ENVIRONMENT AND DEVELOPMENT

Brazil's environmental leadership at risk

Mining and dams threaten protected areas

By **J. Ferreira*, L. E. O. C. Aragão, J. Barlow, P. Barreto, E. Berenguer, M. Bustamante, T. A. Gardner, A. C. Lees, A. Lima, J. Louzada, R. Pardini, L. Parry, C. A. Peres, P. S. Pompeu, M. Tabarelli, J. Zuanon**

POLICY

Over the past two decades, Brazil has emerged as an environmental leader, playing a prominent role in international fora such as the United Nations (UN) Conferences on Sustainable Development. The country has earned praise for the expansion of its protected area (PA) network and reductions in Amazon deforestation. Yet these successes are being compromised by development pressures and shifts in legislation. We highlight concerns for the newly elected government regarding development of major infrastructure and natural resource extraction projects in PAs and indigenous lands (ILs).

Brazil has the largest PA system of any country, covering nearly 2.2 Mkm^2 or 12.4% of the global total (*1*). This network helps conserve some of the most species-rich biomes on Earth and safeguard regionally and globally important ecosystem services [e.g., (*2*, *3*)]. Since 2008, Brazil has lost 12,400 km^2 of PAs due to degazetting and 31,700 km^2 due to downsizing, with an additional 21,000 km^2 threatened by proposals in the National Congress to downsize or degazette reserves in the Brazilian Amazon (*4*). Until now, unplanned agricultural expansion has been the greatest pressure on the environment, but new pressures are being exerted in response to rising demands for hydropower and mineral resources (see the chart). Hydropower accounts for 77% of Brazil's energy supply, while 70% of national potential, much of which is in the Amazon and Cerrado, remains untapped (*5*). The Brazilian government predicts that the majority of this latent capacity will need to be exploited by 2030 (*5*). Mining has grown from 1.6% of gross domestic product in 2000 to 4.1% in 2011; production is expected to further increase by a factor of 3 to 5 by 2030 (*6*).

Brazil has made concerted efforts to create a political and legislative framework supportive of mining and energy sectors. This includes strategic plans and draft legislation (PL 1610/96) to develop new mines in sustainable use reserves and ILs (*5*, *6*). Legislation being debated in the Congress (PL 3682/2012) calls for 10% of even strictly protected areas to open for mining concessions, and general prohibition of new PAs in areas of high mineral or hydropower potential.

Our analysis indicates that across Brazil there are 1.65 Mkm^2 of land with some form of registered mining interest; 1.01 Mkm^2 are in Amazonia (chart, A). While relatively few areas have been physically cleared for mining, at least 20% of all strictly protected areas and ILs overlap with areas registered as under consideration for mining (chart, B), demonstrating the potential for widespread effects if only a small fraction is authorized (chart, D and E). In the Amazon alone some 34,117 km^2 of strictly protected areas (8.3% of their total area) and 281,443 km^2 of ILs (28.4% of the total) lie in areas of registered interest for mining. Few PAs are free from the influence of large hydroelectric dams (chart, C).

This analysis raises four key issues. First, the existing PA network plays a critical role in conserving Brazil's ecosystems, counter to claims that PAs fail to serve their intended function. Second, there is potential for lasting environmental damage from direct, indirect, and cumulative effects associated with many large-scale development projects. Third, environmental mitigation policies are poorly conceived, fall short of international minimum standards for mitigation, and are unlikely to succeed. Finally, systematic inconsistencies and contradictions in the political process, if left unresolved, will undermine the credibility, effectiveness, and transparency of Brazil's PA system and ILs.

Brazil's new government should not squander the country's hard-won environmental leadership.

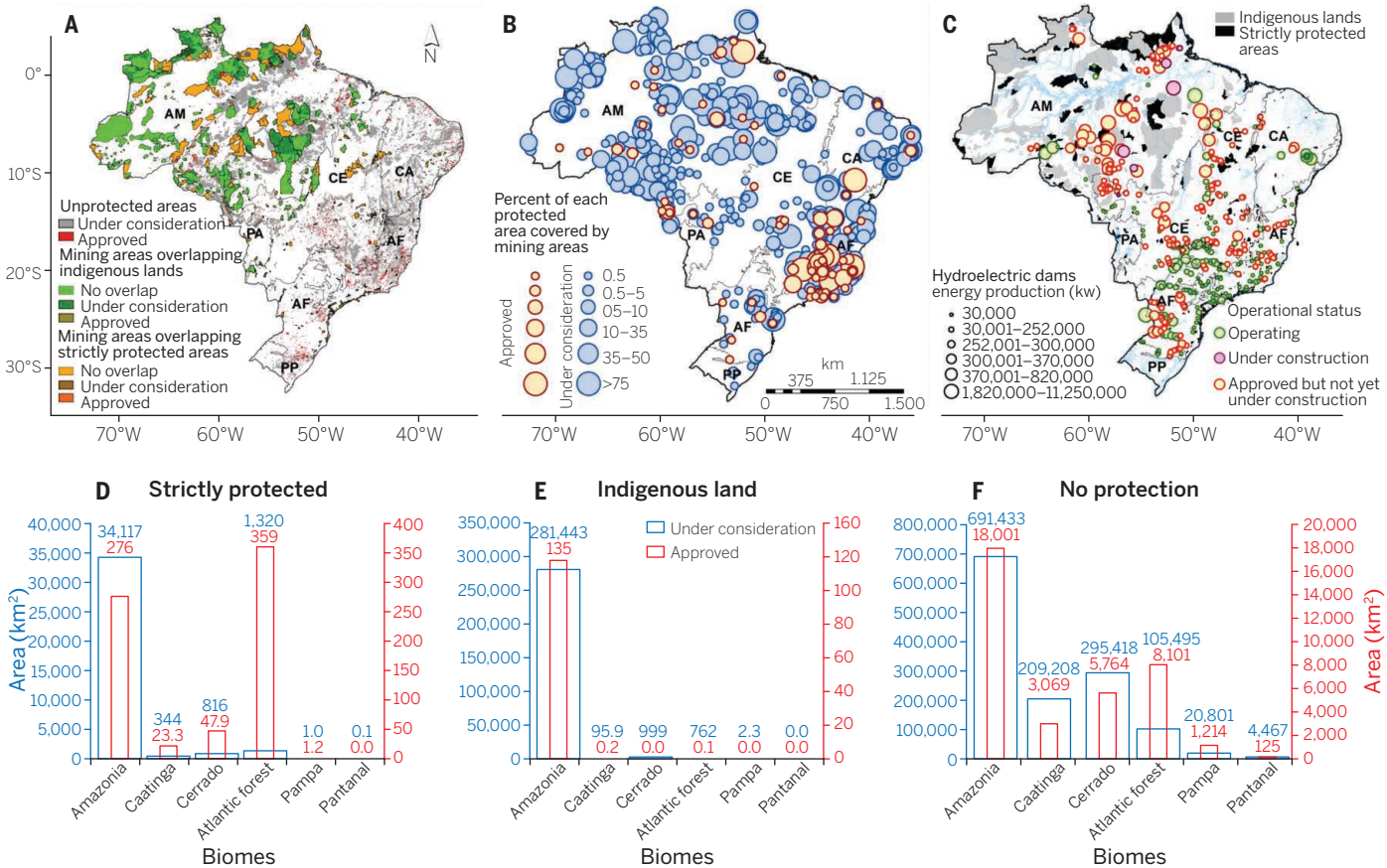
Politicians who support industrial development within PAs argue that many PAs only "lock away" mineral reserves and are nothing more than poorly managed "paper parks," often embroiled in chronic land tenure disputes. Many Brazilian PAs are understaffed, yet there is strong and growing evidence of their key role in conserving Brazilian ecosystems. For instance, the probability of deforestation is 7 to 10 times lower in Amazonian PAs than in surrounding areas (*7*).

Environmental effects of large-scale mining and hydropower within PAs are likely to be multiple and severe. Localized, direct effects can be particularly destructive within hyperfragmented Cerrado and Atlantic Forest biomes, where further loss or degradation of native vegetation could undermine opportunities to restore ecological connectivity and prevent extinctions (*8*). Yet direct local effects of development within PAs may be eclipsed by indirect environmental effects likely to ensue in surrounding regions over decadal time scales, such as increased deforestation, illegal logging, overhunting, and forest fires. Large-scale in-migration of labor and subsequent infrastructure and population growth in new development areas can open up "internal" deforestation frontiers in hitherto relatively undisturbed regions.

Current proposals (e.g., PL 3682/2012) for mitigating environmental damage caused by extractive activities within PAs are inadequate, poorly conceived, and fail to meet international best-practice standards prescribed by the basic mitigation hierarchy: avoid; minimize; mitigate; offset [for example, (*9*)]. In presuming that extraction can be authorized within PAs, the first mitigation option—avoid effects—is discarded. The assumption that there are no "no-go" areas for development could result in irreversible environmental damage.

Mitigation actions can provide substantial conservation benefits relative to a business-as-usual "no mitigation" development scenario (*10*). But mitigation actions for large development projects in Brazil are rarely designed before project approval and initiation and may never be implemented (*11*). Restoration is often viewed as a magic wand, yet there is little evidence that we can restore complex natural ecosystems after large-scale mining (*12*). Mitigation and restoration efforts rarely address indirect and cumulative effects. Recognizing that environmental effects cannot be fully mitigated on-site, proposed legislation to open up to 10% of strictly protected areas for mining recommends that offset areas be twice the size of affected areas (PL 3682/2012). Applying biodiversity offsets here is, at best, inappropriate. Although a case can be made to use offsets to enhance protection of threatened PAs to compensate

See the supplementary materials for author affiliations.
**E-mail: joice.ferreira@embrapa.br*



Distribution of municipal, state, and federal strictly protected areas, indigenous lands, approved mining concessions, areas of registered mining interest, and approved hydroelectric dams in Brazil (A and C). Areas officially approved as mining concessions and publicly registered as under consideration for extraction are compared against the distribution of all strictly protected areas (**D**), ILs (**E**), and unprotected areas (**F**), in addition to the percentage of overlap between all protected areas and approved mining concessions and areas of registered mining interest (**B**). See the supplementary materials for details.

for environmental damage elsewhere, it is counterintuitive to expect that protection elsewhere can compensate, on an ecological like-for-like basis, for effects on PAs. PAs established in part on criteria of vulnerability and irreplaceability may be too risky or impossible to offset (*13*), as is increasingly the case in the most deforested areas of Brazil.

Brazil's National System of Protected Areas was established in 2000 after more than a decade of debate in the Congress, building on public consultation across society and academia and representing a major contribution toward Brazil's international environmental commitments, including UN Conventions on Biological Diversity and Climate Change. In contrast, the process of dismantling PAs to allow industrial development has paid little regard to criticism from Brazilian society, exemplified by a recent campaign in defense of Brazilian PAs by the federal Public Prosecutor's Office. To be credible and fair, any attempt to change and downgrade this legislation should involve the same level of public consultation and democratic due process.

Beyond conservation and stewardship of its own biodiversity and environmental resources, Brazil has a vital role in motivating and supporting adoption of more sustainable development trajectories around the world. Yet, the integrity of Brazil's ecosystems and the credibility of its environmental leadership are jeopardized by recent shifts toward weaker and poorly negotiated environmental safeguards in the national PA system and ILs. This is consistent with recent changes in Brazil's Forest Code, which include an amnesty for large areas that were illegally deforested in the past (*14*). Although there are often strong economic and ethical arguments for development, Brazil should not squander its hard-won record of success and leadership in favor of fast-tracking short-lived development projects that leave a long legacy of environmental damage. We call on Brazil's newly elected government to ensure that individual development initiatives are subject to a comprehensive, socially inclusive, and long-term cost-benefit analysis that allows for any new proposal to be compared against possible alternatives and that takes full account of environmental and social effects, including rights of traditional and indigenous peoples. ■

REFERENCES

1. WDPA, 2012. World Database on Protected Areas. Database accessed in June 2014 from www.protectedplanet.net.
2. A. Veríssimo *et al.*, "Protected areas in the Brazilian Amazon: Challenges and Opportunities" (Imazon, Belém, Brazil; Instituto Socioambiental (ISA), Sao Paulo, Brazil, 2011)
3. D. V. Spracklen *et al.*, *Nature* **489**, 282 (2012).
4. E. Bernard *et al.*, *Conserv. Biol.* **28**, 939 (2014).
5. Brasil Ministério de Minas e Energia (MME), *Plano Nacional de Energia 2030* (MME, Rio de Janeiro, 2007).
6. Brasil Ministério de Minas e Energia (MME), *Plano Nacional de Mineração 2030* (MME, Rio de Janeiro, 2010).
7. T. H. Ricketts *et al.*, *PLOS Biol.* **8**, e1000331 (2010).
8. F. P. L. Melo *et al.*, *Trends Ecol. Evol.* **28**, 462 (2013).
9. Business and Biodiversity Offsets Programme (BBOP), *Guidance Notes to the Standard on Biodiversity Offsets* (BBOP, Forest Trends, Washington, DC, 2012).
10. A. Villarroya *et al.*, *PLOS ONE* **9**, e107144 (2014).
11. P. M. Fearnside, *Environ. Sci. Policy* **38**, 164 (2014).
12. M. Maron *et al.*, *Biol. Conserv.* **155**, 141 (2012).
13. J. D. Pilgrim *et al.*, *Conserv. Lett.* **6**, 376 (2013).
14. B. Soares-Filho *et al.*, *Science* **344**, 363 (2014).

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SUPPLEMENTARY MATERIALS

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