CHAPTER 2 The Drivers of Change

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CHAPTER 2

The Drivers of Change

Prize winning Nelore cattle at the Estancia el Carmen in Santa Cruz, Bolivia (© Luiz Fernando Saavedra Bruno).

IIRSA will unleash economic and social forces that will radically alter the Amazon. Many of these are well known and have been responsible for the ongoing process of deforestation and forest degradation over the past half century. The rapidly evolving dynamic of a global economy makes it essential to visualize the economic and social phenomena that are just beyond our cognizant horizon. In this chapter we describe the major drivers of change and their interrelationship with economic growth and infrastructure investments. Only by understanding the nature and dimensions of these forces can we understand the potential impact of IIRSA investments and develop an effective mitigation strategy to manage growth and development.

ADVANCE OF THE AGRICULTURAL FRONTIER

The greatest threat to the conservation of the Amazon Wilderness Area, the Cerrado Hotspot, and the Tropical Andes Hotspot is land use change caused by the expansion of the agricultural frontier. Despite profound reforms to national economies and massive domestic and direct foreign investments over the last two decades, tens of thousands of peasant farmers continue to migrate ever deeper into the Amazon wilderness, a result of demographic pressure and the entrenched poverty that characterizes the region's nations. At the same time, mechanized farms and cattle ranches are expanding production in frontier areas, taking advantage of low land prices and modern technology to obtain economies of scale and an attractive return on investment. IIRSA-financed highway projects (although they largely involve improvements to existing road networks) will accelerate this process by increasing access to tens of thousands of square kilometers of unclaimed lands. Indeed, modern highways are the most important driver of deforestation in the Amazon. New and improved roads will also change the economics of transportation models: although the primitive, unimproved roads created by timber companies do not offer a viable transportation system, when these are upgraded with raised beds, bridges, and pavement, transportation costs will drop, making remote agricultural producers in the Amazon competitive in national and international markets (Kaimowitz & Angelsen 1998, Lambin *et al.* 2003, Hecht 2005).

The dynamic of land use change varies among the region's nations and has changed over time. In the 1970s and 1980s, governments throughout the region adopted economic and development policies to promote the migration of small farmers into frontier areas and provided a variety of subsidies to cattle ranchers (Hecht & Cockburn 1989, Thiele 1995, Pacheco 1998). The impact of these policies is still visible in the landscape of many parts of the Amazon (Figure 2.1).

In the 1990s, concern about tropical deforestation led governments to revise their policies and end many of the subsidies that supported the agricultural production systems responsible for deforestation. Simultaneously, governments and international agencies invested in protected areas and encouraged the growth of ecotourism (Mittermeier *et al.* 2005). The search for economically viable alternatives to agriculture led to initiatives to improve the management of both timber and nontimber products (Putz *et al.* 2004, Ruiz-Perez *et al.* 2005). However, deforestation has shown no signs of abatement: After a brief respite in the late

Figure 2.1. Migration stimulated by highway construction has left its imprint on Amazonian landscapes; the social and agricultural systems can often be seen in the deforestation pattern: a) Deforestation in Roraima is characteristic of subsistence farmers in remote regions of Brazil who have no market for their agricultural production; many are also gareimpero gold miners. b) Scattered deforestation on the Caguan River in the Caquetá Department of Colombia is believed to be largely dedicated to coca cultivation. c) Large blocks of deforested land are characteristic of the corporate cattle farms of northeast Mato Grosso in Brazil. d) Colonization along a grid of primary and secondary roads in Rondônia, Brazil, has led to a fishbone pattern of deforestation. e) On the Andean piedmont near Pucallpa, Peru, colonists have settled along highways that connect Amazonian tributaries to urban markets in the Andean highlands. f) Complex land-use patterns in Santa Cruz, Bolivia, are the result of colonists from the Andes, Mennonite communities, and corporate farms (Google Earth ™ Mapping Services).

1990s and perhaps again in the past two years,[11] annual deforestation rates have been steadily increasing in both Brazil and Bolivia (Figure 2.2).

Although governments no longer actively promote migration and land use change through organized colonization projects,[12] they continue to support agricultural development, both directly and indirectly. Most obvious is their support for infrastructure investments such as those exemplified by IIRSA (Laurance *et al.* 2004, Hecht 2005). However, other policies have subtle effects as well. For example, state-supported research in tropical agriculture and animal husbandry contributes to the economic profitability of agricultural systems that drive land use change. Similarly, providing titles to individuals and companies that occupy state-owned land confers indisputable economic benefits to the actors that are directly responsible for deforestation (Andersen 1997, Pacheco 1998, Margulis 2004). However, the most important development contributing to deforestation is the linking of global markets to the agricultural sector, which is now firmly ensconced in a free market model based on supply and demand. Thus, the small farmer or large cattle rancher in the Amazon works to maximize the return on his personal investments (Margulis 2004). Market forces are now the single most important factor driving tropical deforestation.

One of tropical ecology's most resilient doctrines is that tropical soils are infertile; many conservation biologists are convinced that deforested landscapes will eventually be abandoned or require long fallow periods to restore fertility. If this were true, agricultural expansion and deforestation would have no economic logic, except in those cases where peasants migrate, practice slash-and-burn agriculture, and then move on in a futile effort to escape poverty (Fujisaka *et al.* 1996).[13] However, modern technology and markets are rapidly enabling agricultural development and making large-scale mechanized agriculture economically feasible (see Text Box 1). Investments in genetically improved cattle breeds and pasture cultivars, combined with efficient meat processing factories and currency devaluations have augmented production to make Brazil the world's largest beef exporter. Eighty percent of the growth in the national livestock herd in the last decade has occurred in Amazonian states. Meanwhile, investments in local transportation and electricity grids have lowered operating costs for producers. IIRSA's investments will accelerate this process by increasing access to tens of thousands of square kilometers of unclaimed lands, thus further improving the competitiveness of Brazilian livestock producers. Similar processes are underway in Bolivia and Colombia, and the Brazilian production model will probably expand to other Andean countries as a consequence of IIRSA projects (Figure 2.3).

In addition, the rediscovery of unique farming methods practiced by pre-Columbian cultures may also provide technologies for modern agricultural development in the Amazon basin. Archeologists have shown that the Amazon has supported intensive agriculture and that the main branch of the Amazon River sustained populations in excess of several million inhabitants (Roosevelt *et al.* 1996).[14] The agricultural production systems of these populations were tightly linked to major rivers, but they also included extensive tree gardens where the soil chemistry was modified by additions of charcoal and ceramics, an agricultural practice that provides an intriguing alternative for development around a revitalized river transport system (Lehmann *et al.* 2003, Glaser & Woods 2004).

Key social actors play an important role in introducing agricultural technology and capital into frontier regions. Mennonite and other expatriate farmers have often been the first to bring mechanized agriculture into an area and have been adept at experimenting with different crops. Mennonites have a cultural tradition of migrating to lands where they had no previous presence and that are often hundreds of kilometers distant from

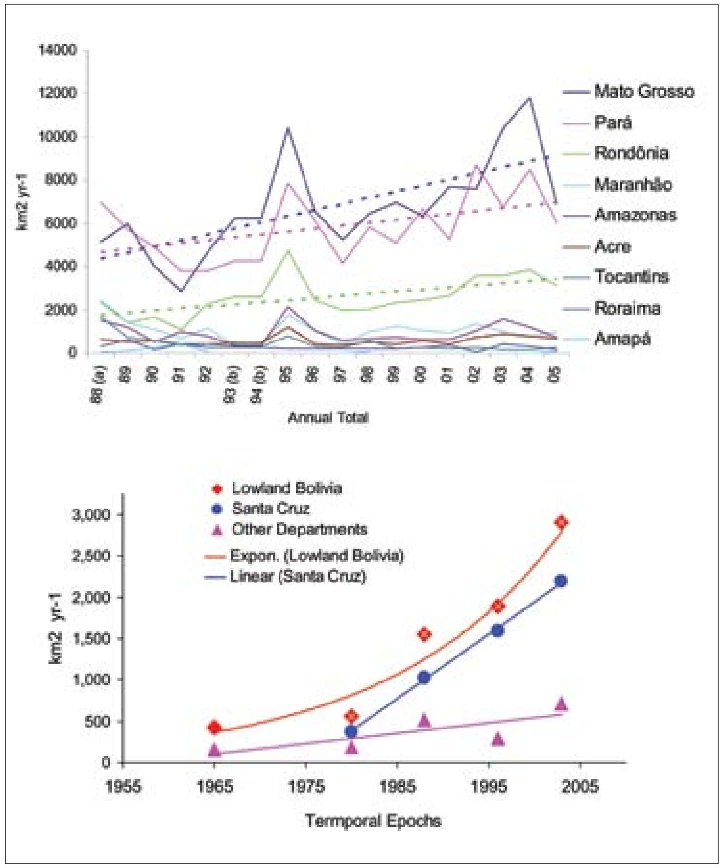

Figure 2.2. Deforestation data fluctuate from year to year, but increase over the mid term, at least in Brazil and Bolivia. IIRSA will open vast areas of previously remote forest, increasing the rate of deforestation over the short term unless measures to counter this trend are taken (modified from PRODES 2007 and Killeen *et al.* 2007).

11 The Environmental Ministry in Brazil has reported a decrease of 31 percent in the 2004 annual deforestation rate in the Brazilian Amazon; more information is available at http://www.socioambiental.org/nsa/detalhe?id=2161.

12 This policy may be changing yet again in Bolivia, where the government of President Evo Morales has announced a land distribution plan aimed at small farmers and landless peasants.

13 The consequences of this model and the predicted poverty are evident in areas settled by peasant farmers with little access to capital or technology, such as the Andean piedmont, Rondônia, and along the Transamazonian Highway in Pará.

14 The current Cabloco culture retains many attributes of this production system, including farming, fishing, and fruit harvesting from tree and palm species in the flooded river valley forests. Pre-Columbian populations also inhabited the uplands to the north and south of the floodplain where they practiced an intensive agriculture using anthropogenic "black earth" soils that were created using a combination of technologies such as charcoal and clay. There is also circumstantial evidence that they created extensive orchards of native trees that served both as a source of fruit, and as an attraction for game (see Mann 2005 for a popular account and review of the pertinent literature).

Text Box 1

How Feasible Is Mechanized Agriculture in the Amazon?

Tropical ecologists have long held that tropical soils are infertile and not economically viable for agricultural development. However, modern technology is disproving this belief and well-capitalized farmers and cattle ranchers are overcoming the limitations of tropical soils (Mertens *et al.* 2002). By using new varieties of cultivated forage grasses, rotational grazing to control weeds, and vitamins to compensate for the lack of micronutrients, ranchers have increased profitability and obtained sustainability. Other factors have also made Amazonian beef competitive in global markets: innovations in animal husbandry, the elimination of foot and mouth disease, and the absence of bovine spongiform encephalitis (mad cow disease), which has hurt European and U.S. competitors. Pasture in the Brazilian Amazon now covers some 33 million hectares and houses around 57 million head of cattle (Kaimowitz 2005).

Farming is also becoming more feasible, thanks to modern technology and cost-effective solutions. In the Cerrado Hotspot, soy farmers apply chemical lime ($CaCO_3$), which changes the pH of soils, resolves aluminum toxicity, and mobilizes plant nutrients that were previously tightly bound to clay particles. In Bolivia, farmers rotate soy with corn or sorghum to manage fungal pathogens. Similar solutions are likely to be discovered and implemented in the Amazon to manage soil fertility and improve pest management. A report for the National Academy of Sciences contends that continuous food crop production is feasible on most Oxisols and Ultisols in the humid tropics and is economically viable when market conditions ensure access to fertilizers and a market for produce (BOA 1993).

their original homesteads. Likewise, second or third generation Andean migrants with experience cultivating tropical crops often spearhead colonization into new areas. Currently, all three groups are actively involved in land speculation on the periphery of Madidi National Park in northern Bolivia.

In Brazil, market forces govern the actions of small and medium-sized resident farmers, as well as the urban investors who own most industrial farms and ranches. Small farmers are often directly responsible for deforestation. Even though their farms are not particularly lucrative, they realize a large capital gain when they sell their land to cattle ranchers and soy farmers who consolidate these small holdings into large agribusiness operations (Fearnside 2001a, Margulis 2004). In the Andean countries, deforestation is largely the result of peasants practicing subsistence agriculture, which is supplemented by cash crops that are commercialized in urban areas on the coast or in the highlands (Gomez-Romero & Tamariz-Ortiz 1998, Kalliola & Flores-Paitan 1998). In some localized areas the cash crop is coca, which is used to produce illicit drugs (Figure 2.1b). By integrating Brazilian and Andean economies, IIRSA will accelerate the trend for Andean farmers to adopt Brazil's more efficient production systems and radically increase the rate of land use change in the western Amazon, as happened previously in both eastern Paraguay in the 1980s and Bolivia in the 1990s (Steininger *et al*. 2001, Pacheco & Mertens 2004). There are, for example, recent reports of farmers adopting mechanized rice production near Pucallpa, Peru (Figure 2.1e).

In Bolivia, peasant and industrialized agriculture have coexisted over several decades, but in the last few years mechanized agriculture and intensive cattle farming have expanded dramatically as the region has become linked to global markets (Pacheco 1998, Kaimowitz *et al*. 1999, Pacheco & Mertens 2004). With this expansion of market-driven agriculture, land speculation has become an increasingly important driver of land use change (Pacheco 2006), and the area under cultivation has been growing at annual rates that approach 20 percent over the past decade (Figure 2.2b). Technological transfer is occurring not just from

Figure 2.3. Cattle farming in Brazil is based on a successful business model that uses improved genetic stock, cultivated grasses, rotational grazing, and supplemental vitamins fine-tuned to essential soil minerals. Brazilian technology is exported to this ranch in Santa Cruz, Bolivia, where livestock productivity is closely monitored by computer (© Luiz Fernando Saavedra Bruno).

Brazilian investors to Bolivian agribusiness, but also from the agribusiness sector to peasant agriculture.[15]

A reform of world trade could also dramatically increase the pressure on tropical forest ecosystems. Agricultural production is more profitable in Latin America than in North America, Europe, or Japan thanks to fuel subsidies, low labor costs, land values, and tax exemption or avoidance.[16] Regional farmers already successfully compete in international markets, particularly China,[17] and increased access to markets in developed countries would dramatically increase pressure on natural habitats. The new interest in biofuels will also bring pressures on tropical forest ecosystems, especially if these fuels are derived from species adapted to tropical climates and soils (see section on biofuels below).

IIRSA's integration corridors will open up vast areas in the interior of the continent to migration, land speculation, and deforestation (Figure 2.4). The dimensions of agricultural expansion that will accompany these changes have not been adequately evaluated by the studies commissioned by IIRSA; in some cases, agricultural expansion may be a desired outcome and a legitimate motivation for investments. However, in remote areas where natural ecosystems still predominate, the potential environmental impacts related to agriculture must be foreseen and described so that appropriate mitigation measures can be incorporated into IIRSA investments (see Chapter 6).

15 A recent flight over a peasant colonization zone (San Julian) near Santa Cruz, Bolivia, revealed that approximately 25 percent of the fields were planted in row crops, including soy, sunflower, and maize. Agribusinesses enterprises are proactively engaging small farmers by providing credit during the planting season that is payable in grain after harvest (pers. comm. D. Onks, General manager ADM/São, Santa Cruz, Bolivia).

16 Land values range from \$20–\$300 ha−1 (Santa Cruz, Bolivia) to \$200–\$1,000 ha−1 (Matto Grosso do Sul, Brazil), compared with \$2,000–\$7,000 ha−1 (Iowa, USA). See http://www.extension.iastate.edu/agdm/articles/leibold/LeibDec01.htm.

17 Large-scale soy farmers in Bolivia experienced returns as high 100 percent on capital in 2005, with yields of 2 metric tonnes (Mt) ha−1 and prices at \$240 per Mt, while breaking even at \$140 Mt.

FORESTRY AND LOGGING

Improved access to markets will also bring profound changes to the forest products industry, which is based on the extraction and exploitation of both timber and nontimber forest products. The most environmentally sustainable sector in this industry is also one of the most economically profitable activities in the southwestern Amazon: the collection, processing, and transportation of Brazil nut. The southwestern Amazon has some of the highest densities of Brazil nut in the Amazon (Peres *et al.* 2003), with northern Bolivia alone annually exporting about \$70 million worth of nuts, representing about 50 percent of the global production of this important Amazonian commodity (Bolivia Forestal 2007). Ironically, IIRSA highways will improve the profitability of this sector over the short term by decreasing transportation costs, but over the medium term, exports will decline as deforestation and forest fragmentation devastates Brazil nut populations. Even if trees are left standing on deforested landscapes, studies have shown that individual trees in pastures fail to produce fruit and suffer high rates of mortality (Ortiz 2005).

IIRSA will have an equally profound effect on the timber industry. Amazonian hydrovias and modern highway corridors will connect the remote regions of the western Amazon basin with the Pacific coast (see Figure A.1). Currently, timber extraction in these areas is highly selective; only a few species are well known in international markets and have wood characteristics that make them particularly attractive.[18] Although this type of logging has been criticized by both the timber industry and conservationists as inefficient and leading to the commercial extinction of these high unit–value species (Uhl & Viera 1989, Blundell & Gullsion 2003, Kometter *et al.* 2004), the overall structure, function, and biodiversity of the forest remain essentially intact, even though the pressure on these few species might be great (Gullison & Hardner 1993). However, improved transport systems in the western Amazon would change the business model of the regional timber sector (Figure 2.5), making it more like the exploitation model that has prevailed in the eastern and southern Amazon. This type of semi-intensive logging, sometimes erroneously referred to as selective logging, has been shown to be very damag-

18 Mahogany (Sweitenia macrophylla), spanish cedar (Cedrela odorata), cerajiera or roble (Amburana cearensis).

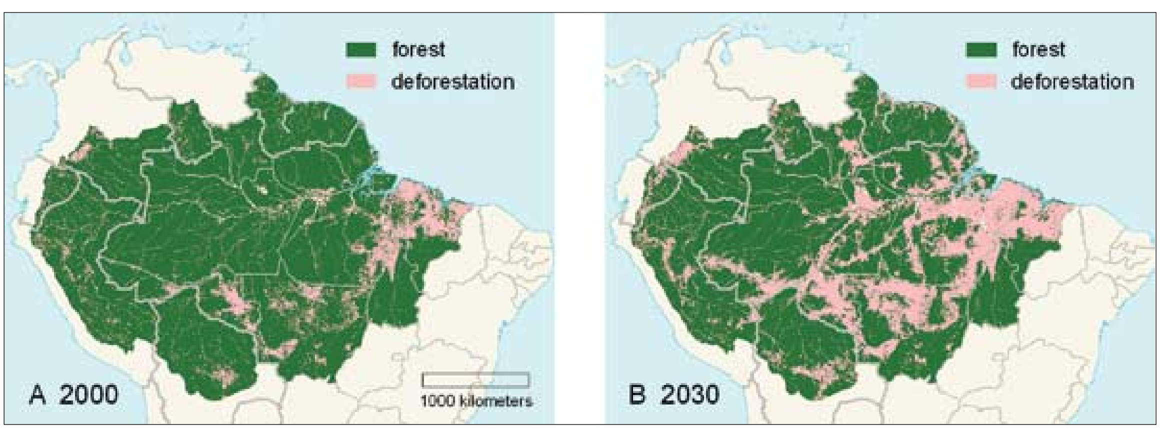

Figure 2.4. Statistical models based on past trends (map A) can provide insight into the distribution of future deforestation (map B). This model probably underestimates deforestation on the Andean piedmont because it did not factor in impacts from IIRSA investments (Britaldo Soares, Universidade Federal de Minas Gerais).

ing to the forest structure (Uhl *et al.* 1997, Asner *et al.* 2005) and will eventually lead to forest degradation, the loss of economic value in the forest, and eventual conversion of the forest to pasture, crops, or plantation forestry—despite ongoing attempts to make the industry sustainable (see Text Box 2).

Given the current scenario, IIRSA investments will have both positive and negative impacts on the forest products sector. Improved transport systems will increase profits for both timber and nontimber producers. However, increased deforestation caused by the IIRSA highways will lead to a progressive erosion of the resource base that supports the forest products sector. Likewise, better access to remote regions will lead to increased logging intensity by both the formal and informal sectors; this logging, whether it is certified or not, will most likely not be truly sustainable in maintaining natural forest ecosystems (Figure 2.6). Under the best of circumstances, the deforested landscapes adjacent to the IIRSA highway corridors will be converted to plantation forestry that produce wood, conserve soil resources, and contribute to the hydrological processes that support regional weather systems. However, these forest plantations will fail to conserve the biodiversity of natural forest ecosystems. Environmental evaluations and the subsequent action plans need to address the issue of long-term forest degradation, particularly the impact of opening the western regions of the Amazon to commercial exploitation of timber.

GLOBAL AND REGIONAL CLIMATE CHANGE

Climatologists estimate the consequences of global warming using global circulation models (GCMs), which integrate geophysical processes and energy flows in the atmosphere, oceans, and on the land. Although model projections are uncertain, they help indicate the potential consequences of climate change on continental and global scales (IPCC 2007). One GCM (HadCM3LC) incorporates principles of plant physiology into its land surface component, showing how the increasing temperatures and dryness in the Amazon may lead to dieback of the humid tropical forests (Cox *et al.* 2000). Eventually, plants will absorb less carbon through photosynthesis than is released by soil respiration, turning the Amazon ecosystem into a net source of carbon and further exacerbating global warming. This model assumes that tropical plant species will not adapt to high temperatures and drought. This assumption is supported by the response of the Amazon ecosystem to dry phases of El Niño–Southern Oscillation (ENSO), a climatic phenomenon characterized by wet/dry and warm/cool phases in different parts of the southern hemisphere (Potter *et al.* 2004, NOAA 2007). During dry phases of ENSO, the Amazon becomes a net source of carbon due to increased respiration and wildfire (Giannini *et al.* 2001, Coelho *et al.* 2002, Foley *et al.* 2002).

Figure 2.5. Bolivia and Peru have granted commercial logging concessions (hatched areas) in permanent production forests and are implementing forest certification processes in the hopes of attaining sustainability (Modified from *Superintendente Forestal*, Bolivia and INRENA, Peru).

Text Box 2

Sustainable Forestry: Fact, Fiction, or Just Wishful Thinking?

Forest ecologists have proposed a series of management recommendations to ensure sustainability; these have become very popular in the past decade and are upheld by programs that certify sustainable logging. They include the adoption of rotational harvests of 20 to 30 years, reduced impact logging methods, fire control, and the conservation of key wildlife species (Putz *et al.* 2004). However, studies have shown that individual trees require decades to grow into the canopy and attain reproductive maturity (Gullison *et al.* 1996, Brienen & Zuidema 2006), while the proposed harvest quotas are often well above the combined annual growth rates of the species with economic potential (Dauber 2003).

Foresters argue that target species will shift between harvest cycles and that remnant populations exploited in the first cycle will grow and regenerate to maintain populations. Although this might be the case in a well-regulated industry, the current regulatory environment in the Amazon ranges between lax and chaotic (Powers 2002). A more likely scenario given current certification guidelines will be a sequential extinction of species and the loss of the forest's residual economic value. At this point, concessionaires will either abandon their concessions or adopt plantation forestry, growing short rotation species to produce pulp, biofuel, and timber. This scenario may be acceptable to the forest products sector (Lugo 2002, Hecht *et al.* 2006), but will not ensure the conservation of the biodiversity in the Amazon Wilderness Area or the Tropical Andes Biodiversity Hotspot (Rice *et al.* 2001).

The HadCM3LC model predicts that global climate change will essentially tip the eastern and central Amazon into conditions very similar to the dry phase of the ENSO phenomenon (Figure 2.7), initiating a feedback cycle that shifts the Amazon from an evergreen to a savanna ecosystem within the next century (Betts *et al.* 2004, Cox *et al.* 2000). These authors stress the uncertainty of their models and, in a recent evaluation of the HadCM3LC model outcome, Li *et al.* (2006) applied eleven GCM models developed for the Intergovernmental Panel on Climate Change (IPCC 2007) and found that although overall precipitation levels did not change in most models, seasonality was enhanced with increased precipitation in the wet season and decreased precipitation in dry seasons, thus enhancing water stress. Corraboration that the Amazon has been warming was recently provided by Malhi and Wright (2005) who showed a temperature increase of 0.25°C per decade since the 1970s.

In addition to these ecosystem changes caused by global climate change, deforestation could also alter the regional climate of the Amazon. Global deforestation contributes about 20 percent of the total annual anthropogenic emissions of greenhouse gases and, consequently, is a major contributor to global climate change (IPCC 2007). However, deforestation also affects local and regional hydrological cycles that drive the formation of thunderstorms in the Amazon (Werth & Avissar 2002, Avissar & Werth 2005, Feddema *et al.* 2005). The importance of forest cover in maintaining high levels of precipitation in the Amazon has been a basic tenet of ecosystem ecology for decades (Chen *et al.* 2001). In summary, the tropical rainforest ecosystem of the Amazon depends on the humid trade winds that bring water from the Atlantic Ocean; however, about 25–50 percent of the rain that falls on the Amazon comes from evapotranspiration and precipitation through convective systems that form thunderstorms (Salati & Nobre 1991, Eltahir & Bras 1994, Garreaud & Wallace 1997). When the landscape is nearly completely deforested, the amount of water cycled through convective systems decreases by about 10–25 percent (Shukla *et al.* 1990, Nobre *et al.* 1991, Henderson-Sellers *et al.* 1993, Laurance 2004). Deforested landscapes are warmer than forest landscapes. Combined with smoke produced by forest fires to clear land, deforestation can delay the onset of the rainy season (Koren *et al.* 2004, Li & Fu 2004).

Figure 2.6. Logging on the Amazonian frontier typically targets old-growth trees between 100 and 300 years old, like these shown on this logging truck in Brazil. However, certification programs are based on harvest cycles of 20 to 30 years, which are insufficient to ensure regeneration of native timber species (© John Martin/CI).

Incongruously, some studies show that partially deforested landscapes experience an increase in precipitation as greater evaporation over forests leads to increased precipitation over pastures (Avissar & Liu 1996, Negri *et al.* 2004). However, rainfall is dramatically reduced with increasing deforestation, and precipitation levels decrease when more than 50 percent of the landscape has been deforested (Kabat *et al.* 2004). Like all climate change phenomena, long-term trends are often masked by short-term cycles or simply random fluctuations. For instance, recent above-average precipitation in the southern Amazon basin has been attributed to decadal-scale phenomena that have masked the impact of deforestation at the regional scale (Marengo 2006).

Although the rate and scale of future change remains a subject of conjecture, there is ample evidence of past climate change in lakebed deposits and in the current distribution of plant species. During the last glacial maximum, about 20,000–25,000

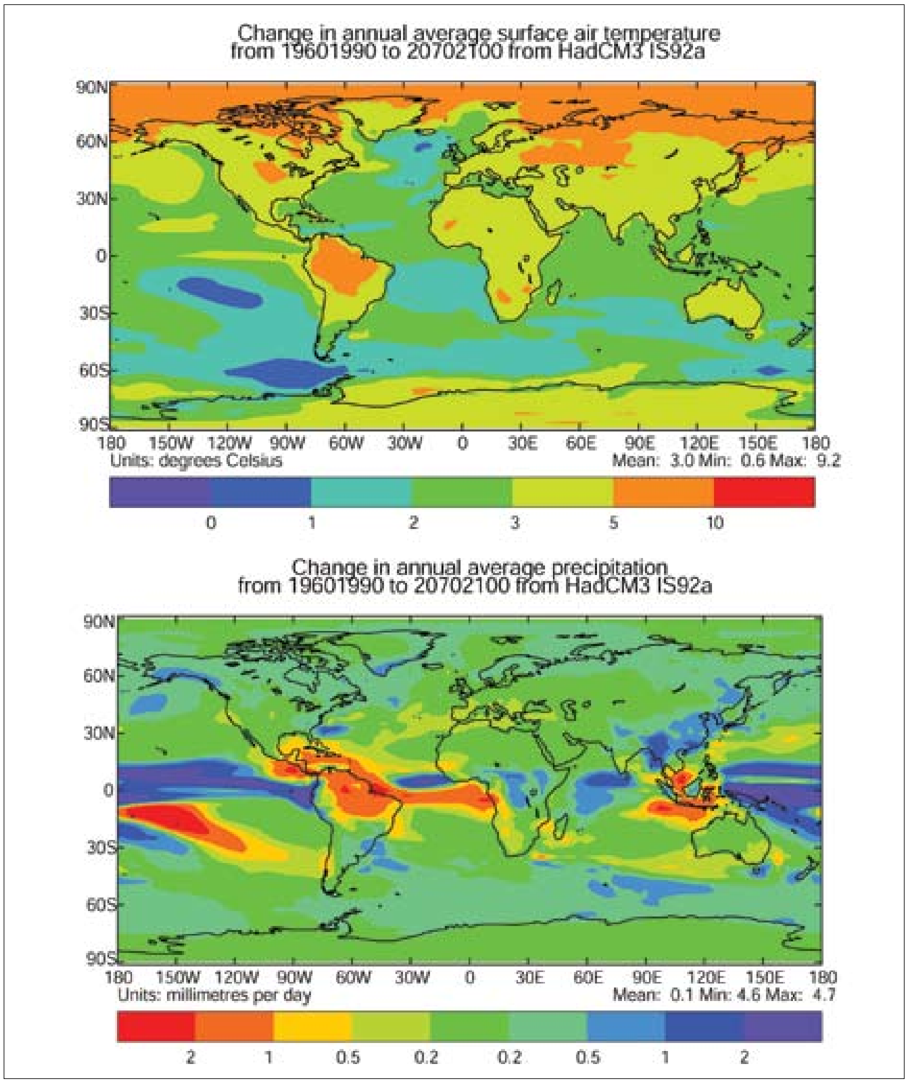

Figure 2.7. Temperature and precipitation changes. Some global circulation models predict that the Amazon will become warmer and drier, leading to a die-back of the Amazon forest; a more likely outcome would be a shift from a humid evergreen to a seasonally dry forest (Betts *et al.* 2004, see http://www.metoffice.com/research/hadleycentre/models/HadCM3.html).

years ago,[19] the distribution of humid forest species shrank to a much smaller region in the western equatorial Amazon; correspondingly, much of the geographic area currently considered to be "Amazonian forest" has been occupied by species previously restricted to seasonally dry deciduous forests and savannas that now predominate on the periphery of the Amazon (Mayle *et al.* 2004, Pennington *et al.* 2005). Subsequently, species responded to climate change by shifting their distributions as the Amazon became a warmer and wetter environment. There is ample evidence that humid forest species have expanded their distribution over the past few hundred years (Grogan *et al.* 2002, Mayle *et al.* 2004). The future climate in the Amazon may be warmer and drier, causing a forest dieback, or—if we are lucky—warmer and wetter, so that species continue to expand their distribution. In either case, species distributions will adjust to changing environmental conditions, but only if climate change is sufficiently slow and migratory corridors remain intact on Amazonian landscapes. If climate change is too rapid and corridors of natural habitat are not maintained, then many species will face extinction.

Unfortunately, no attempt has been made by member governments or multilateral agencies to evaluate the impacts of IIRSA transportation corridors on regional and global climate change. This oversight is particularly unfortunate given the ongoing research that the National Aeronautics and Space Administration (NASA), in collaboration with the Brazilian (INPE) and European (ESA) space agencies, has performed as part of the Large Scale Biosphere–Atmosphere Experiment in the Amazon (Gash *et al.* 2004). Their results show that increased deforestation along IIRSA highways will affect the regional climate by modifying local hydrological systems. Carbon emissions from deforestation will further exacerbate global warming, while changes in regional weather patterns may lead to further forest degradation; worse yet, highway corridors composed of anthropogenic landscapes will impede the ability of species to adapt to climate change.

19 During the Pleistocene era, continental glaciers expanded and contracted periodically over tens of thousands to hundreds of thousands of years. The last glacial maximum occurred approximately 25,000 to 20,000 years ago.

WILDFIRE

Each year, millions of hectares of Amazon forest suffer from fire (Figure 2.8) (Cochrane & Laurance 2002, Cochrane 2003). Most fire is related to land clearing; however, fire also spreads into the standing forest causing degradation (Cochrane *et al.* 1999). Fires have occurred throughout history in the seasonal forests situated on the margins of the Amazon (Barbosa & Fearnside 1999), as well as in the central Amazon where they are associated with mega-Niño[20] events (Meggars 1994). However, the frequency and extent of fires have been increasing in the past few decades due to two phenomena, both related to improvements in the road infrastructure (Cochrane 2003). First, as roads are extended into remote areas and more land is cleared, the forest becomes fragmented, creating a greater ratio of forest edge to interior; thus a larger area of forest is exposed to pasture fires. Second, as increased logging opens up the forest canopy, it degrades the forest, allowing greater penetration of light that causes the forest floor to become drier, creating the conditions for forest fires (Cochrane *et al.* 1999, Nepstad *et al.* 1999). If climate change leads to increased drought, there will be an even greater incidence of forest fire (Nepstad *et al.* 2004).

Although fires in humid tropical forests are usually low-intensity ground fires that leave most of the mature trees standing, trees do suffer extensive damage to their cambium, with up to 50 percent mortality over the next few years (Barlow *et al.* 2002); in seasonal deciduous forests where trees have evolved bark that is somewhat resistant to fire, adult mortality can be as high as 27 percent (Pinard & Huffman 1997, Pinard *et al.* 1999). Greater adult mortality creates canopy gaps that allow greater penetration of light, increasing grass cover, creating the conditions for recurrent fires (Barlow *et al.* 2002). Wildfire also affects vertebrate populations. Large mammals, particularly ungulates, are absent from recently burned forest, an absence that is exacerbated by hunting in populated areas. Over the medium term, the increased mortality of adult fruit-bearing trees leads to a decline in frugivore species of monkeys and birds, whereas a reduction in forest floor detritus negatively affects ant-birds and other forest floor species that feed on invertebrate detritivores (Barlow *et al.* 2002).

IIRSA investments will increase the incidence and severity of wildfire. Currently, wildfire is most severe during El Niño years when drought conditions predominate; if the more pessimistic models regarding climate change are true, wildfire will become even more prevalent, particularly in the degraded forests that will occupy the landscapes surrounding IIRSA corridors. The environmental action plans that accompany the IIRSA investments should prioritize fire control and fire management programs as part of an environmental mitigation package. Without adequate steps to limit fire, other measures to conserve and protect forest fragments will be undermined.

HYDROCARBON EXPLORATION AND PRODUCTION

The western Amazon is the world's largest unexplored region of hydrocarbon potential outside Antarctica (Figure 2.9). The Andean piedmont and front ranges have long been identified as areas with potentially large reserves. Existing production in Argentina, Bolivia, Ecuador, and Peru is estimated on the basis of reserves situated in the Mesozoic and Paleozoic sedimentary formations on the eastern slope of the Andes and adjacent piedmont (Figure 2.10). Exploitation of these reserves has been slow because the inaccessibility of the region makes costs of exploration, production, and transportation high. Discoveries in the central Andes have tended to be rich in natural gas, a hydrocarbon that, until recently, was difficult to commercialize. Advances in natural gas liquefaction technology and a growing demand for fuels that emit

20 A mega-Niño event occurs when the phenomenon is both longer and more severe in intensity than the norm.

Figure 2.8. Wildfires in tropical forests are completely different than those in temperate ecosystems; often they are low-intensity ground fires that leave the tree canopy intact. Nonetheless, fires increase tree mortality, allowing for greater light penetration and lowering humidity levels in the understory. This sets the stage for recurrent wildfire and forest degradation (© Greenpeace).

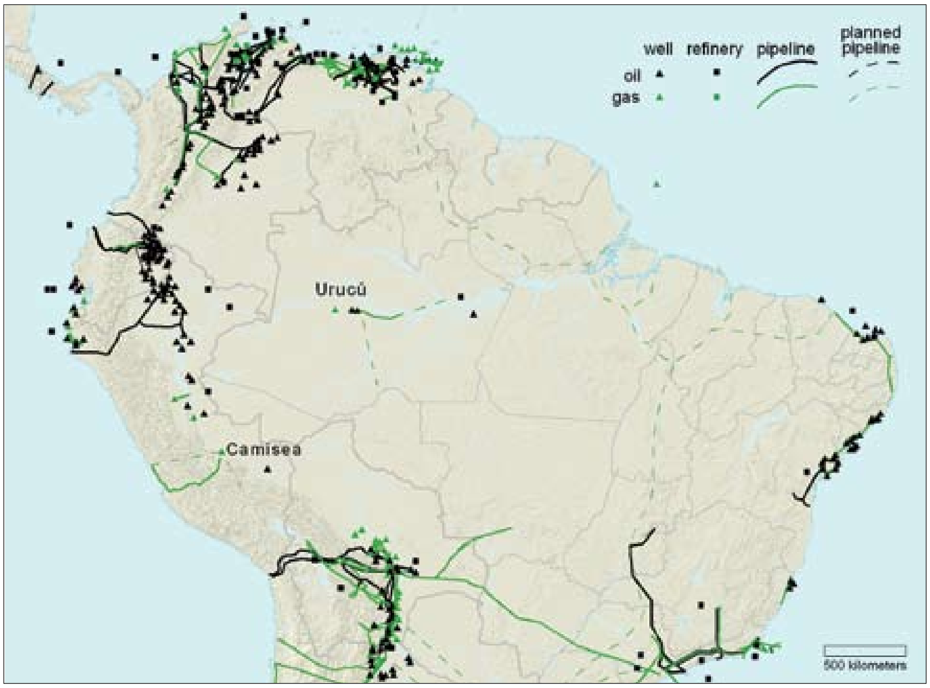

Figure 2.9. The western Amazon and Andean piedmont contain some of the world's last unexplored regions with significant potential for oil and gas. The discovery of gas in the Urucú basin in Amazon State has greatly increased the potential for discovering new reserves in the western Amazon (Modified from the World Energy Atlas).

less carbon have increased interest in the natural gas reserves of the western Amazon and central Andes.

The recent climb in oil prices is stimulating investment and exploration in areas that were previously not economically attractive. This new dynamic is most conspicuous in Peru, which has issued fifteen new exploration blocks in the last 12 months, many of them contiguous with the Brazilian border. A similar process is underway in Ecuador as it expands production to fill the recently completed heavy crude oil pipeline (OCP according to its Spanish acronym). All three major pipelines completed in the last decade have spurred further exploration and production, because once the transport problem is resolved, additional upstream investments are necessary to fill the pipelines.[21]

The development of *Urucú* gas fields in the Brazilian state of Amazonas has changed the way petroleum geologists view the Amazon. Most hydrocarbon exploration in the western Amazon has been concentrated near the Andes Mountains, where the process of mountain building has created anticlines that trap hydrocarbons.[22] However, the alluvial plain situated between the *Urucu* concession and the Andes lies over deep sedimentary rocks that were deposited prior to the breakup of Gondwanaland, dating from the geological eras (50 to 150 million years ago) that typically have the greatest hydrocarbon potential. Consequently, the entire western Amazon must now be viewed as an area with relatively high hydrocarbon potential. A gas pipeline is under construction and will have the capacity to provide Manaus with 10 million cubic meters per day, enough to make Manaus self-sufficient in energy generation and to provide feedstock for the petrochemical industry. A spur pipeline to Porto Velho in Rondônia is in the advanced planning stage (Figure 2.9).

In the last three decades, the petroleum industry has adopted standards to minimize environmental impacts. Seismic exploration, which typically covers tens of thousands of hectares, now uses helicopters, and the mid-term impact associated with transects is negligible. Exploratory wells are usually restricted to a relatively small area, and the use of directional drilling allows multiple production wells on a single platform (Rosenfeld *et al.* 1997). Current design standards, construction, and pipeline maintenance have reduced the impact of right-of-ways, while geographic models and improved materials have lessened the probabilities of catastrophic failures in pipelines.[23]

21 Construction of the Bolivia–Brazil pipeline was initiated prior to the discovery of Bolivia's vast (~54 trillion cubic feet) gas reserves. The Oleoducto de Crudo Pesado (OCP) oil pipeline in Ecuador is currently using only half of its capacity, and exploration and new production is underway in Yasuní National Park and other areas (pers. comm. R. Troya, TNC-Ecuador). The Camisea pipeline, which was constructed with a 32-inch-diameter pipe up to approximately the continental divide, and then reduced to a 24-inch-diameter pipe, was designed for more capacity than its present configuration and without the proven reserves to fill it. A second pipeline is being constructed that will originate at the continental divide and take gas to a separate port facility where it will be liquefied and exported. Gas to fill the first pipeline comes from Block 88, the original discovery made by Shell in 1993, whereas the gas to fill the second pipeline will come from the adjacent concession, Block 56 (http://www.camisea.com).

22 The geological structure of these submontane hydrocarbon reservoirs makes them very profitable because the gas is ejected from the reserves under high pressure and very few wells can produce enough gas to fill a pipeline. However, wells must perforate the reservoir at the highest point of the geological stratum (typically an anticline); consequently, they are situated on ridge tops, which maximizes the environmental impact because of the construction of roads and drilling platforms on steep inclines. Directional drilling from the base of the mountain is considered to be too risky because it increases the possibility of "missing" the top of the formation and damaging the reserve (pers. Comm. S. Smythe, BG-Bolivia).

23 Several of the largest multinational energy companies have formed a partnership with conservation organizations to develop practical guidelines, tools, and models to improve environmental management, particularly to reduce the threats to biodiversity via The Energy & Biodiversity Initiative (EBI 2003).

Figure 2.10. Oil and gas exploration has increased in remote wilderness areas of the Andean foothills, as shown by this oil well in eastern Bolivia (© Hermes Justinian/Bolivianature.com).

Regardless of these advances, industrial accidents still happen, and oil spills that cause severe environmental impacts occur, especially in the eastern Andes where very high rainfall and unstable topography have contributed to several recent oil spills in both Bolivia and Peru. In addition, and more importantly, drilling platforms and pipelines require roads that can support heavy machinery,[24] and the construction of roads usually leads to colonization and deforestation. Peru has managed to develop a petroleum infrastructure with limited deforestation: the extreme remoteness of production fields and the decision to use river transport for heavy equipment has kept the oil fields in northern Peru relatively free of secondary deforestation associated with colonization (Figure 2.11).

The presence of foreign oil companies can exacerbate deforestation, as local land speculators use the foreign companies' presence as a pretext to expand their own claims. In Amboró National Park in Bolivia, peasant leaders argue that if a region is to be open to foreign oil companies, then it must also be opened up for national citizens who are both landless and poor. Even the most positive aspects of hydrocarbon production will negatively affect the environment. In Peru, 50 percent of the royalty revenues from the Camisea concession will be channeled back to the Cuzco regional government. Like local governments everywhere, the government will use this income to invest in schools and hospitals, which is laudable; however, they will also invest in roads and bridges that will lead to increased forest degradation.

It is unrealistic to expect the Andean nations to forgo the opportunity to exploit their hydrocarbon reserves; demands for economic growth are too great, and the expansion of the hydrocarbon sector is enshrined as state policy. In Bolivia and Ecuador, hydrocarbon exploitation has been defined as a national strategic priority and is allowed within protected areas, including national parks. Peru currently does not allow the exploration of hydrocarbons within national parks, but the rest of the eastern lowlands are rapidly being put out to bid for oil and gas exploration.

Nonetheless, despite national policies to promote the exploration of hydrocarbons, it has become one of the most conflictive issues in Andean society. Large sectors of the impoverished population have not benefited from the wealth generated by the hydrocarbon sector, whereas export earnings for multinational corporations have surged. Some civil groups have opposed oil exploration and production in remote areas on environmental and social grounds, and opposition to multinational oil companies has contributed to the success of recent political candidates in Ecuador and Bolivia.[25] However, once this debate over the role of multinational firms has been resolved, increased exploration and production is a foregone conclusion.

Part of IIRSA's policy and investment agenda is to integrate energy grids (oil and gas pipelines, as well as high-tension electric lines); however, unlike highways and hydrovias, energy transport systems are largely owned and operated by private entities or state-owned corporations. As such, the IIRSA executive and technical committees exercise a less influential role in planning and constructing oil and gas pipelines. However, the same multilateral institutions involved in IIRSA finance these investments, and the same government ministries actively promote hydrocarbon expansion programs.[26]

Large multinationals have come to recognize their responsibility in mitigating secondary impacts as part of a comprehensive environmental and social management plan (EBI 2003). However, many Amazonian hydrocarbon concessions are being developed by second-tier companies, which are smaller, regional in focus, or come from a nontraditional global market.[27] These companies often place less emphasis on environmental management, which holds less weight with their shareholders and

[24] The AGIP pipeline in Amazonian Ecuador is an exception and was constructed without deforesting the right-of-way. It is supported on stilts like the Alaska pipeline and was built using a specially designed machine that moved forward on rails as the pipeline was extended. However, most companies prefer to bury pipelines for safety reasons, particularly in populated areas. The right-of-way is usually maintained free of woody vegetation, because roots can invade the coating of a pipeline and shorten its lifespan.

[25] In Ecuador, a legal ruling allowed the government to rescind a contract with Occidental Petroleum. In Bolivia, existing contracts were modified to change the royalty and tax structure associated with concessions, as well as the role of the state in joint ventures.

[26] The IDB made a loan of $135 million, and CAF made one of $75 million to Transportadores de Gas de Peru (TGP) to construct a gas pipeline connecting Camisea to the Pacific coast. IDB assumed a leadership role in organizing the environmental evaluation and the subsequent management plan (http://www.iadb.org/exr/pic/camisea/status.cfm).

[27] These include smaller companies from the developed world as well as energy companies from Latin America, Russia, and East Asia (see http://www.perupetro.com.pe/ for a list of companies that have recently acquired exploration concessions).

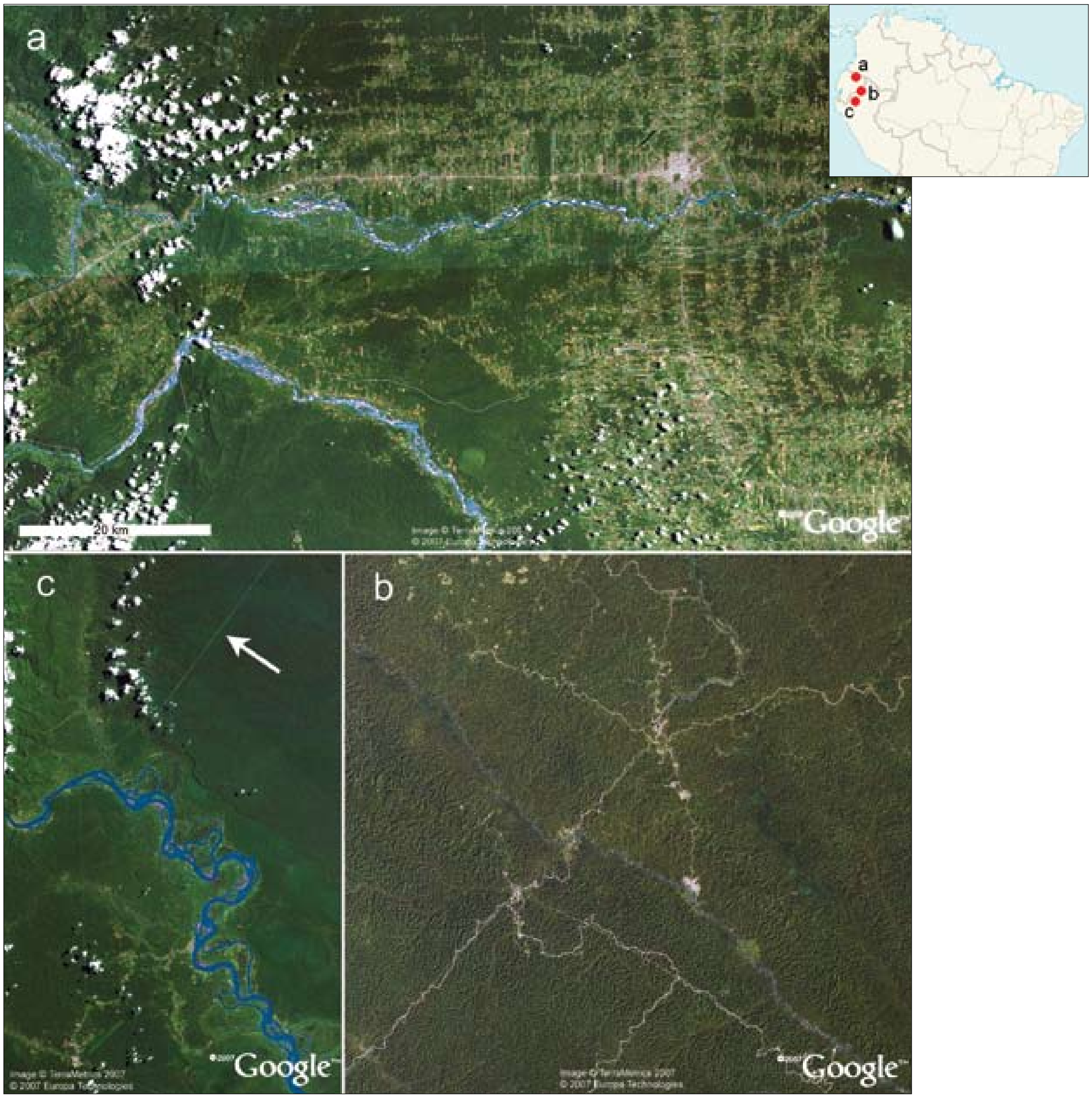

Figure 2.11. (a) In Ecuador, pipelines and roads were built concurrently during the 1960s, leading to colonization and deforestation. (b) In contrast, the remote producing fields in northern Peru were treated like offshore oil platforms; workers were transported by air, and equipment by river barge. (c) As a result, pipeline right-of-ways in Peru (arrow) were not converted into highways, and large scale deforestation has been avoided (Google Earth ™ Mapping Services).

home markets. When oil field development is shared by multiple operators, these smaller companies avoid responsibility for secondary impacts and are able to pass on the responsibility to the government or financing agency. Many commercial banks that finance these operations also lack solid environmental and social review processes.[28] Similarly, the need to improve the capacity of national regulatory agencies to monitor hydrocarbon exploration and production is essential given the more diverse corporate partners that characterize current energy development in the Amazon basin.

28 A group of commercial banks recently adopted a set of guidelines known as the Equator Principles to improve their environmental and social evaluation process (see http://www.equator-principles.com/principles.shtml).

The four major energy transport projects in Bolivia, Ecuador, and Peru all predate IIRSA, but the economic benefits associated with those projects are a perfect manifestation of the goals of IIRSA.[29] Similarly, Petrobras, with the support of BNDES, has devised a strategic plan to create a national grid of gas pipelines to link domestic supplies to urban markets. Any discussion of development in the western Amazon and Andes should address the implications of increased hydrocarbon exploration and production, and the relationships between energy exploration and infrastructure, regional development, human migrations, and agricultural expansion.

29 Bolivia: Gas Trans Bolivia (GTB), Gas Oriente Bolivia (GOB); Peru: Transportadores de Gas de Perú (TGP); Ecuador: Oleoducto de Crudo Pesado (OCP).

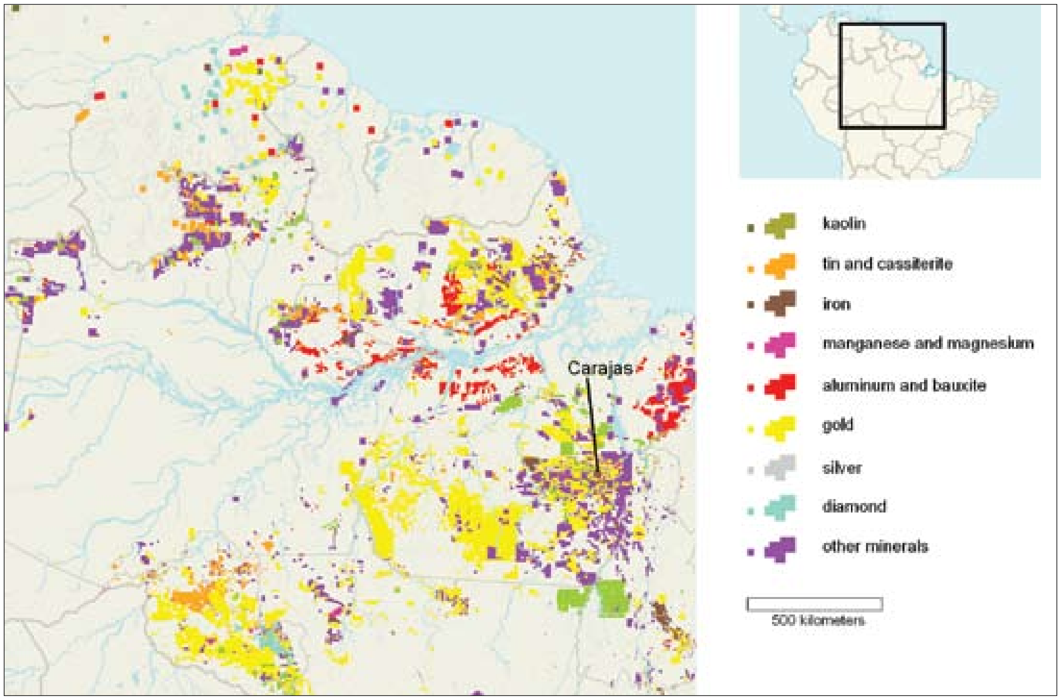

Figure 2.12. The Precambrian rocks of the Brazilian and Guayana Shields hold strategic reserves of many industrial minerals, as well as gold, silver, and diamonds (Modified from Departamento Nacional de Produção Mineral (DNPM) and Global InfoMine. See http://www.infomine.com/).

Figure 2.13. (a) Small-scale placer gold miners on the Huaypetuhe River in southern Peru produce between $100 and $200 million annually—almost five times the income earned from ecotourism. (b) The strip mines west of the Trombetas River in northern Pará State, Brazil, are among the world's largest producer of bauxite ore for aluminum (Google Earth ™ Mapping Services).

MINING

Mining is an important economic activity in the eastern Amazon where Precambrian rocks hold strategically important reserves of industrial minerals, including bauxite, iron ore, manganese, zinc, tin, copper, kaolin, and nickel, as well as less well known minerals such as zirconium, tantalum, titanium, beryllium, and niobium, which have become essential for modern technology (Figure 2.12). Bauxite is essentially old alluvium with concentrated levels of aluminum due to millions of years of weathering in tropical climates. The Amazon has huge bauxite reserves, particularly on ancient tertiary landscapes situated adjacent to the main course of the Amazon River and on the coastal plain of northern South America (Figure 2.12 and 2.13b). The ongoing growth of the aluminum sector and the development of a similar value-added production chain for transforming copper ore from mines in Pará State are securely entrenched in Brazil's development plans.[30]

Similarly, the Andean countries have a long tradition of mining with gold, silver, tin, and copper being the foundation of the mining industry in the high Andes. State-controlled enter-

[30] The Sossego, Salobo, and Alemão mines are all within 100 km of Carajás, and the existing infrastructure in rail and port facilities makes them some of the most competitive copper mines in the world. See http://www.cvrd.com.br.

prises predominate in Venezuela,[31] with multinational corporations operating in the coastal nations of Guayana and Suriname, as well as in Bolivia,[32] Brazil,[33] and Peru. Large industrial mines are strategically important to the economies of Latin America because they produce export commodities that generate royalty income for governments and contribute to the national balance of payments. Large mines are notorious for having direct, local impacts on the environment, but they do not typically cause regional-scale alterations comparable to the deforestation brought about by agriculture and ranching. However, industrial mines often lead to other investments that bring about secondary impacts several orders of magnitude greater than the mines themselves. For example, mines produce large volumes of bulk cargo that require modern transportation systems, leading to increased migration. Governments usually seek to add value to natural resources and produce jobs, whereas corporations seek to reduce transportation costs by transforming bulk minerals into industrial commodities such as steel and aluminum ingots (Kinch 2006). These metallurgical industries are energy intensive, which can affect terrestrial and aquatic ecosystems alike.

A case in point is the Greater Carajás Project in southeast Pará, Brazil, which has been the subject of an extensive and prolonged debate (Fearnside 1986). The operator of the concession, the Companhia Vale do Rio Doce (CVRD) and the Brazilian state took early action to manage the environmental and social impacts associated with what is now the world's largest iron ore mine, including the creation of 800,000 hectares of protected areas and indigenous reserves. Nonetheless, the construction phase of the project and the parallel improvement of the regional highway network stimulated migration into the region. The landscape surrounding the mining concession and its complex of protected areas and reserves is now largely deforested. CRVD's construction of an 800-kilometer rail line to service the Carajás mine has come under particular criticism because it contributed to the development of pig iron and cement factories that rely on vegetable charcoal. The demand for charcoal over the 30-year life of the rail line has been estimated at 1.5 million hectares of lost forest, surpassing the amount of forest habitat set aside as protected area by approximately 50 percent (pers. comm. CI-Brasil 2007).

Because the use of native wood species to produce charcoal is illegal under Brazilian law, pig iron producers are obligated to use charcoal made from eucalyptus plantations. Nonetheless, charcoal is an anonymous commodity, and there is a robust contraband trade. This stems naturally from the synergy between the industry's energy needs and the economic interests of cattle ranchers, who produce charcoal as a byproduct of land clearing (Fearnside 1989b) and who see it as a logical way to cash in on a capital asset and finance the establishment of their farms.[34,35] Realistically, this market will end only when native forests have been completely exterminated. Unfortunately, charcoal production is also often associated with exploitive labor practices characterized by many outside observers as a form of slave labor (Treece 1988).

Bauxite mines and aluminum smelters also have long-term secondary impacts on aquatic systems. Aluminum smelters require massive amounts of electrical energy; the decisive factor in developing an aluminum processing facility is not the availability or quality of bauxite ore but access to inexpensive energy. In Brazil, Venezuela, and the Guayanas, hydroelectric power is the preferred energy option due to high rainfall and topography. These reservoirs have, however, several key environmental impacts: they interrupt seasonal high and low water flows in rivers, reduce sediment loads, and interrupt the migratory behavior of fish species (see below).

Large industrial-scale gold mines exist or are under development in the three coastal states of Guyana, Suriname, French Guiana, and Venezuela, as well as in parts of Amapá and Pará states in Brazil in the eastern Amazon and in the high Andes of Peru and in the Condor region of Ecuador. Industrial-scale gold mines are usually associated with hard rock deposits where the concentration of mineral gold is extremely low. Cyanide is used to leach the mineral gold from the bulk ore, a process that releases heavy metals previously immobilized in the rock. Consequently, industrial gold mines produce tailings and effluents that remain environmental hazards for centuries.[36] Containment dams and synthetic membranes isolate water treatment ponds where the cyanide is removed and heavy metals are precipitated out of the water column. However, these ponds are susceptible to catastrophic failure with devastating consequences for the downstream watershed. The environmental standards of the world's mining corporations have been widely criticized and the economic consequences of poor environmental management are now so large that international mining companies enthusiastically embrace the environmental standards promoted by the World Bank (Warhurst 1998).

Although the greatest volume of gold ore is produced by industrial mines, the most common form of gold mining in the Amazon and Andes is conducted by small-scale cooperatives that extract mineral gold from alluvial sediments using rudimentary placer mining technology and mercury to concentrate the gold (Hanai 1998). The environmental impact of placer mining can be devastating, as giant dredges plow through the landscape, overturning the top layer of soils to get at the gold concentrated in sediments from ancient riverbeds. Placer mining leaves behind a lunar landscape that is devoid of vegetation and wildlife (Figure 2.13b). The use of mercury, with its well-documented impacts on neurological function and birth defects, poses an even more insidious environmental threat. Studies have shown that it has been accumulating in the Amazon over several decades and, like

31 The Corporación Venezolana de Guayana (CVG) mines iron ore, bauxite, gold, zinc, and other minerals, while managing steel and aluminum plants and electrical generating facilities (http://www.embavenez-us.org/kids_spanish/mining.energy.htm).

32 The Bolivian state mining company, COMIBOL, which dominated the industry from 1952 to 1984 and was dismantled in the 1980s, is once again taking a leading role in organizing joint ventures under the current government.

33 The Companhia Vale do Rio Doce was privatized by the Brazilian government in the 1990s and is now one of the world's largest mining companies with its headquarters in Rio de Janeiro.

34 O LIBERAL (Brazil) 21-11-05, reported fines by Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA) of R$598 for the use of illegally logged vegetable charcoal that originated in southern Pará State.

35 There are an estimated 20,000 charcoal factories in Pará and Maranhão (http://www.ipsenespanol.org/interna.asp?idnews=31041).

36 Typically 30 tons of ore are needed to produce 1 ounce of pure gold; in contrast, iron ore is between 70 percent and 90 percent mineral.

many toxic substances, is concentrating in the higher tiers of the ecological food chain (Maurice-Borguin *et al.* 2000).

In Brazil, cooperative miners known as *garimpeiros* have a history of creating "gold rushes" to remote localities, where populations can boom overnight into temporary communities numbering in the tens or even hundreds of thousands. *Garimpeiros* are a disruptive presence in remote areas traditionally populated by indigenous groups; they often introduce infectious diseases and resort to violence to establish their presence (Hanai 1998). Cooperative mining may also help advance the agricultural frontier because many *garimpeiros* are peasant farmers and invest the capital they acquire from prospecting into rural property. The intensity of *garimpeiro* mining oscillates with the international price of gold: during the 1980s, hundreds of thousands of *garimpeiros* worked the alluvial sediments in Tapajos, Pará, Roraima, and Rondônia, while similar groups in Bolivia and Peru were active in both montane and lowland regions of those countries. Compared with corporate mines, cooperative miners cause much greater cumulative environmental damage; however, cooperative mining creates many more jobs than super-efficient corporate mines. Regulation of cooperative mining is largely ineffective because governmental agencies do not have the resources to impose effective control nor the political will to confront large populations of impoverished people. Programs aimed at decreasing the environmental damage of cooperative mines also have the very important added benefit of increasing social welfare for an economically deprived sector of the population.

Although IIRSA does not include mining projects in its portfolio of investments, its investments in highways, hydrovia, railroads, and energy grids directly benefit the mining sector in that mines and their related processing and smelting industries are heavily dependent on energy and transportation costs. The agencies that coordinate IIRSA are fully aware of the synergistic nature of their investments.[37] Many, if not most, of the protected areas in the region also contain significant mineral reserves, and mining is allowed within most sustainable use areas; some countries explicitly allow mineral exploitation within a broader category of protected area. In Bolivia, mining is legally allowed within even the highest category of national park (Ricardo & Rolla 2006). The synergies between IIRSA and mining have positive aspects, particularly the generation of wealth and jobs; however, the negative aspects of mining are that it will increase deforestation and degrade aquatic systems. The potential long-term conflict between mining and protected area management is an issue that should be resolved, so that the mining sector does not oppose the creation of protected areas and recognizes that some protected areas should be exempt from any sort of mining activity.

HYDROELECTRIC POWER AND ELECTRICITY GRIDS

Bauxite mining is one of the most obvious examples of a secondary impact — in which investments in one sector (mining) lead to investments in another sector (hydroelectric power). Part of the incentive for investing in new hydroelectric facilities in the Amazon stems from government policies to process mineral

[37] A recent example is the approved IDB loan of $750 million to Venezuela for the expansion of the hydropower facility on the Caroni River. This facility supports the mining and processing activities of the Corporación Venezeloana de Guayana.

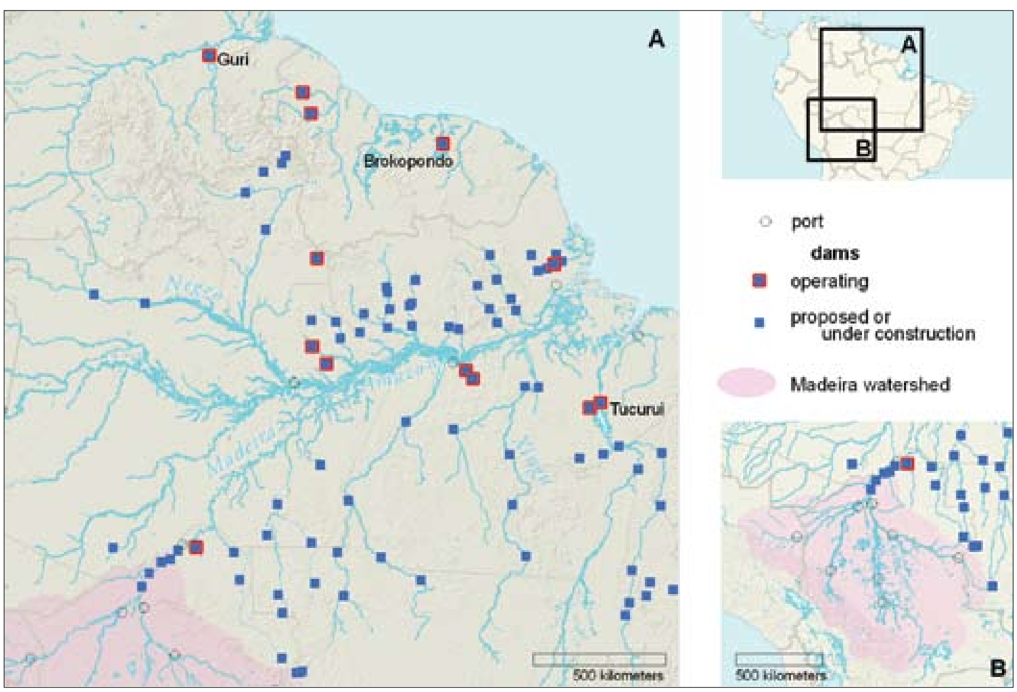

Figure 2.14. a) Guri, Brokopondo, and Tucuruí are the three largest hydroelectric facilities in the greater Amazon. The Amazon and Tocantins watershed represent 6% of the world's potential hydropower, with 68% of its undeveloped hydropower potential in Brazil. b) Controversy about the environmental impacts of river dams surrounds projects planned for the Xingu and Madeira rivers (Agência Nacional de Energia Eléctirca and Amazonian Scenarios Database, Woods Hole Research Center).

resources rather than merely exporting ore to overseas markets; in the terminology of governmental planning ministries, this is "adding value." Aluminum smelting is the most energy-intensive industrial process in the world, using about 2 percent of the world's energy and about 8 percent of total energy production in Brazil (Cadman 2000). In northern Brazil, the metallurgical sector consumes about 50 percent of the installed energy capacity, representing an annual subsidy between $200 and $400 million (LaRovere & Mendes 2000). The hydrological resources of the greater Amazon[38] are massive, and at least three of the world's largest hydroelectric facilities have been built with the express purpose of subsidizing the development of aluminum smelters: 1) the Gurí complex on the Caroni River in Venezuela; 2) the Brokpondo Reservoir in Suriname; and 3) the Tucuruí Reservoir on the Tocantins River in Pará State (Figure 2.14). The environmental impacts of these hydroelectric facilities are far greater than those created by the mine or the industrial smelters that process the bauxite ore (Fearnside 1999, 2001a). As Amazonian urban centers consume more electricity, the energy needed to support the aluminum industry must be provided by new facilities.

To review the social and environmental impacts of dams, The World Commission on Dams chose Tucuruí as one of seven case studies over its 30-year lifespan (LaRovere & Mendes 2000). Some impacts were expected, such as changes in inundation regimes that altered sedimentation rates and fertility levels on the floodplains below the dam. In addition, the reservoir experienced greater than expected eutrophication due to the decay of massive amounts of submerged biomass. The nutrient-rich waters caused an explosion of aquatic plants, which at their maximum extent in the 1980s covered 25 percent of the surface area of the lake before falling to current levels of approximately 10 percent. The abundance of floating plants fostered an increase in mosquito populations and impeded navigation and fishing. The submerged vegetation produced anoxic benthic environments that led to increased emission of greenhouse gases, particularly methane and carbon dioxide (Fearnside 1995, 2002, LaRovere & Mendes 2000). These direct impacts are common to all reservoirs in the tropics.

Each of these three mega-hydroelectric facilities on the Amazon River is situated at the lower part of a river basin (Figure 2.15). This location is advantageous for the production of energy, which depends on the volume of water that can be channeled through a turbine. However, placing a dam near the mouth of a river also maximizes its potential environmental impact because all upstream portions of the basin will essentially be isolated from other aquatic populations (see Chapter 4). Like all reservoirs, these three massive reservoirs will fill with sediment over time; consequently, engineers have proposed constructing dams upstream to prolong the life of these keystone facilities on the mouths of the river. This engineering logic is currently being carried out in the Tocantins-Araguaia River basin where twenty-five major dams and generating stations are being built on the two

[38] Here the term "greater Amazon" refers to the whole of the Amazon and Orinoco basins, as well as the multiple independent basins of the northeast coast of South America.

Figure 2.15. Large hydroelectric projects like the Raul Leoni Dam at Gurí on the Caroni River in Venezuela provide subsidized energy for aluminum smelters. Like many dams, it is situated near the mouth of a large river to maximize electrical energy production, which depends on water volume and vertical drop. However, placing the dam at the mouth of the river also isolates fish populations of the entire watershed from the rest of the Orinoco basin (© Daniela Vizcaino/CI).

major rivers, with another seventy smaller hydropower stations on upstream tributaries (Figure 2.14).

It is precisely this logical process of maximizing and protecting a strategic investment that has mobilized opposition to the Belo Monte Hydroelectric Complex on the Xingu River; a proposed facility that would generate approximately 11,000 megawatts and cost approximately $7 billion.[39] Belo Monte was first proposed two decades ago and was shelved because of public opposition to its perceived environmental and economic costs (Junk & de Mello 1987). However, the current government has attempted to resurrect the program as part of its development agenda for northern Brazil. Belo Monte is seen as being efficient in terms of energy per dollar invested and area flooded, and it would provide energy for the expansion of planned bauxite and copper smelting facilities.[40] However, the construction of the Belo Monte facilities would lead to economic, environmental, and social outcomes similar to Araguaia-Tocantins, including the construction of other dams upstream on the Xingu,[41] which is home to thirty-seven different ethnic groups that represent four distinct major linguistic families. The inevitable environmental impacts would be magnified by the social impact on these communities (Fearnside 2006a).

Other large dams in the region are the Balbina Dam near Manaus and the Samuel Reservoir near Porto Velho in Rondônia, which were constructed to generate power for urban markets. Both reservoirs illustrate the challenges that faced the civil engineers who designed and built these facilities in the Amazon wilderness. Insufficient information about local topography led to errors in mapping the inundation zone and underestimating the potential impact. In the case of Balbina, the reservoir turned out to be much larger than originally anticipated, resulting in one of the worst ratios in the world between the size of the reservoir and the energy generated by the hydroelectric facility (Fearnside 1989a). Engineers who designed the Samuel Reservoir were forced to build an elongate 15-kilometer dike along a lateral ridge to raise the level of the lake so as to meet the energy demands of Porto Velho (Fearnside 1995, 2005a).

Hydroelectric energy is an important component of the IIRSA investment portfolio. Twelve dams are planned for the headwater regions of Andean Ecuador where their environmental impacts would be minimized because they mimic the abundant natural barriers that characterize rivers and streams.[42] The most expensive project in the entire IIRSA portfolio is the Madeira River Hydroelectric Power Project near the cities of Porto Velho and Abunã on the border between Pando, Bolivia, and Rondônia, Brazil (Figure 2.14b). This project includes a series of dams and turbines that will produce 7,500 megawatts[43] at an estimated cost of $4.5 billion (Wanderley *et al.* 2007). The motivation for this project is largely to increase domestic energy production in Brazil; however, dams would flood the rapids that have obstructed river traffic, and a series of locks would create a river transport system connecting the Upper Madeira watershed with the main branch of the Amazon River. Known as the Madeira-Mamoré Hydrovia, this waterway would provide a low-cost alternative for exporting commodities from Rondônia and Acre,[44] as well as the incipient agricultural zones of northern Bolivia and southern Peru (see Figure A.2).

The Madeira hydroelectric complex will have a variety of environmental impacts. Proponents argue that flooding will be minimized because the dams will be only a few meters in height, an engineering decision dictated by the relatively flat local topography. Nonetheless, approximately 100,000 to 200,000 hectares of seasonally inundated forest will be permanently flooded, causing a radical change in a keystone habitat that provides ecosystem services such as nesting and feeding for fish populations. Dams will also act as barriers to migratory fish species that are important food resources for local populations and the foundation of the commercial fish industry (see Chapter 4). The proponents of the Madeira project have suggested that mitigation programs will alleviate negative impacts on migratory species, but previous experiments with fish ladders have not been successful in other regions of the world. Although the construction company of the Madeira projects contracted an environmental impact study, which was approved by the Brazilian Institute for the Environment and Renewable Resources (IBAMA) in October 2006,[45] civil groups in Brazil and Bolivia, particularly the local communities that will be directly affected by the reservoirs, question the impartiality of the study and continue to oppose the construction of the project.[46]

Large, complex hydroelectric energy projects are a sign of development and are largely welcomed by rural residents because they bring affordable energy to areas that have long been dependent on expensive hydrocarbon energy. In addition, the development the Araguaia-Tocantins, Madeira, and Paraná-Paraguay hydrovias will lower the cost of grain export for producers from the agricultural heartland of central Brazil in increasingly competitive international commodity markets. Politicians of all persuasions are enamored with dams because they are massive construction projects that provide employment opportunities for thousands of individuals with low skill levels and stimulate local economies. These synergies are exactly what entice the promoters of IIRSA.

39 This is 30 percent more than the capacity of the Tucuruí hydroelectric facilities; feasibility studies are part of the current PPA investment agenda. However, critics agree that due to fluctuating water levels, the facility will rarely produce at the installed capacity.

40 In 2002, CRVD expressed its willingness to participate in a construction consortium; CVRD has investment interests in aluminum smelters located in Pará State (http://www.isa.org.br).

41 There will be another separate dam, the Altamira, better known by its former name of Babaquara.

42 The recently elected President of Peru, Alan Garcia, has offered to provide the western regions of the Brazilian Amazon with electricity produced in Andean hydropower stations, and the IIRSA Amazon hub includes a high-tension line to connect Pucallpa with Cruzeiro do Sul in western Acre State.

43 Itaipu, the large hydroelectric facility on the Paraná River in southern Brazil, generates 14,000 megawatts of energy. A nuclear power plant on average produces about 8 megawatts of energy, and the new thermoelectric facility in Cuiabá generates 400 megawatts of energy.

44 See http://www.riomadeiravivo.org/debate/docapresentados/PortoVelho-Maio2006-Alcides.pdf.

45 In December 2006, IBAMA initiated a series of public consultations with local communities, and the decision to proceed with the project is expected in 2007. For more information, see http://www.ibama.gov.br/novo_ibama/paginas/materia.php?id_arq=4535, and http://www.riosvivos.org.br/canal.php?canal=318&mat_id=9898.

46 The consortium contracted to conduct the environmental impact analysis for the hydroelectric facilities (Furnas/Oderbrecht) are also likely to participate in the bidding for its construction (Oderbrecht) and operation (Furnas).

Nonetheless, dams and reservoirs have multiple direct and indirect environmental impacts that are well documented and that cannot be easily mitigated (see Chapter 3). Mega-hydroelectric projects in particular should be avoided on primary rivers that integrate major watersheds because they negatively impact huge upstream areas. In contrast, multiple small hydropower stations situated upstream on tertiary tributaries have a relatively small footprint in spatial terms and limit the degree of aquatic ecosystem fragmentation. The economic, social, and environmental tradeoffs among development options are precisely what strategic environmental evaluations are designed to elucidate (see Chapter 6) and should be conducted for all hydropower projects at the basin scale as part of early-stage feasibility studies before the modification of infrastructure investments becomes politically difficult, if not impossible.

BIOFUELS

The growing demand for biofuels could stimulate another investment boom that would dwarf all previous commodity-based exploitation in the Amazon. This demand is driven by governments seeking alternatives to fossil fuels, which are becoming less appealing due to political instability, climate change, and a perceived impending scarcity of oil. The projected market for biofuels is so large that it could stimulate deforestation far beyond the most pessimistic scenarios envisioned by conservationists (see Text Box 3) (Laurance *et al.* 2001, 2004, Câmara *et al.* 2005, Soares-Filho *et al.* 2006). Brazil, which has the most advanced biofuel technology in the world, has led the way in using sugar cane alcohol as an alternative to traditional fossil fuels. It is now also promoting the production of biodiesel as part of its national strategy for energy independence and, since 2006, has required that 2 percent biofuel be mixed with traditional fossil fuel diesel (Kaltner *et al.* 2005). Brazil has also made a commitment to replace 5 percent of diesel consumption with biodiesel by 2013.

This early shift to biodiesel will be made possible with soy, which is receiving a lot of attention as a biofuel source due to existing production and processing capacity in Brazil. However, African oil palm (*Elaeis guineensis* Jacq.) will dominate the biodiesel market over the mid term due to its chemical properties, energy content, and oil yield on a per hectare basis, producing approximately eight times more oil than soy (Figure 2.16).[47] Brazil has already increased research and development efforts for the African oil palm, which has a long history of cultivation in northeast Brazil. Oil palms are cultivated in the Huallaga Valley of Peru, Amazonian Ecuador, and the Colombian Chocó region. The African oil palm is the most successful tropical crop in the world in gross productivity and market value, which explains why it has been a leading driver of deforestation in Indonesia and Malaysia (Kaimowitz & Angelsen 1998).

Ethanol derived from grains and sugar cane is also being promoted by producer groups as an alternative biofuel in Brazil and the United States. Brazil has a long and successful history of adapting its domestic fleet of motor vehicles to gasoline-ethanol combinations, and of improving the productivity and adaptability of sugar cane. However, an emerging technology may soon revolutionize the production of ethanol throughout the world. The current basis of ethanol production is the conversion of starch and sugar, compounds found in the tissues of plant storage organs; these offer an easily mobilized form of chemical energy. However, a much more abundant carbohydrate is cellulose, the principal constituent of plant structural tissues; cellulose can only be metabolized by specialized micro-organisms that have evolved the necessary enzymes for breaking down cellulose into its constituent sugar molecules. Modern biotechnology has now harnessed these enzymes into an industrial process that converts cellulose to ethanol. The implications of this second-generation alcohol technology have yet to be fully understood by the popular press, but essentially, any plant biomass can now be converted into en-

[47] Soy produces between 2 and 4 metric tons per hectare and in the tropics can produce two harvests per year; approximately 20 percent of the total soy yield is vegetable oil. In contrast, oil palm produces between 5 and 6 tons of vegetable oil per hectare on an annual basis. Palm oil also has higher energy ratio per unit volume.

Text Box 3

Biofuels: The Next Deforestation Threat

Biofuels are being heavily promoted as a climate-friendly energy source and are the object of venture capital investors around the globe. However, demand will most likely spread the cultivation of biofuel crops farther into the Amazonian frontier where land values are lower and production costs promise to make them competitive in future markets. The current emphasis on sugar cane and soy to produce ethanol and biodiesel will eventually shift to other crops adapted to conditions of the humid tropics.

The biggest threat comes from palm oil (Figure 2.16), perhaps the most productive tropical crop in the world and one that is well adapted to areas with mean annual precipitation rates over 2,000 mm and dry seasons shorter than 3 months (Kaltner *et al.* 2005)—climatic conditions characteristic of the wilderness areas in the central and western Amazon. The entire region, including the relatively steep slopes of the Andes and the marginal lands of the Cerrado that have escaped the plow, also has potential for elephant grass plantations or some other high biomass yield species that will be a feedstock for the rapidly developing second-generation technology of cellulosic alcohol.

Unless effective regulatory measures are implemented, these market forces will lead to a boom in deforestation that will surpass all previous deforestation cycles. Biofuels represent the greatest latent threat to the conservation of the Amazon Wilderness Area, as well as to the Tropical Andes and Cerrado Biodiversity Hotspots.

Figure 2.16. African oil palm is a potential biofuel crop that produces up to six times more vegetable oil per hectare than soy and could improve the livelihood of tens of thousand of tropical farmers. It also threatens the Amazon forest as a new—and powerful—driver of land use change if its cultivation is not restricted to previously deforested and degraded lands (© John Buchanan /CI).

ergy—greatly increasing the efficiency of biofuel production.[48]

Many scientists argue that biofuels are a false panacea due to the energy required for their production. Recent studies have demonstrated that the cost-benefit ratio varies depending on the production system and, in many cases, biofuel crops are net energy producers (Hill *et al.* 2006). A more important constraint to converting the global economy to biofuels will be the competition with food crops for arable land, especially as the planet's population doubles over the next century. Major energy corporations have questioned whether it is ethical to promote biofuels, arguing that they will lead to the conversion of arable land in developing countries where human populations are undernourished. However, the promoters of cellulosic ethanol technology point out that this production system is well suited for marginal lands where traditional crops cannot be competitively cultivated. In the United States, biofuel production could lead to the conservation or even the restoration of millions of hectares of native prairie, where the leaves and stems of the native switch grass (*Panicum virgatum*) can be harvested to produce approximately 12 metric tons per hectare of biomass annually (Radiotis *et al.* 1999). The productive capacity of tropical grasses is far superior to switch grass; one of the most productive tropical forage species, elephant grass (*Pennistem purpureum*), can be harvested three times per year to produce between 35 and 50 metric tons per hectare of biomass under ideal conditions of water and nutrient availability (Espinoza *et al.* 2001).

48 Biomass refers to live plant tissue and is composed largely of cellulose, although it may also contain lignin and chemicals characteristic of wood; biomass is approximately 50 percent carbon and 50 percent oxygen, hydrogen, and other trace elements.

This new biofuel market will, hopefully, lead to plantations on the approximately 60 million hectares of Amazon landscape that have already been deforested, including the secondary forest that predominates in the colonized zones on the Andean piedmont and the degraded pastures in cattle ranching regions of Brazil. However, the fear is that market forces will eventually prevail, and the demand for food will require the full productivity of the world's best arable land, with biofuels relegated to marginal land where food crops do not provide adequate yields.[49] Unfortunately, most of the Amazon and Andes Mountains fit into that latter category. African oil palm and elephant grass are ideally suited to the tropics, being perennial species adapted to high precipitation regimes and acidic soils; most importantly, they are incredibly productive on a per hectare basis.

GLOBAL MARKETS AND GEOPOLITICS

Peasant farmers, cattle ranchers, agribusiness companies, and land speculators are the most conspicuous agents of change in the Amazon and in the adjacent regions of the Andes and Cerrado, but these local actors are influenced directly or indirectly by international markets and policy decisions made in New York, Lima, Rio de Janeiro, Beijing, and other major urban centers. Iron ore, petroleum, soy, rice, timber, cinchona bark, rubber, and Brazil nuts are all commodities whose price is set by international markets. Commodity markets have historically fluctuated widely, stimulating investments and bankrupting businesses that did not understand the inherent risk of boom and bust markets. Nations and corporations attempt to limit their risk by creating vertical business models that protect their economies from shortages and high prices. In the Amazon, however, the reaction has often been to adopt an extractive mentality that maximizes profits over the short term while prices are high; even renewable resources are treated as if they were minerals and are exploited until they are nearly an exhausted resource.[50]

The most conspicuous market phenomenon of the last decade has been the rapid growth of the oilseed industry, particularly soy but also sunflowers and rape seed. The international market for soy has been driven by demand from East Asia, particularly China, and has been partially responsible for the rapid growth in mechanized agriculture in central Brazil and for the conversion of almost 50 percent of the Cerrado ecosystem. Competition in international markets is one of the major reasons for IIRSA and PPA investments, because transportation is a major component in establishing the cost of soy exports. For example, the principal market for Bolivian soy has been Andean countries, where tariff preferences under the Andean Community of Nations Treaty (CAN) have provided Bolivian exporters a price advantage over producers from other countries. This trade advantage is now

49 A study recently published by the National Academy of Sciences found that neither ethanol nor biodiesel can replace petroleum without having an impact on the food supply. If all American corn and soybean production were dedicated to biofuels, that fuel would replace only 12 percent of gasoline demand and 6 percent of diesel demand. The study concludes that the future of replacing oil and gasoline lies with cellulosic ethanol produced from low-cost materials such as switch grass or wheat straw, grown on agriculturally marginal land or from waste plant material (Hill *et al.* 2006).

50 Two famous examples are quinine in the nineteenth century and mahogany in the twentieth century.

scheduled to terminate because Colombia and Peru have reached free trade agreements with the United States, whereas Venezuela purchases grains from Argentina and Brazil, whose prices are more competitive than Bolivia's. Thus, because Bolivia's future ability to compete in international soy markets depends to a large extent on transportation costs, the country is, not surprisingly, anxious to improve its infrastructure. IIRSA investments in highways, railroads, and hydrovias address these concerns.

The Amazon basin also has enormous potential as a source of high-quality hardwood timber. Currently, most exports from Bolivia and Peru are destined for the United States, with growth in the U.S. market occurring at a 25 percent annual rate since 2003 (PROMPEX 2006). Currently, there is no appreciable trade in timber between the Pacific coast of South America and China; however, this may change, especially as IIRSA investments in hyrdovias and highway corridors reduce transport costs. China has more than tripled its imports of timber in the last decade (Sun *et al.* 2004), and traditional sources of tropical hardwood are rapidly being depleted in Southeast Asia (Curran *et al.* 2004). Plantation forestry in both China and Southeast Asia will play an important role in meeting future demand. However, Amazonian timber could find a niche in the Chinese market for high-quality hardwood for the manufacture of flooring and furniture. Chinese furniture manufacture is an important part of the forest products industry; fully 50 percent of all imported wood in China is re-exported as finished products, with furniture making up approximately 32 percent of those exports (Sun *et al.* 2004). In 2005, Peru reported its first sale of hardwood flooring to the Chinese market (PROMPEX 2006). No systematic economic analysis has been conducted on this potential new market and its environmental and social impact on the Amazon Wilderness Area.

The most important international commodity is oil, and one of the most obvious links between global markets and geopolitics is the simultaneous impact of political unrest in the Middle East and the increased demand for oil in China. The current high price of oil has stimulated exploration and production throughout the world, including in the western Amazon and Andean piedmont. Although increased production worldwide will eventually lead to a decrease in oil prices, some analysts think the mid- to long-term price will remain well above historically low levels (Hickerson 1995). In search of stable energy supplies, state-owned corporations such as the China National Petroleum Company (CNPC) have acquired overseas oil reserves free from the control of foreign multinational corporations. Chinese-owned subsidiaries are exploring for oil in Peru (PetroPeru 2006) and Ecuador (ChinaView 2006), and the CNPC has also acquired a 36 percent stake in the OCP pipeline in Ecuador, which ensures control not only of petroleum reserves, but also of the transport system needed to bring those reserves to their domestic market.

Brazil is likewise expanding its sphere of economic influence. Petrobras holds 14 percent of Bolivia's natural gas reserves and is a shareholder in the pipelines that connect those reserves with Brazil's domestic markets. Petrobras is also actively involved in exploring gas and oil reserves in Ecuador and Peru, including within Yasuní National Park and in concessions adjacent to Camisea. Future growth of the Peruvian reserves near Camisea may resurrect part of Shell Oil's original business plan from the early 1990s for a pipeline to connect Camisea with Brazil. Brazil's growing influence is reflected in its recent commitment to support the executive offices of the Organization of the Amazon Cooperation Treaty (OTCA). The mission of the OTCA is to promote economic growth and conserve the natural ecosystems of the Amazon basin. IIRSA is mentioned in the OTCA strategic plan as an explicit priority and is fully justified by the original OTCA treaty. Brazil has played an active role in rejuvenating the role of the OTCA and is helping finance individual IIRSA projects via loans to Brazilian construction companies through BNDES and other Brazilian financial institutions.

Brazil is not the only Amazonian state that is attempting to expand its influence in the region. The President of Venezuela, Hugo Chavez, has been particularly energetic in promoting a "Bolivarian" vision of regional integration that is both independent of the United States and based on state intervention in national economies (Figure 2.17). As part of that vision, he has announced that the state energy company (PDVSA) is willing to invest in a *Gasoducto del Sur* to connect Venezuela to Argentina and Uruguay via Brazil.[51] According to projected prices for natural gas in international markets, this pipeline is only marginally viable on an economic basis; however, the Southern Cone countries may be willing to subsidize its construction to diversify energy sources, while Venezuela seeks to open new markets for its huge gas reserves.[52] The *Gasoducto del Sur* meets all the development criteria in the vision and mission statements of IIRSA and offers intriguing possibilities to create a continental energy transport system.

In the Amazon, the economic impact of a continental-scale energy grid would be enormous. If natural gas prices within the region remain subsidized, it would spur investments in other industries linked to natural resources—the foundation of the Amazonian economy. For example, in order to establish the country's first steel mill, the Bolivian government recently agreed to provide gas at below-market prices to attract foreign investments in an iron ore mine and processing facility. Gas pipelines would also mean a proliferation of electrical generation facilities and the extension of rural electrical grids. Modern highways combined with abundant energy resources would lead to explosive growth; deforestation would increase at near exponential rates, and the Amazon would be radically and permanently altered.

The future development of the Amazon will be driven in part by political factors and will be influenced by the electoral processes in South America. Voters have been rejecting the traditional elites and the political parties that have dominated over the last few decades, instead supporting new political groups called "social movements." Governments in Bolivia, Ecuador, and Venezuela and opposing political parties in Colombia and Peru

51 Although it may sound farfetched, it was included as a goal in a recently signed agreement between PDVSA and ENARSA (http://www.abn.info.ve/go_news5.php?articulo=27174&lee=3); in addition, the Russian gas giant Gazprom and Petrobras have initiated discussions to jointly develop this pipeline (Reuters 2006).

52 Venezuela has an estimated 147 trillion cubic feet of natural gas reserves, approximately triple those of Bolivia and ten times those discovered at Camisea, Peru (http://www.dinero.com.ve/196/portada/energia.html).

Figure 2.17. IIRSA is a manifestation of the political determination of South America countries to integrate their economies, a goal that is broadly supported by all sectors of society and which will transcend the periodic changes of the electoral process (© Getty Images).

advocate a larger role for the state in managing the national economy. Some criticize multinational corporations that exploit the mineral and energy resources of the region, and civil groups often use environmental issues to obstruct hydrocarbon exploration, particularly in protected areas and indigenous reserves. However, once elected, politicians—and the voters they represent—usually energetically support natural resource exploitation as a means to generate economic growth.

In Bolivia, opposition to hydrocarbon exploitation was based not on a concern for conservation, but on a perception that the business arrangement with multinational companies was unfair to the country and indigenous peoples. A new relationship between the state and the multinationals was recently negotiated, and the new government has promised a portion of the oil royalties to indigenous groups. Consequently, opposition to exploration has essentially dissipated; exploration and production are now viewed as strategic priorities. Importantly, the lead institution is no longer a distrusted foreign multinational, but a state-owned company with broad public support. Historically, state-owned companies have not adopted the most rigorous environmental and social policies, although some companies such as Petrobras have successfully changed corporate cultures, adopting environmental standards common to the industry.

In Latin America, governments and opposition movements speak of the need to establish "policies of the state" versus "policies of the government." The former refers to strategic objectives and decisions that are broadly supported by all sectors of society and that transcend the periodic swings of the electoral process. Important examples are Bolivia's demand for access to the Pacific Ocean, Venezuela's decision to maintain managerial control over the exploitation of its mineral and hydrocarbon resources, and Brazil's fierce defense of its sovereign right to manage the conservation of Amazon biodiversity. IIRSA is another such "policy of the state" and as such, it transcends current governments and the wills of individual leaders. However, IIRSA also represents an opportunity to conserve the biodiversity of the Andes Mountains and the Amazon because it provides a forum to address the multiple threats of development directly and to provide integrated alternatives that respond to the legitimate needs of Amazonian society for economic growth and development. Key to the reform of IIRSA is the recognition that the nations of the Amazon have sovereignty over their natural resources. Each nation must thus be convinced that its own national strategic interest is best served by conservation. The recent resurrection of the Organization of the Amazon Cooperation Treaty (OTCA), with its recognition of the centrality of biodiversity conservation, provides an appropriate and timely mechanism for perfecting the collective state policies represented by IIRSA.