Infrastructure and Conservation Policy in Brazil

JOHN REID* AND WILSON CABRAL DE SOUSA JR.†

*Conservation Strategy Fund, 17670 Indian Creek Road, P.O. Box 606, Philo, CA 95466, U.S.A., email john@conservation-strategy.org
†Divisão de Engenharia de Infraestrutura, Instituto Tecnológico da Aeronáutica (ITA), Praça. Mal. Eduardo Gomes 50, Vila das Acácias, São José dos Campos 12228-900, São Paulo, Brasil

Abstract: *The development of transportation and energy infrastructure has been a major driver in the conversion of natural ecosystems in Brazil since the nineteenth century. Although this pattern is present in most countries, Brazil differs in the scale of opportunities that are still available to build its physical infrastructure while pursuing an ambitious conservation agenda. This advantage stems from the magnitude of intact ecosystems, a dynamic policy environment, and the increasing availability of biological and economic data needed to harmonize conservation with public works. Success depends on integrating conservation and infrastructure planning, rather than relying on the project based, largely ineffective environmental assessment process. Front-loading environmental mitigation and compensation will also help, as will improving public access to, and understanding of, information on the environmental and economic values at stake in major infrastructure decisions.*

Infraestructura y Políticas de Conservación en Brasil

Resumen: *A partir del siglo XIX, el desarrollo de la infraestructura eléctrica y de transporte ha sido el principal conductor de la conversión de ecosistemas naturales en Brasil. Aunque este patrón se presenta en casi todos los países, Brasil es diferente en la escala de oportunidades aun presentes para construir su infraestructura física y perseguir una agenda ambiental ambiciosa. Esa ventaja deriva de la magnitud de los ecosistemas intactos, una política ambiental dinámica y la creciente disponibilidad de datos biológicos y económicos requeridos para armonizar la conservación con las obras públicas. El éxito depende de integrar la planificación de infraestructura y de conservación, en lugar de depender del muy ineficaz proceso de evaluación ambiental, basado en el proyecto. Llevar a cabo a la mitigación y compensación ambiental antes de inciar la construcción también ayudará, así como también lo hará el mejoramiento del acceso del público a, y la comprensión de, la información sobre los valores ambientales y económicos en juego en las decisiones trascendentales sobre infraestructura.*

Introduction

Transportation, energy, and communications infrastructure open up territory to economic activities and promote development by lowering production costs in populated areas. These virtues have turned infrastructure development into a key driver of ecosystem destruction in Brazil, but one that is dependent on public policy. Positive government action, as such, can bring vast environmental gains. We examined the role of government in infrastructure and the conservation impact of infrastructure projects on Brazilian biomes, and reviewed existing policy instruments designed to limit environmental damage. Here we highlight some planned megaprojects and suggest ways of better reconciling infrastructure development with nature conservation.

Why Are Public Works Public?

Economists generally espouse the premise that goods and services can most efficiently be provided by private enterprise, although public investment or involvement in economic activities can sometimes be justified—in, for example, curbing the abuses of monopolists. Roads, pipelines,

Paper submitted December 30, 2004; revised manuscript accepted January 20, 2005.

and power lines all represent natural monopolies, industries for which it makes practical sense to have just one firm supplying the service in a given place. Government must either be that firm or regulate it so that the firm does not underproduce, maintain high prices, and collect excess profits called "monopoly rents." Public investment can also distribute resources more equitably. Transportation and energy are basic inputs of most goods and services, regarded as basic economic rights—like clean water and education—a philosophy manifested in Brazil's current *Luz Para Todos* (Electricity for All) electrification program. Transportation and energy can be either universally subsidized or specifically subsidized through special low-income rates to ensure that all citizens receive them. Business losses are then covered by taxpayers (in the former case), ratepayers, or a combination of the two (in the latter case).

Managing risks that otherwise suppress private investment is another justification for public investment. Projects with a high ratio of fixed to variable costs, such as dams, carry a high risk. For the investor, 80–90% of a dam's cost accrues during its construction. If there is no private buyer of sufficient scale, a utility that is owned or regulated by the government must step in and ensure adequate sales to repay investment capital. Governments can build dams and feed the power into the nationally owned grid or offer long-term power purchase agreements to private investors. Large projects in remote environments are also particularly vulnerable to cost overruns and delays (Bacon et al. 1996). In addition, hydrological data are often insufficient to predict production with confidence. Private entrepreneurs are generally unwilling to assume these risks alone, so governments are included as partners.

Generating and conserving public goods produced by nature (e.g., biodiversity) is another justification for government intervention. Public goods are those from which people cannot be excluded, and their use by one person precludes use by another (e.g., a given kilowatt-hour of electricity cannot be used twice). Infrastructure generally consumes rather than produces public goods. Users can easily be excluded from roads, pipelines, railways, and the benefits of dams. Transportation, transmission, and distribution systems performing at or near capacity, also produce a "rival" service: users crowd, displace, or impose increased risk on one another. Yet infrastructure projects usually eliminate public goods, such as biodiversity, that flow from intact natural ecosystems. This "consumption" of public goods makes infrastructure not just a matter of public policy but also of environmental policy.

Conservation Impacts

Infrastructure projects have direct physical effects, such as flooding, deforestation, and earth moving. They also have broadly felt indirect impacts—they provide access to remote regions and stimulate new economic activity. Roads generally wreak the most damage. Paved (as opposed to unpaved) roads are especially robust predictors of deforestation in the Amazon (Pfaff 1999). New roads increase the abundance of accessible land relative to other factors of production, making resource mining an economically rational strategy (Schneider 1994). Outright deforestation is compounded by increased fire risk in selectively logged forests served by the expanding road network (Nepstad et al. 2001). Although other forms of linear infrastructure—pipelines, transmission lines, and railways—have similar direct impacts, their indirect effects are less significant because they result in less multipurpose access.

Dams have notable impacts on aquatic biodiversity, terrestrial habitat through flooding, and downstream riparian ecosystems because seasonal flooding and sedimentation patterns are changed. Migratory fishes can be entirely eradicated even where fish ladders are installed. Dams can also emit more greenhouse gases than thermoelectric plants where they are sited in flat, densely forested areas (Fearnside 1995, 1997). Large dams in Brazil have changed hydrological regimes, destroyed archeological sites, diminished water quality, and led to proliferation of disease-bearing insects (Pará IDESP 1991). They also displace people, and in Brazil this has spawned anti-dam activism led by the Movement of Dam-Affected Peoples. Where dams are part of an interbasin water diversion, there are important impacts related to the reduction in flows and aquifer recharge in the source basin and increased flows and genetic transfer into the receiving basin.

Although a full accounting of the conservation impacts caused by infrastructure projects throughout Brazil is beyond the scope of this paper, we highlight some of the conflicts in Brazil's five terrestrial biomes.

Atlantic Forest

Brazil's overland transportation network took hold in the early nineteenth century, when mule trails were hacked through the coastal Atlantic Forest to the gold fields of Minas Gerais. Upland coffee production followed, and by mid-century an estimated 500,000 mules were plying these tracks, grazing around 2,500 km^2 of deforested land (Dean 1995). In 1867 railroads began linking Rio de Janeiro to Três Rios and Santos to Jundiaí, with lines reaching into coffee-growing states constructed in the ensuing decade. Steam engines consumed millions of trees, accounting for around 620 km^2 of Atlantic Forest destruction annually by 1950, when diesel and electric locomotives began replacing them. Trains also opened vast new areas for coffee planting, encouraging abandonment of older groves near the coast (Dean 1995).

Small municipal hydroelectric dams serving all the major cities in the Southeast Atlantic Forest appeared after

1900. The first diversion projects—the Guandú and Billings complexes—soon followed, as did larger hydro plants, although none involved large reservoirs because of the favorable topography and heavy flows. That changed in 1973, however, with the construction of Itaipú on the broad Rio Paraná—at the time it was the world's largest hydroelectric scheme. The 12,600-megawatt (MW) project flooded the Sete Quedas Falls, along with 1,350 km^2 of land, 770 in Brazil and 580 in Paraguay.

Expansion of federal highways in the 1960s and 1970s affected most parts of the national territory, and the Atlantic Forest was no exception. In the early 1970s, for example, southern Bahia had the last large tracts of lowland Atlantic Forest but lost around 80% of these in the decade after the BR-101 opened in 1971 (Dean 1995). Even today, new coastal roads are affecting forest and near-shore marine resources (Jablonski 2003) as real-estate development targets the last of Brazil's remote beaches.

Caatinga

The demand for water in the semiarid Caatinga drives infrastructure choices and has the most serious environmental impact, even though the region has few dams. Sobradinho, built in 1979 on the Rio São Francisco, created the country's largest reservoir (4,214 km^2). The smaller Itaparica dam was completed a decade later. The São Francisco Valley Development Authority (Companhia de Desenvolvimento dos Vales do Sao Francisco e do Parnaíba [CODEVASF]), a federal agency, has diverted freshwater systems for irrigation projects since the 1970s. Its mandate now includes the Parnaíba Valley and more than 980,000 km^2 in two river basins touching eight states and the federal district. It actively manages more than 100,000 ha of irrigated land in 25 projects (CODEVASF 2005). Some irrigation projects have dramatically transformed regional economies, whereas others (e.g., Jaíba in Minas Gerais, funded by the World Bank) are roundly criticized. A controversial project to divert about 3% of the São Francisco River for irrigation and urban use in the northern Caatinga has been criticized on financial, environmental, and energy-generating grounds over the last 12 years (Suassuna 2000). Despite this, it was recently endorsed by Brazilian President Luiz Inacio Lula da Silva.

Cerrado

The Cerrado, central Brazil's vast and varied woodland-savanna biome, was largely intact until the 1970s. Railroads had reached Campo Grande by 1935, continuing to Mato Grosso and Anápolis in Goiás, but the lack of feeder roads for agriculture limited habitat conversion. Roads were built in the 1950s to link the new capital in Brasília to the country's economic hubs in the south, and to Belém in the north. With the opening of BR-153, broad swathes of the northern Cerrado in Goiás and what is now Tocantins state opened to agricultural expansion. In the 1970s, the federal government built another wave of highways to facilitate colonization of the Amazon and Cerrado. Many nonfederal feeder roads were also built, leading to the conversion of 30.6 million ha of the Cerrado to soybeans, corn, rice, beans, coffee, manioc, and cattle pasture (1970–1985) (Pro-Cer & WWF 1995). This process has continued unabated, slowed only by drought and economic downturn. In all, around 120 million ha have been lost.

Soybeans have supplanted cerrado and, most recently, transitional areas between the Cerrado and the Amazonian forests. Clearing is first for pasture, and then pasture is converted to soybeans, moving the cattle-ranching frontier into new habitat and continuing the cycle. With soy come improved roads, electricity, and grain-processing facilities, and as land values increase, agroindustrial concerns such as sugar cane alcohol and animal feedlots. Although soy planting is the best-known threat, planted pastureland covers more than 10 times the area of former cerrado now occupied by soybeans (Barros-H. 2003). The feedback loop of agriculture and infrastructure has led to improved railroad links with several Atlantic ports (Vitória, Santos, and Paranaguá), roads (BR-163 to Santarém), and shipping canals proposed for the Madeira and Alto Paraguai.

The Cerrado's main watersheds are rapidly being converted to hydroelectric generation, following the stepping-stone model established in the Tietê-Paraná basin. In the 1960s, large dams were constructed on the Rio Grande and in the cerrado of the upper Rio São Francisco (Três Marias). Two megadams on the upper and lower reaches of the Rio Tocantins (Serra da Mesa in 1997 and Tucuruí in 1984) anchor the regional grid and are now accelerating buildup of smaller dams across the watershed (Poole 1999). The other larger rivers that drain the cerrado to the north, such as the Xingu and Araguaia, remain undammed, although President Lula's government has development plans for both.

Amazonia

The spotlight turned to the Amazon in the 1970s and 1980s as controversial dams and roads were built, many with financing from the World Bank. The Balbina dam is cited as one of the worst examples of hydroelectric development. It flooded 3108 km^2 of forest and displaced 107 Waimiri-Atroari people but provided only a modest 300 MW of capacity (e.g., WCD 2000; McCully 2001). Balbina's sprawling, shallow reservoir has emitted more greenhouse gases than a fossil fuel plant of equal capacity (Fearnside 1995). Tucuruí on the Rio Tocantins, the second biggest dam in Brazil, was completed in the mid-1980s. It supplied power from the north to the national grid for the first time and to a local aluminum industry. The 2875-km^2 reservoir inundated an estimated 13.4 million m^3 of timber and caused many environmental and social

Table 1. Highlights of Brazil's Multiyear Plan 2004–2007.*

Project	*Characteristics*	*Observations*
Belo Monte Dam	11,181 MW installed capacity; 440 km² reservoir area; $5.7 billion cost, including transmission system	uncertainty about energy generation and construction costs; Babaquara upstream storage reservoir also in the Plano Plurianual—potentially much larger conservation impacts
Paving of the BR-163 Cuiabá-Santarém Highway	993 km; $264 million cost	nongovernmental organizations' proposals to invest in protected areas and "governance" before the road is completed
Rio Madeira Hydroelectric Complex and *hidrovia*	two dams in Brazil: Jirau, $3.58 billion cost, 3900 MW, 258 km² reservoir and Santo Antônio, $3.35 billion cost, 3580 MW, 271 km² reservoir	link in continental scheme to join Amazon and Plata basins; three upstream dams in Bolivia envisioned; possible far-reaching land-use impacts as soybean planting is stimulated; Madeira is largest sediment transporter in Amazon—potentially large downstream floodplain impacts
Coarí-Manaus Gas Pipeline	gas transport from Urucú field to Manaus; 417 km of underground pipe; $393 million cost	deforestation risk along the pipeline route; project proceeding under detailed environmental/social program; possibility of a second line to Porto Velho
North-South Railway	2,066 km; $1.6 billion cost	likely expansion of the agricultural frontier and further migration into the Amazon
Diversion of the Rio São Francisco	transfer of water to the semiarid northeast for agriculture and domestic use, 126 m³/s; $6 billion cost	questionable economic efficiency and equity; opposition from São Francisco watershed committee; compensatory diversion from Tocantins Basin would affect Jalapão region

**Source: Secretaria de Planejamento e Investimentos Estratégicos et al. 2004.*

problems common to large dams (Pará IDESP 1991). It is set to expand from 4200 MW to 8000 MW.

The Transamazon Highway (BR-230) was connected to the 1950s-era BR-153 Belém-Brasília highway in the 1970s. In the early 1980s, BR-364 was built as the backbone of the *Polonoroeste* colonization scheme in Rondônia. Other unpaved roads, such as BR-163 from Cuiabá to Santarem, were opened during the early 1970s. These roads and the dams provided transportation links and energy for nearly two decades of Amazon development and deforestation but were badly run down by 2000.

In the early 1990s, the march of large projects slowed because of economic instability, reduced government investments, a chastened World Bank, and growing environmental and social movements. The stalled Belo Monte hydrocomplex represented an unusual instance of a megaproject derailed by social and indigenous resistance, although it is likely that the previously mentioned factors helped to keep the project dormant during the 1990s.

Pantanal

The most controversial and important infrastructure project in the Pantanal is one that has yet to exist—the Paraguai-Paraná *hidrovia* (waterway). Commercial and military navigation on the upper Rio Paraguai has been important since the mid-nineteenth century. By 1930 Corumbá was Latin America's third largest port, despite its distance from the Atlantic Ocean (Corumbá Municipality 2005). Although cattle ranching in the Pantanal is still the mainstay of the economy, Pantanal shippers transport huge quantities of soybeans away from Mato Grosso. Shipping is costly and stimulates permanent pressure for works to improve navigability and economies in time and fuel. The project has been on hold since the mid-1990s, when non-governmental organizations raised a multitude of environmental and technical concerns (CEBRAC et al. 1994; EDF & CEBRAC 1997). In the meantime, agribusiness leaders have pushed forward on alternative land-based transport corridors.

The Pantanal is still mostly roadless, thanks to seasonal flooding. When the new BR 262 link from Campo Grande to Corumbá was completed in 1986, the old route through Porto Manga was given protected area status as a scenic parkway. Although the road is still used mostly by local ranch owners (L. Hasenclever, personal communication), it represents an interesting attempt to make redundant infrastructure into an environmental asset.

On the Drawing Board

In the mid-1990s, large projects along "development axes" were promoted without reference to conservation needs or compensation. These plans, called *Brasil em*

Ação (Brazil in Action) and later *Avança Brasil* (Advance Brazil), emphasized development in the Cerrado and Amazon biomes. Researchers such as Laurance et al. (2001) prophesied doom for the Amazon's forests if such plans become reality.

Today, the same projects are promoted under different procedures. The financing role, formerly played by a flush federal purse and the World Bank, is occupied by private-sector contractors, energy consumers, and regional development banks such as the Inter-American Development Bank and the Andean Development Corporation (Corporación Andina de Fomento [CAF]). Nationalist overtones are muted, international integration ascendant, and cooperative efforts between public and private entities the mechanism for getting projects done.

The $65 billion 2004–2007 Multiyear Plan (Plano Plurianual) guides Brazil's federal-level infrastructure spending (Secretaria de Planejamento e Investimentos Estratégicos et al. 2004). Two key concerns for conservation are evident in the plan. First, hydroelectric plants, waterways, transmission lines, and roads in Amazonia total US$6.7 billion for 2004–2007. They include extending the capacity of the Tucuruí Dam, construction of dams in Amapá (Bambú and Santo Antônio), Pará (Belo Monte), Tocantins (Estreito, Ipueiras, Peixe Angical and Salvador), and Rondônia (Jiraú, Rondon II and Santo Antônio), and feasibility studies for Belo Monte, Babaquara, São Luís do Tapajós and Cachoeira Porteira, all in the state of Pará. Brazil expects to spend US$1.9 billion on roads in four of the Amazonian states, Amazonas, Mato Grosso, Pará, and Rondônia from 2004–2007 (Secretaria de Planejamento e Investimentos Estratégicos et al. 2004). Second, infrastructure development is tied to promoting exports such as soybeans, minerals, metals, timber, and energy. Although the growth of these exports may be inevitable, real economic development— local improvement in standards of living and human productivity—may prove more evasive.

Current Approach to Environment-Infrastructure Conflicts

Brazil has already made important progress in addressing the environmental impacts of construction projects. Many legal instruments and policies have been revised or created since adoption of the 1988 Constitution, including (1) reformulation of the National Council for the Environment (Conselho Nacional do Meio Ambiente [CONAMA]); (2) establishment of the National Water Resources Policy (Política Nacional de Recursos Hídricos); and (3) passage of the 1998 Environmental Crimes Law (Lei de Crimes Ambientais), which establishes financial and other penalties for damaging the environment.

Environmental licensing, environmental compensation, and, to a lesser degree, fines are important regulatory instruments. Licensing involves completing an environmental impact assessment (EIA) and an environmental impact report (RIMA), a collection of generally qualitative information that is often of poor quality and questionable thoroughness, with no clear mechanism for influencing decisions (Fonseca 1995; Sousa et al. 2002). The EIA/RIMA process often fails to pinpoint important mitigation actions and is so slow that both developers and the environment suffer. Conflicts are often referred to state or federal environmental councils, which can lead to political, rather than technical, decisions. Government agencies also have a limited capacity to enforce mitigation requirements once a project does go ahead (e.g., Gribel 1993).

Environmental compensation made under extrajudicial agreements called "terms of conduct adjustment" are gaining ground. These deals were initially derided by environmentalists as small payments for the privilege of abusing the environment. Critics contended that the environmental programs created under this model did little to compensate for the real damages from major infrastructure projects. Reduced to the requirement of maintaining natural areas proportional in size to the degraded site, but not necessarily associated in any way with it, the terms of adjustment option has served to justify high-impact projects at a minimal cost to the investors. When compensation measures are approved, companies often protect the cheapest possible land regardless of its conservation value. No consensus has formed with regard to compensation. A CONAMA task force found that consistent standards and better control of the financial flows from compensation agreements are needed if this mechanism is to be successful (minutes of the second meeting of the Environmental Compensation Working Group available from http://www.mma.gov.br/port/conama).

Fines resulting from the Environmental Crimes Law have also had mixed results. Because the value of damage can exceed the value of a company's assets, these fines (the limit is R$50 million) offer some deterrence. Yet weak enforcement and the extensive appeals allowed under Brazil's judicial system attenuate the preventive value of the fines. It is estimated that only about 5% of the fines registered in the National Environment System have actually been paid; the rest are under appeal.

The expected costs (taking into account the probabilities of being caught, prosecuted, convicted, and made to pay) of committing a logging infraction in one part of the Atlantic Forest is equal to around 9% of profit that can be made by cheating, a figure that is probably not worse, and may be substantially better, than elsewhere in Brazil (Akella & Cannon 2004).

How to Do It Right

Unlike many countries, Brazil has great opportunities to pursue conservation and sensible infrastructure development, and could put forth a global model. Achieving that goal will take long-range planning that integrates biological and economic data, up-front investments in environmental mitigation and compensation, stronger enforcement, and more effective public participation.

Nature usually loses under the environmental mechanisms described previously, which are all oriented toward preventing and reducing harm on a project-by-project basis. Either the damage is done (fines), or the project characteristics—its site, scale, and technology—are fixed by the environmental licensing stage. Integration of the long-range planning work of the economic ministries with ambitious and scientifically grounded conservation planning within environmental agencies and private conservation organizations is needed. Overlapping these priorities will show where development projects should be avoided and where they can be built with favorable economic results and minimal damage.

The creation of a centralized database of potential infrastructure investments—ranked according to economic returns, environmental impacts, and social costs and benefits—will clarify for all sides where the greatest opportunities lie for high-return, low-impact infrastructure and where the most acute conflicts are likely to arise. A more data-intensive, in-depth approach to this objective is proposed in Sheng's (2004) review of methods for analyzing the development value and tradeoffs of various investment alternatives, with relaxed geographic and sectoral constraints.

Where projects requiring mitigation or compensation, or both, are approved, the environmental measures should be guaranteed before the first bucket of concrete is poured. Bahia's Ilhéus-Itacaré road, built in 1997, was one of the first to require a protected area as environmental mitigation (Reid & Bowles 1997). Although the park was decreed, it has yet to be implemented. Once the blacktop was complete, leverage quickly dissipated for the "required" conservation actions. The only sure way to avoid this sort of outcome is to require up-front compliance with environmental conditions or inclusion of an environmental agency with funding.

Finally, Brazilian citizens need to participate fully in major public investment decisions. In the last 15 years, nongovernmental organizations have acquired the technical capacity to comment on legal and scientific aspects of EIAs. Watershed committees are legally recognized mechanisms for public control over development, although many watersheds are still without committees or personnel with lack the technical capacity needed to make management decisions.

Public participation in the economic and financial aspects of infrastructure projects can be decisive, but is still inadequate because of the lack of access to economic information and the lack of economic expertise among civil society organizations. Although environmental impact information is now public as a matter of national legislation, economic information is still routinely kept secret, limiting oversight on whether public investments are efficient or whether economic gains are sufficient to justify environmental sacrifices.

Conclusion

Brazil has great potential to harmonize infrastructure development with nature conservation. Important intact areas remain in all biomes, particularly the Amazon. Yet there is great pressure to proceed with public works development under traditional, ineffective, project-by-project, environmental review procedures. Integrated planning of conservation and infrastructure can optimize Brazil's gains in both areas. Measures to make environmental mitigation stick and give the public a fuller, more reasoned say in decisions will go far toward enabling Brazil, and other countries, to develop sustainably.

Literature Cited

Akella, A. S., and J. B. Cannon. 2004. Strengthening the weakest links: strategies for improving the enforcement of environmental laws globally. Conservation International, Washington, D.C.

Bacon, R. W., J. E. Besant-Jones, and J. Heidarian. 1996. Estimating construction costs and schedules: experience with power generation projects in developing countries. Technical paper 325. World Bank, Washington, D.C.

Barros-H.,R. P. 2003. O futuro ameaçado do Cerrado brasileiro. Ciência Hoje **33:**34–39 (in Portuguese).

CEBRAC (Centro Brasileiro de Referência e Apoio Cultural), ICV (Instituto Centro de Vida), and World Wide Fund for Nature (WWF). 1994. Hidrovia Paraguai-Paraná: Quem paga a conta? CEBRAC, ICV, and WWF, Brasília (in Portuguese).

CODEVASF (Companhia de Desenvolvimento dos Vales do São Francisco e do Parnaíba). 2005. Realizações (in Portuguese). CODESVASF, Brasilia. Available from http://www.codevasf.gov.br/menu/empresa/realizacoes (accessed January 2005).

Corumbá Municipality. 2005. História de Corumbá (in Portuguese). Municipality of Corumbá, Brazil. Available from www.corumba.com.br/corumba/index.htm (accessed January 2005).

Dean, W. 1995. With broadax and firebrand: the destruction of the Brazilian Atlantic Forest. University of California Press, Berkeley.

EDF (Environmental Defense Fund) and CEBRAC (Centro Brasileiro de Referência e Apoio Cultural). 1997. O projeto de navegação da hidrovia Paraguai-Paraná. Relatório de uma análise independente. EDF, Washington, D.C., and CEBRAC, Brasília (in Portuguese).

Fearnside, P. M. 1995. Hydroelectric dams in the Amazon as sources of "greenhouse" gases. Environmental Conservation **22:**7–19.

Fearnside, P. M. 1997. Greenhouse-gas emissions from Amazonian hydroelectric reservoirs: the example of Brazil's Tucuruí dam as compared to fossil fuel alternatives. Environmental Conservation **24:**64–75.

Fonseca, I. A. Z. 1995. Uma revisão dos EIA/RIMA sobre manguezais. Master's thesis. University of São Paulo, São Paulo (in Portuguese).

Gribel, R. 1993. Os mamíferos silvestres e as grandes barragens na Amazônia. Pages 125–133 in Bases científicas para estratégias de preservação e desenvolvimento da Amazônia. Volume 2. Instituto Nacional de Pesquisa da Amazônia, Manaus, Brasil (in Portuguese).

Jablonski, S. 2003. Conservation priorities and the main causes of biodiversity loss of marine ecosystems. Pages 66–85 in C. Galindo-Leal and I. de Gusmão Câmara, editors. The Atlantic Forest of South America: biodiversity status, threats, and outlook. Center for Applied Biodiversity Science and Island Press, Washington, D.C.

Laurance, W. F., M. A. Cochrane, S. Bergen, P.M. Fearnside, P. Delamônica,

C. Barber, S. D'Angelo, and T. Fernandes. 2001. The future of the Brazilian Amazon. Science **291:**438–439.

McCully, P. 2001. Silenced rivers: the ecology and politics of large dams. Zed Books, London.

Nepstad, D., G. Carvalho, A. C. Barros, A. Alencar, J. P. Capobianco, J. Bishop, P. Moutinho, P. Lefebvre, and U. L. da Silva Jr. 2001. Road paving, fire regime feedbacks, and the future of Amazon forests. Forest Ecology and Management **5524:**1–13.

Pará IDESP (Instituto de Desenvolvimento Econômico-Social do Pará). 1991. Zoneamento ecológico-econômico do estado do Pará. Estudos Paraenses **1**(58). IDESP, Belém, Brasil (in Portuguese).

Pfaff, A. S. P. 1999. What drives deforestation in the Brazilian Amazon? Evidence from satellite and socioeconomic data. Journal of Environmental Economics and Management **37:**26–43.

Poole, A. 1999. The challenges and limits of large dams in Brazil. World Commission on Dams. Available from http://www.dams.org/kbase/submissions/showsub.php?rec = ins074 (accessed January 2005).

Pro-Cer (Cerrado Ecological Research Society) and WWF (World Wide Fund for Nature). 1995. De grão em grão, o Cerrado perde espaço. Pro-Cer and WWF, Brasília.

Reid, J., and I. Bowles. 1997. Reducing the impacts of roads on tropical forests. Environment **39:**11–13, 32–35.

Secretaria de Planejamento e Investimentos Estratégicos, Ministério de Planejamento, Orçamento e Gestão. 2004. Plano plurianual 2004–2007. Projeto de lei (in Portuguese). Secretaria de Planejamento e Investimentos Estratégicos, Ministério de Planejamento, Orçamento e Gestão, Brasília. Available from http://www.amazonia.org.br/arquivos/80804.pdf (accessed January 2005).

Schneider, R. R. 1994. Government and the economy on the Amazon frontier. Regional studies program report 34. Latin America and the Caribbean Technical Department, World Bank, Washington, D.C.

Sheng, F. 2004. Comprehensive assessment of development options. Conservation International, Washington, D.C.

Sousa Jr., W. C., P. Garcia, F. Mamede, M. Monteiro, P. Sinisgalli, A. K. Bueno Schlogle, and R. Seroa da Motta. 2002. Análise da viabilidade sócio-econômico-ambiental da transposição das águas da bacia do rio Tocantins para a bacia do rio São Francisco na região do Jalapão. Cadernos de política ambiental. Volume 1. Conservation International do Brasil, Brasília (in Portuguese).

Suassuna J. 2000. A transposição de águas do São Francisco poderá ocasionar um "processo vaga-lume" no sistema elétrico nordestino (in Portuguese). Fundação Joaquim Nabuco, Recife, Brasil. Available from http://www.fundaj.gov.br/docs/tropico/desat/vglume.html (accessed January 2005).

WCD (World Commission on Dams). 2000. Dams and development: a new framework for decision-making. Earthscan, London.