7,700,041	77,000,414	7,537,486	28,655,256	1,491,251
2025	557,375	2,824	1,122	575,862	18,487	2,310,864	8,480,871	84,808,710	7,808,296	30,059,646	1,404,391
2026	554,552	2,824	1,066	574,797	20,245	2,530,634	9,287,428	92,874,276	8,065,565	31,378,431	1,318,784
2027	551,728	2,824	1,012	573,784	22,057	2,757,064	10,118,425	101,184,247	8,309,971	32,613,655	1,235,224
2028	548,904	2,824	962	572,823	23,919	2,989,820	10,972,640	109,726,404	8,542,157	33,767,962	1,154,307
2029	546,081	2,824	914	571,909	25,829	3,228,587	11,848,914	118,489,138	8,762,733	34,844,428	1,076,467
2030	543,257	2,824	868	571,041	27,785	3,473,063	12,746,142	127,461,419	8,972,281	35,846,436	1,002,008
2031	540,433	2,824	824	570,217	29,784	3,722,964	13,663,277	136,632,770	9,171,351	36,777,563	931,127
2032	537,609	2,824	783	569,434	31,824	3,978,017	14,599,324	145,993,238	9,360,468	37,641,497	863,934
2033	534,786	2,824	744	568,690	33,904	4,237,966	15,553,337	155,533,367	9,540,129	38,441,965	800,469
2034	531,962	2,824	707	567,983	36,021	4,502,566	16,524,417	165,244,174	9,710,807	39,182,683	740,718
2035	529,138	2,824	672	567,311	38,173	4,771,584	17,511,712	175,117,124	9,872,951	39,867,307	684,623
2036	526,315	2,824	638	566,673	40,358	5,044,799	18,514,411	185,144,111	10,026,987	40,499,402	632,095
2037	523,491	2,824	606	566,067	42,576	5,322,001	19,531,743	195,317,434	10,173,322	41,082,420	583,018
	Remnant Forest Cover					Totals		Totals			
	86%			93%		5,322,001	19,531,743		195,317,434		41,082,420

Table A.4 A model estimating the economic value of a scenario where four countries (Bolivia, Peru, Ecuador and Colombia) agree to reduce the annual rate of deforestation by 5% every year for 30 years (Sustainable Scenario) compared to a scenario with an annual increase of 2.5% in deforestation that may accompany IIRSA highway projects on the Andean piedmont (Business As Usual Scenario). The baseline value is derived from published and on-line studies using satellite images (see table A2); the value of 125 metric tons of carbon per hectare is a conservative estimate derived from plot-based biomass studies conducted in the Amazon (Baker *et al.*, 2004); the market value of a metric ton of carbon ($10) is near the current value quoted on the Chicago Climate Exchange (CCX) for carbon financial instruments.

Years	Baseline Scenario Deforestation Rate (1,000 ha yr-1)	Baseline Scenario Forest Cover (1,000 ha)	Business As Usual Scenario Deforestation Rate (1,000 ha yr^{-1})	Sustainable Scenario Deforestation Rate (1,000 ha yr^{-1})	Business As Usual Scenario Forest Cover	Sustainable Scenario Forest Cover (1,000 ha)	Difference in Deforestation between Scenarios (1,000 ha)	Total Accumulated Carbon Offset 125 t/ha (x1,000 t)	Total Reduced CO_2 Emissions (×1,000 t)	Total Accumulated Value @ $10/t CO_2 (x$1,000)	Annual Payment @ $10/t CO_2 (x$1,000)	Total Accumulated Value at NPV @ $10/t CO_2 (x$1,000)	Annual Payment at NPV @ $10/t CO_2 (x$1,000)
2007	186,285												
2008	185,785	500	513	475	185,772	185,810	38	4,691	17,216	172,162	172,162	172,162	172,162
2009	185,284	500	526	452	185,246	185,358	112	13,956	51,218	512,182	340,020	437,519	265,357
2010	184,784	500	539	429	184,707	184,929	221	27,686	101,608	1,016,079	503,897	816,104	378,585
2011	184,283	500	552	408	184,155	184,521	366	45,781	168,018	1,680,180	664,101	1,269,694	453,590
2012	183,783	500	566	387	183,589	184,134	545	68,150	250,111	2,501,111	820,931	1,779,428	509,734
2013	183,283	500	580	368	183,009	183,766	758	94,708	347,578	3,475,781	974,670	2,329,604	550,176
2014	182,782	500	595	349	182,414	183,417	1,003	125,378	460,137	4,601,373	1,125,592	2,907,210	577,606
2015	182,282	500	610	332	181,804	183,085	1,281	160,091	587,533	5,875,331	1,273,959	3,501,521	594,311
2016	181,782	500	625	315	181,179	182,770	1,590	198,783	729,535	7,295,354	1,420,023	4,103,750	602,228
2017	181,281	500	641	300	180,539	182,470	1,931	241,400	885,938	8,859,383	1,564,029	4,706,750	603,001
2018	180,781	500	657	285	179,882	182,185	2,303	287,891	1,056,559	10,565,592	1,706,209	5,304,766	598,016
2019	180,280	500	673	270	179,209	181,915	2,706	338,212	1,241,238	12,412,383	1,846,790	5,893,211	588,444
2020	179,780	500	690	257	178,520	181,658	3,139	392,326	1,439,837	14,398,372	1,985,990	6,468,481	575,270
2021	179,280	500	707	244	177,813	181,414	3,602	450,201	1,652,239	16,522,389	2,124,017	7,027,801	559,320
2022	178,779	500	725	232	177,088	181,182	4,094	511,811	1,878,347	18,783,466	2,261,077	7,569,085	541,284
2023	178,279	500	743	220	176,345	180,962	4,617	577,134	2,118,083	21,180,831	2,397,365	8,090,821	521,736
2024	177,778	500	761	209	175,584	180,753	5,169	646,155	2,371,390	23,713,903	2,533,072	8,591,976	501,155
2025	177,278	500	780	199	174,803	180,554	5,751	718,863	2,638,229	26,382,286	2,668,383	9,071,908	479,932
2026	176,778	500	800	189	174,003	180,365	6,362	795,252	2,918,576	29,185,764	2,803,478	9,530,300	458,391
2027	176,277	500	820	179	173,183	180,186	7,003	875,321	3,212,430	32,124,295	2,938,531	9,967,093	436,794
2028	175,777	500	840	170	172,343	180,016	7,673	959,074	3,519,801	35,198,007	3,073,712	10,382,446	415,352
2029	175,277	500	861	162	171,481	179,854	8,372	1,046,518	3,840,719	38,407,194	3,209,186	10,776,682	394,236
2030	174,776	500	883	154	170,599	179,700	9,101	1,137,665	4,175,231	41,752,310	3,345,116	11,150,258	373,576
2031	174,276	500	905	146	169,693	179,554	9,860	1,232,533	4,523,397	45,233,969	3,481,659	11,503,736	353,478
2032	173,775	500	928	139	168,766	179,415	10,649	1,331,143	4,885,294	48,852,940	3,618,970	11,837,752	334,016
2033	173,275	500	951	132	167,815	179,283	11,468	1,433,519	5,261,014	52,610,140	3,757,200	12,153,002	315,250
2034	172,775	500	975	125	166,840	179,158	12,318	1,539,690	5,650,664	56,506,639	3,896,499	12,450,217	297,216
2035	172,274	500	999	119	165,841	179,039	13,198	1,649,691	6,054,365	60,543,650	4,037,011	12,730,157	279,940
2036	171,774	500	1,024	113	164,817	178,926	14,108	1,763,557	6,472,253	64,722,530	4,178,881	12,993,592	263,434
2037	171,274	500	1,050	107	163,768	178,818	15,051	1,881,329	6,904,478	69,044,781	4,322,250	13,241,293	247,702
	Remnant Forest Cover												
	92%				88%	96%		1,881,329	6,904,478		68,872,619		13,241,293

Table A.5 Protected Areas and Indigenous Lands in the Amazon Wilderness Area (See Figure 5.3).

Amazon Wilderness Area	Area (km^2)	Protected Area Total (km^2)	% Protected Area	Indigenous Land Total (km^2)	% Indigenous Land	Total Protected Areas and Indigenous Lands (km^2)	% Protected Areas and Indigenous Lands
Brazil	4,231,358	951,235	22.5	941,760	22.3	1,758,856	41.6
Bolivia	354,496	37,282	6.3	76,722	21.6	103,565	25.7
Colombia	448,130	62,549	14.0	211,110	47.1	256,320	57.2
Ecuador	70,840	16,434	23.2	12	0.0	16,445	23.2
Peru	659,586	154,692	21.0	154,317	12.8	205,831	31.2
Venezuela	416,919	300,675	72.1	1,835	0.4	300,806	72.1
French Guiana	83,267	39,847	47.9	0	-	39,847	47.9
Guayana	210,025	5,157	2.9	6,693	3.2	11,850	5.6
Suriname	146,101	22,184	15.2	0	0.1	22,184	15.2
Total	6,620,722	1,590,055	24.0	1,392,449	21.0	2,715,705	45.0

Table A6. Protected Areas and Indigenous Lands in the Legal Amazon of Brazil (modified from the Instituto Socioambiental (http://www.socioambiental.org/uc/quadro_geral).

Brazilian State	Area (km^2)	Protected Area Total (km^2)	% protected	Indigenous Area Total (km^2)	% Indigenous Area	Total Protected and Indigenous (km^2)	% Protected and Indigenous
Acre	152,581	51,230	33.6%	24,283	15.9%	75,513	49.5%
Amapá	142,815	89,152	62.4%	11,860	8.3%	101,012	70.7%
Amazonas	1,570,746	260,682	16.6%	428,719	27.3%	689,401	43.9%
Maranhão	331,983	13,862	4.2%	19,220	5.8%	33,082	10.0%
Mato Grosso	903,358	28,360	3.1%	135,129	15.0%	163,489	18.1%
Pará	1,247,690	308,742	24.7%	284,397	22.8%	593,139	47.5%
Rondônia	237,576	56,480	23.8%	49,659	20.9%	106,139	44.7%
Roraima	224,299	14,467	6.4%	103,843	46.3%	118,309	52.7%
Tocantins	277,621	10,672	3.8%	23,914	8.6%	34,586	12.5%
Legal Amazon	5,088,668	833,646	16.4%	1,081,023	21.2%	1,914,669	37.6%

Table A.7 Protected Areas and Indigenous Lands in the Countries of Northern South America

Individual Countries	Area (km^2)	Protected Area Total (km^2)	% Protected	Indigenous Area Total (km^2)	% Indigenous Land	Total Protected Area and Indigenous Land (km^2)	% Protected Area and Indigenous Land
Bolivia	1,085,047	186,486	17.19	202,778	18.69	326,978	30.13
Brazil	8,484,839	1,234,755	14.24	1,051,632	12.40	2,152,224	25.06
Colombia	1,137,921	106,374	9.35	263,264	23.14	344,861	30.31
Ecuador	256,212	49,103	19.17	97	0.04	49,196	19.20
French Guiana	83,267	39,847	47.86	0	0.00	39,847	47.86
Guayana	210,025	5,157	2.90	6,693	3.19	11,850	5.64
Peru	1,291,445	203,909	15.79	174,735	13.53	260,982	20.21
Suriname	146,101	22,184	15.18	0	0.00	22,184	15.18
Venezuela	912,557	400,558	43.89	2,041	0.22	400,878	43.93
Total	13,607,414	2,248,373	16.5	1,701,240	12.5	3,609,002	29.0

Figure A.1. IIRSA investments in the northwest Amazon and on the Andean piedmont will link the waterways of Amazonian tributaries (Putumayo, Napo, Marañon, and Ucuyali) via trans-Andean highways to the Pacific Coast. However, these East - West highways will also create a piedmont corridor that stretches from Pucallpa in central Peru to the Putumayo in Colombia. Development and deforestation along that corridor will isolate the Andean and Amazonian biota and limit the ability of numerous species to adapt to future climate change.

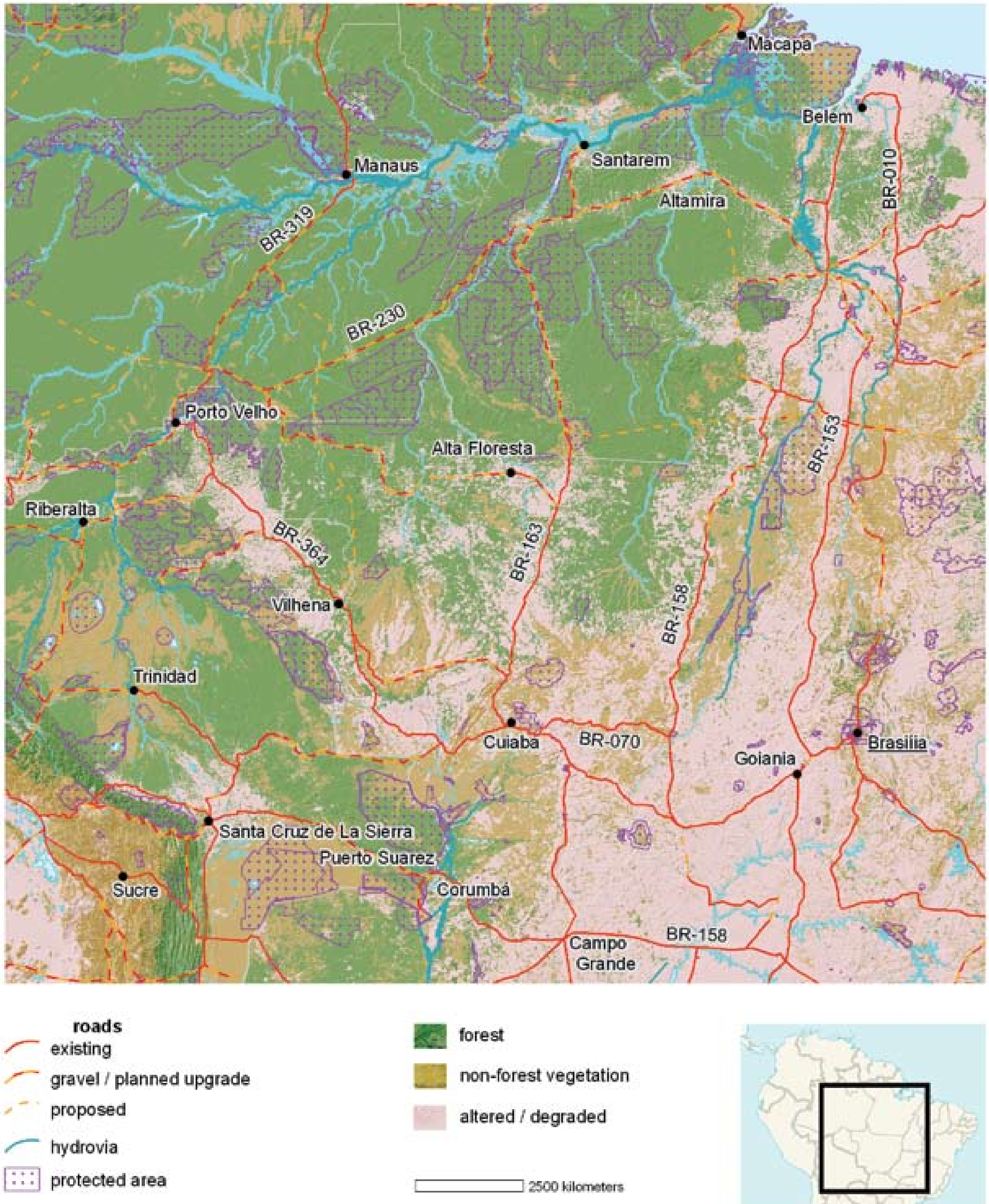

Figure A.2. The southwest Amazon and adjacent regions of the central Andes will be heavily impacted by four IIRSA highway corridors that will connect the Brazilian Cerrado with Pacific ports: (1) the Bioceanic Corridor between Mato Grosso do Sul and the Chilean coast via Santa Cruz, Bolivia; (2) the Bolivian Northern Highway, will connect the Bolivian Altiplano with the frontier regions adjacent to Acre and Rondônia in Brazil; (3) the Inter-Oceanic Highway of southern Peru will connect Acre and Rondônia with the Pacific coast of Peru; and (4) the Rio Branco-Cuzeiro de Sul-Pucallpa Highway, which will transect some of the most remote regions of the western Amazon. In the other direction, the Maderia– Mamore hydrovia will be linked to the main trunk of the Amazon River by the dams and locks between Puerto Velho, Brazil and Riberalta, Bolivia.

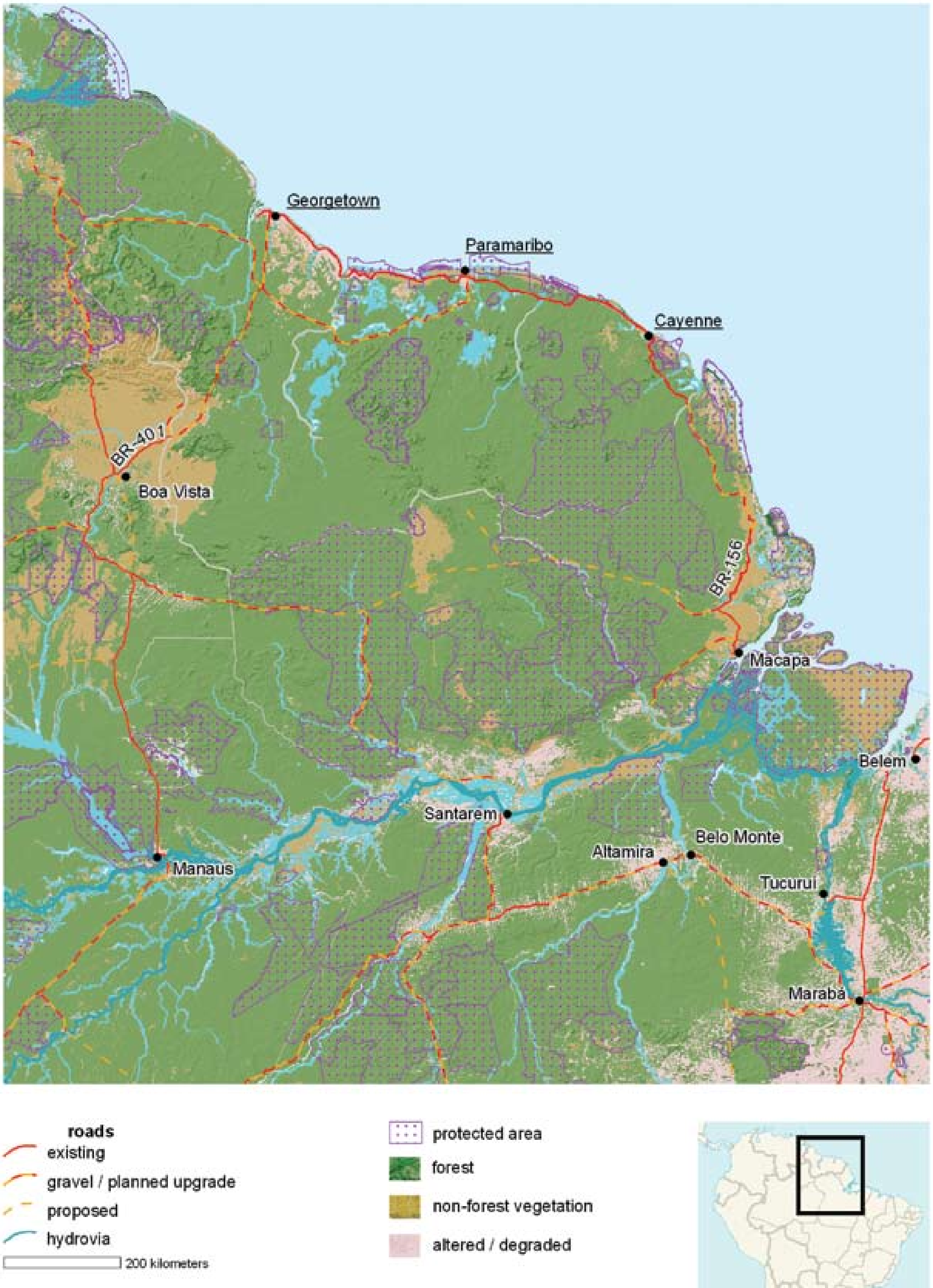

Figure A.3. The ArcoNorte refers to the highway system that will integrate the countries of the Guayana Shield in the northeastern Amazon. This sparsely populated region is generally considered to be the least threatened region of the Amazon, and large areas in Brazil have been designated as protected areas; however, the exploitation of the region's rich mineral and timber resources may become economically attractive following the completion of IIRSA investments.

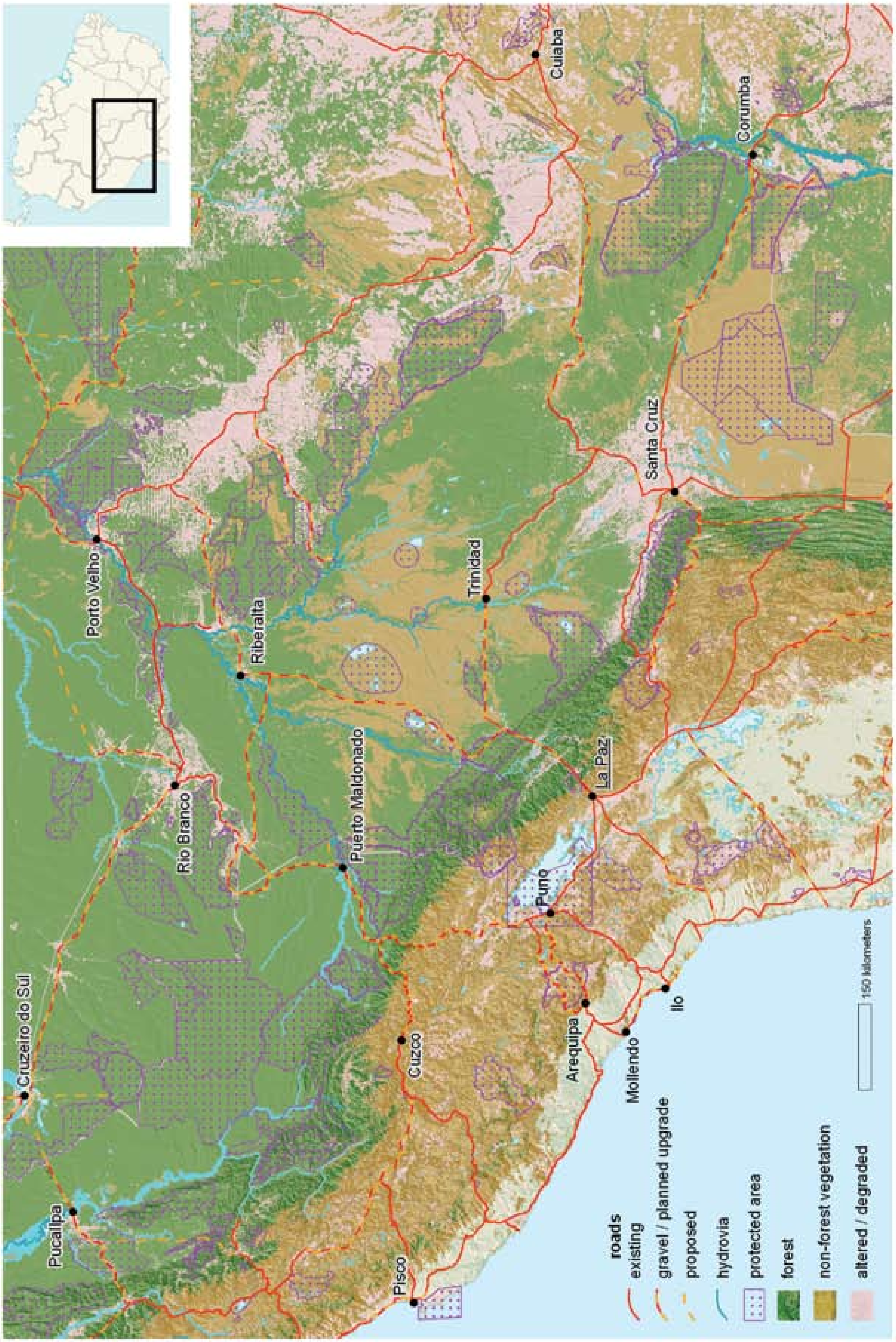

Figure A.4. The southeastern Amazon is also known as the arc of deforestation because most development has occurred here over the past 30 years. Investments in transportation will accelerate this trend by improving regional highway networks and hydrovias. New railroads will provide export corridors for the region's agricultural commodities.

About the Author

Tim Killeen is a conservation biologist whose research interests have evolved over the course of his career, starting with the taxonomy and ecology of grasses, to later focus on dendrology, plant community ecology, and biodiversity patterns at local and regional scales. Efforts to map biodiversity led to an interest in remote sensing and geographical information systems, which eventually included an on-going effort to document the impact of habitat conversion and climate change on biodiversity. His collaboration with colleagues from North American and European universities has advanced the understanding of forest dynamics and paleoecology of Amazonian ecosystems. In addition to research, Dr. Killeen has engaged both private and public sectors in environmental evaluations of large infrastructure projects, including gold mines, gas pipelines, and transcontinental highways. These experiences stimulated his interest in understanding the underlying causes of deforestation, particularly the economic and social drivers of change on the agricultural frontier. His conservation efforts in Bolivia have included advising on the design of the national protected area system, fostering community based ecotourism, and training students in botany, ecology and geography. He serves on the Board of the Chiquitano Forest Conservation Foundation and the Bolivian Institute for Forest Research, while acting as a Scientific Advisor at the Noel Kempff Mercado Natural History Museum. His dedication and accomplishments were recognized in 1999 when he received the Biodiversity Leadership Award from The Bay and Paul Foundations. He is currently a Senior Research Scientist with the Center for Applied Biodiversity Research (CABS) at Conservation International. He lives in Santa Cruz, Bolivia with his two children Erin and Peter.