

Introduction

Brazil, conservatively estimated to contain more than 13% of the world's biota (Lewinsohn & Prado; citations without a year are papers in this special section), inspired the concept of a megadiverse country (Mittermeier et al. 1997). Indeed, with five major biomes and the largest river system in the world, Brazil arguably contains the largest continental biota on Earth. Although Brazil's biodiversity is impressive, the papers in the following section indicate that it is undoubtedly much greater than we currently know. The Amazon Basin, responsible for most of Brazil's terrestrial and freshwater biodiversity, sustains about 40% of the world's remaining tropical rainforest (Peres). Brazil also contains two global biodiversity hotspots (the Cerrado and the Atlantic Forest) and the world's largest tropical wetland (the Pantanal). It is the world's fifth largest country and the largest among tropical countries, with a territory of 8,514,877 km² and jurisdiction over 3.5 million km² of coastal waters. Brazil is home to more than 183 million people and currently represents the eleventh largest world economy.

In this special section on Brazilian conservation, prepared to mark the XIX meeting of the Society for Conservation Biology in Brasília, a number of specialists—most residing in Brazil—highlight issues that reflect on what will and will not be conserved in the coming decades and discuss the country's conservation challenges and opportunities. Perhaps the best news, described by Mittermeier et al. and others in this collection, is that a strong, capable, and growing science base now exists in Brazil, exceeding that of virtually every other tropical country. Brazil's capacity for research across a multitude of disciplines that touch on conservation is substantial, and Brazilians are also strong participants in conservation science at the international level. This capacity emerged mostly in the last two decades from rather incipient beginnings, demonstrating the value of investing in academic programs and training in developing countries. The worst news, on the other hand, is the scale of the remaining challenges, especially in the face of Brazil's longstanding quest for national integration, economic growth, and poverty reduction.

Although these papers focus on Brazil, they highlight many of the key challenges and opportunities more generally associated with conservation in the tropics. The presidents of Brazil and Peru reached an agreement in December 2004 to construct the Transoceanic Highway, stretching from the Atlantic coast of Brazil across the Amazon and Andes through some of Peru's most biologically diverse virgin rainforests to Peru's Pacific ports. Barring

focused intervention, the highway will forever change the lives of millions of people whose communities lie near its proposed route. The interests of uncontacted indigenous groups, prostitutes, loggers, small peasant farmers, cattle ranchers, and soy producers will converge on a likely unsustainable path. The highway will also have global impacts—global prices for tofu, beef, and cattle feed will go down, and the increased burning of Amazonian forests will likely push Brazil above its current rank as the world's eighth largest producer of greenhouse gas emissions. The highway's likely impact on carbon emissions is particularly troubling in light of data from the Brazilian Institute for the Environment (IBAMA), which show a 36% increase in forest fires in 2004 compared with 2003 in the state of Mato Grosso (Amigos da Terra-Amazônia Brasileira 2005).

The What, Where, and How of Conservation in Brazil

In this special section, introductory essays are followed by papers on the what, where, and how of conservation in Brazil. This organizational structure demonstrates our view that the "what" and the "where" are components of conservation that more clearly lie within the biological and ecological sciences, whereas the "how" is largely rooted in human dimensions and social sciences. The first three articles give a very brief overview of the history, context, and status of conservation. Mittermeier et al. highlight many of the influential individuals and projects that have significantly affected conservation in Brazil and discuss the distinctive characteristics of Brazilian conservation efforts. The past and present of Brazilian protected areas is the theme of the next two articles: Marina Silva, the current Minister of the Environment of Brazil, provides a government perspective on the accomplishments of the Lula administration in terms of protected area creation and ongoing consolidation, a task that has been at the forefront of the country's conservation efforts for the last two decades. Rylands and Brandon focus on the evolution of the protected area system.

The next eight papers cover several issues related to species conservation in Brazil. The first addresses the question "How Many Species Are There in Brazil?" (Lewinsohn & Prado). The next seven describe the state of knowledge, threats, conservation status, and habitat assessment for plants (Giulietti et al.), terrestrial invertebrates (Lewinsohn et al.), biodiversity in inland waters (Agostinho et al.), amphibians (Silvano & Segalla),



Figure 1. Major biomes of Brazil, based on the terrestrial ecoregions defined by Dinerstein et al. (1995). Additional data from DCW (Digital Chart of the World).

reptiles (Rodrigues), birds (Marini & Garcia), and mammals (Costa et al.). These articles underscore the global prominence of Brazil's biodiversity, highlighting, for instance, the country's remarkable mammal (more than 530 described species), plant (60,000 species), and amphibian (765 species) diversity.

Brazil has five main biomes (Fig. 1), along with marine and coastal areas. But Brazil is better known internationally for the plight of the Amazon, discussed in the articles dealing with the biogeography and overall patterns of Amazonian endemism (Silva et al.), the dynamics of deforestation in the Amazon (Fearnside), and the need to expand the scale of conservation efforts and extent of parks and reserves there (Peres).

The subsequent articles focus on the biomes where human impacts have been greatest. The Atlantic Forest, addressed by Tabarelli et al., is a tropical rainforest hotspot with high levels of endemism that is highly fragmented by agriculture and urban centers, such as Rio de Janeiro and São Paulo. The Caatinga—a mosaic of thorn scrub and seasonally dry forests (Leal et al.)—has relatively lower endemism but has not yet reached the high levels of degradation in the Atlantic Forest and Cerrado.

The Cerrado, the other Brazilian hotspot, is the world's richest savannah in botanical diversity and harbors many endemic plant, bird, fish, reptile, amphibian, and insect

species (Klink & Machado). The Pantanal lowlands contain the richest wetland avifauna in the world (Harris et al.).

Brazil also has 7637 km of coastline, which harbor a huge coastal and marine flora and fauna. With extensive estuaries, coastal lagoons, and mangrove forests, more than 3000 km of coral reef ecosystems, and a benthos crossing tropical, subtropical, and temperate marine environments, Brazil faces marine conservation challenges that are becoming significant (Amaral & Jablonski). The final group of articles deals specifically with the challenges and opportunities for conservation in Brazil, which we summarize briefly in the paragraphs that follow.

First, despite an increasing level of understanding of Brazilian biodiversity, many important knowledge gaps remain to be addressed if science is to have a positive influence on conservation action. Virtually all the articles in the species and biome sections stress the limits of existing information on the natural history, ecology, and habitats of the majority of currently recognized species. For example, in Brazil 7 new primate species and 18 new bird species were described in the last 10 and 12 years, respectively. Lewinsohn and Prado note that we can expect impressive numbers of species belonging to less conspicuous taxonomic groups to be found and described in the coming decades as a result of intensified field surveys.

The description of new taxa is essential, but beyond that, adequate information on the geographic distribution of most species remains scant. Agostinho et al. discuss the need to assess freshwater biodiversity in protected areas (largely established for terrestrial biodiversity) and carry out surveys of the diversity and distribution of freshwater species. The degree of knowledge across taxa, habitats, and biomes is heterogeneous. Peres provides an excellent summary of priority areas for additional research in the Amazon. Conservation action may be best informed by increasing research focused on the invertebrates of the Caatinga and the Pantanal, whereas a better understanding of plant diversity and distribution will help pinpoint priorities for conservation in the Cerrado.

A megadiverse nation such as Brazil will always be fertile territory for biodiversity research, but because conservation action is urgently needed, strategic studies must be prioritized and implemented soon. One particular route is to increase our understanding of the groups about which our knowledge, while improving, remains fragmented (i.e., vertebrates and plants), thereby making it easier to refine priorities for habitat protection. For example, the results of the recently completed Global Amphibian Assessment can be used to help identify key biodiversity areas (Eken et al. 2004; Stuart et al. 2004). Furthermore, a relatively modest investment in making more accessible the existing information on selected invertebrate groups, such as Lepidoptera and Odonata, would go a long way toward complementing analysis of species priorities drawing on vertebrate data. It is also likely that the type and depth of study needed in some areas will vary substantially. For example, the Amazon, the Atlantic Forest, and the Cerrado need more research oriented toward biodiversity and biogeography. In contrast, in the Pantanal and Caatinga, we need to better understand ecosystem functioning to instruct site management.

There have been at least five major exercises that examined areas of biological relevance spanning all Brazilian biomes and the marine realm, but it is still necessary to prioritize the areas based on level of threat and overall irreplaceability (Rodrigues et al. 2004). Brazil has recently committed, through the Convention on Biological Diversity, to build a comprehensive terrestrial system of protected areas by 2010 and a marine system by 2012. Although much progress has been made in this arena (Rylands & Brandon), many gaps remain in the current system that need particular attention. This, in turn, will require targeted investment in biogeographic research on threatened and other species of conservation concern.

Second, the level of threat to species and ecosystems is considerable and rising. Most of the articles in this series paint a sobering picture of the level of threat for known species and their habitats. The direct ecological impacts (e.g., habitat destruction, fragmentation, or disturbance; resource depletion; alteration of fire regimes;

modification of water regimes; contamination) are the result of the common litany of threats (e.g., large-scale development and infrastructure; land conversion; energy and mining; unsustainable human uses; pollution; urbanization; tourism) resulting from the same root causes of biodiversity loss throughout much of the tropics. These problems are not unique to Brazil.

The threat across biomes is highly heterogeneous. Fearnside discusses deforestation in the Amazon, putting into perspective media reports that have made annual losses of forest equivalent to, say, the size of Belgium, seem banal. In contrast, Fearnside observes that, although still a wilderness, the current level of threat to the Amazon now allows us to construct plausible future scenarios ranging from significant forest degradation to massive deforestation. Patterns of deforestation also reflect differently on biodiversity conservation targets because the Amazon is increasingly understood not as a homogeneous unbroken forest surrounding a great river, but as comprising at least eight distinct areas of endemism segregated by major rivers that in turn are made up of hundreds of other significant water courses that have functioned as engines of speciation (Silva et al.).

Other biomes are facing significant challenges as well. Although estimates vary, human alteration of the Caatinga is between 30.4% and 51.7%, and what remains is highly fragmented (Leal et al.). Inappropriate land uses have led to a desertification that is currently threatening 15% of the region and will likely drive the subsistence farmers who live throughout the region into new, previously unfarmed areas. More than half of the Cerrado (1 million km²) has been transformed into pasture and cash crops in the past 35 years, with large-scale agricultural conversion for soy and cattle remaining the biggest threat (Klink & Machado). Although the Pantanal has been affected by substantial alteration of adjoining areas, the greatest threats are now habitat clearing and introduction of exotic grasses—estimated to have affected 40% of the forest and savanna habitats (Harris et al.). Finally, the Atlantic Forest epitomizes the biodiversity hotspot concept—a region of very high biodiversity that is under extreme threat. Only 7% of the forest remains as isolated fragments (Tabarelli et al.) in a region where 40% of the 20,000 plant species are endemic.

Although the levels of threat and their proximate causes are addressed primarily in the species and biome articles, many of the other papers discuss some of the ultimate causes of foreseeable biodiversity loss. The future of conservation in Brazil will largely depend on how these are resolved. Fearnside describes the underlying forces that impel Amazonian deforestation—especially government policies related to taxation, credit, subsidies, land tenure, and settlement; lack of intergovernmental coordination; and the way international agreements and treaties are structured. The articles by Schwartzman and

Zimmerman, Silva et al., and Peres highlight the role, and the necessity, of maintaining very large and complementary reserves for indigenous peoples and for strict biodiversity protection. Some commentators have recently depicted these models as polar extremes, when in fact they are mutually reinforcing and together can bring about large-scale conservation results. For instance, indigenous reserves, beyond their own intrinsic contribution to conservation objectives, can act as buffers to intrusion into strictly protected areas. Conversely, these strict reserves can help maintain ecosystem services and serve as sources of wildlife populations used by Amerindians. In the Amazonian context there are compelling arguments for these kinds of strategies because the region vitally needs megareserves to ensure long-term conservation (Peres). The arguments are examined in detail by Tabarelli and Gascon, who address the consequences of habitat fragmentation, perhaps the most insidious of threats in the biodiversity-rich tropics after outright land conversion.

Underlying most habitat conversion are public policies supporting transportation, energy, and communications infrastructure that open areas for conversion, colonization, and other uses. Brazil has billions of dollars of public works projects on the drawing board. Reid and Sousa discuss whether and how they could be implemented. The specter of new areas being opened and the rush of landless peasants to claim them is real. Owners of large- and medium-sized ranches are currently responsible for 70% of Amazonian land clearing (Fearnside). But with numbers estimated to be in the millions, Brazil's landless peasants could become a significant threat to the Amazon. Cullen et al. demonstrate how land invasions can be at odds with conservation goals in the absence of rural land-use planning. The decline in resources for conservation, tied to a heavy dependence on the public sector and reduced foreign aid, is described by Young.

Despite the challenges, the gaps in knowledge, and the high degree of threat facing all biomes in the country, a sense of opportunity emerges from most of the papers in the special section. As noted by Fearnside, "One of the greatest impediments to effective action is fatalism. Fatalism acts as a deterrent to taking action that involves commitment of substantial financial resources and the acceptance of perceived or real political risks." Opportunities for countering this fatalism are described next.

Third, opportunity abounds to identify creative solutions to threats and to build on the areas where Brazil has shown leadership. Although many of the authors in this special section point to the generally high levels of threat to biodiversity in Brazil, they also provide numerous reasons for cautious optimism provided Brazilian decision makers make choices that favor environmental and economic sustainability over short-term gains. Mittermeier et al. briefly summarize some of Brazil's conservation his-

tory and highlight the factors that set it apart from other megadiverse countries, including a strong capacity for conservation science, a strong and capable network of nongovernmental organizations (NGOs) with good links to science and government, and a promising program of species protection. These trends are reinforced by decisive action in the expansion of the protected areas systems mentioned in Rylands and Brandon and especially in the commentary by Minister Marina Silva. Park creation at federal, state, and municipal levels is inspiring. For example, the state of Amapá has recently committed to establishing a biodiversity corridor that spans 10 million ha, including within it the largest tropical forest protected area in the world, the Tumucumaque Mountains National Park, with 3,882,376 ha.

The level of optimism of the contributing authors toward conservation in Brazil depends on their area of focus. For those dealing with species conservation, Brazil's megadiversity is easily overwhelming because analyses must be based on limited knowledge about the taxonomic status and distribution of species and the degree of threat in the wild. In contrast, authors focusing on biomes are generally more positive in outlook because of various priority-setting activities that have been carried out recently. These have provided a firmer baseline for measuring conservation progress.

Conservation opportunities and actions often arise when a crisis is apparent (Brandon 1998; Tabarelli & Gascon). Until recently, the Atlantic Forest was a place where the odds of conservation success appeared low: widespread deforestation and severe habitat alteration and fragmentation had led to the highest concentration of threatened species in the country. But many areas are now on the track to recovery, species-level priorities can in most cases be pinpointed to the site level, and consciousness of the problem has become widespread across different sectors of society. Initiatives are being executed at multiple scales, supported by public policies, NGOs, and, in some cases, even within the politically influential landless movement. Institutional capacity is growing and multiple sectors have become increasingly willing to collaborate. In an unanticipated turn of events, the Atlantic Forest, the biome that was once in the direst of conditions, might be the one with the strongest and most supportive context for the future.

The outlook is hopeful in other biomes as well. Both the institutional structures and the conservation initiatives in the Atlantic Forest are providing a template for how to proceed in the Caatinga. Strong working relationships among NGOs and between NGOs and the Ministry of Environment have led to research, a working group, and recommendations for urgent actions for conservation in the Cerrado (Klink & Machado). The situation in the Pantanal hangs largely in the balance of decisions to be made on infrastructure (Harris et al.). The conservation

prospects of previously overlooked taxa are also improving. For instance, a recent decree listed a number of aquatic invertebrates and fishes as endangered, overexploited, or threatened with overexploitation (Normative Decree No. 5, 21 May 2004, Brazilian Ministry of the Environment). Catching threatened species is prohibited, and the decree instructs that recovery plans be developed and implemented for all species listed.

The papers on Brazil's conservation challenges and opportunities all highlight proactive actions—most, but not all, in the public sector. Although Brazil has recently done a better job than many other countries in supporting indigenous peoples and their territories, substantially more work remains. Schwartzman and Zimmerman demonstrate the rationale for conservationists' increasing their support for indigenous reserves and territories, in particular, by helping identify ways ecosystem services can be valued and indigenous peoples compensated for the protection of their territories and wildlife resources. Cullen et al. explore how conservation organizations and the landless movement can work together to influence public policy by identifying land that will best support small-scale agriculture, generate employment, conserve habitat, and provide connectivity between forest fragments.

In terms of conservation, Brazil has a number of things going for it, but it is vitally important that the country's links between science and policy be strengthened (Tabarelli & Gascon). Many of the papers in this series highlight Brazil's strength in conservation science. In July 2005, Brazil is hosting not only the international meeting of the Society for Conservation Biology, but also the meeting of the Association of Tropical Biology and Conservation. These complement well-attended regular meetings of Brazilian scientific societies, such as the Brazilian Society of Ornithology, the Brazilian Society of Mastozoology, the Brazilian Society of Primatology, the Brazilian Society of Zoology, the Brazilian Society of Herpetology, the Brazilian Society of Limnology, and the Brazilian Society of Ecology. In most cases these meetings include between 500 and 1000 participants, mostly students or young professionals, which attests to Brazil's growing scientific and conservation response capacity. The same phenomenon has yet to develop for the social sciences in Brazil as they relate to environmental issues, but hopeful signs exist, such as the growing Brazilian Society for Ecological Economics. The challenge will be to transfer the outcomes of this science to the arena of public policy. Several papers, especially those by Silva et al. and Mittermeier et al., identify an emerging generation of conservation leaders in Brazil who are open to new ideas. Young notes that some local leaders have been willing to try new mechanisms of financing conservation, such as economic instruments for environmental management, project compensation funds, tax incentives, and tradable development rights. This has helped make Brazil one of the most innovative countries in the world for conservation finance.

The exuberant and inspiring pace of park creation, the large size of some of the newest areas created, the use of science in driving the expansion of the protected areas system, and the awareness of the need for landscape-scale action to complement protected areas strategies will all be put to the test by the government's willingness, beyond the Ministry of the Environment, to embrace a greener agenda, particularly with regard to infrastructure development and agriculture policies. Large areas remain intact in all biomes, and it is possible to "harmonize infrastructure development with nature conservation" (Reid & Sousa). Maybe we should start trusting some hopeful signs, such as Brazil's recent eleventh-place global ranking in the 2005 Environmental Sustainability Index (Esty et al. 2005). Brazil was ranked above the average score for its gross national product, which can largely be attributed to increased local capacity and to aggressive programs to combat illegal logging.

Brazil is the birthplace of the Convention on Biological Diversity, the major accomplishment of the 1992 Earth Summit in Rio, the largest gathering of heads of states in modern history. Its prominence in the global conservation agenda as a top megadiverse country and its emerging comparative advantage in scientific capacity, coupled with immense challenges going forward, make Brazil a fertile test bed for innovative conservation strategies. Brazil has an upcoming opportunity to regain leadership in global biodiversity by using the capacity it has built over the past 13 years to increase its commitment to conservation and sustainable development. This opportunity is represented by Brazil's hosting of the eighth Meeting of the Conference of the Parties to the Convention on Biological Diversity, 8–19 May 2006. Conservation science can play a major role in orienting these potential new commitments.

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