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Temporal and spatial investments in the protected area network of a megadiverse country

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ABSTRACT. Protected area networks are the cornerstone strategy for biodiversity conservation worldwide. They are efficient even in the face of human pressures. Brazil is a megadiverse country and for this reason it should not be left out of discussions on biodiversity conservation. Here we present a temporal and spatial analysis of the historical national investments in the country's protected area network. We compare this investment in the light of international biodiversity agreements (e.g., CBD), and evaluate trends and biases in the establishment of protected areas. We obtained the following data from a database maintained by the Brazilian government: the number of protected areas, the dates when they were established, their size and category (strict protection or sustainable use). Our results show that Brazil does not meet the recommended international levels of protection, that its network coverage favors a few of its biomes only, and that the temporal flow of investments has varied greatly. Even though there is a tendency for an increase in the establishment of protected areas, there has been a noteworthy change in the categories more recent protected areas are inserted. Until the 1980's the network was comprised mostly of strict protection sites, whereas the newly created sites are mostly intended for sustainable use. This reflects a serious philosophical and practical change in the role of the national protected area network, and may affect its objectives in preserving the biodiversity of a country that plays a key role in the global biodiversity conservation scenario.

KEY WORDS. Biodiversity; Brazil; conservation; policy.

The world has entered into a phase of mass extinctions (Myers 1990), and up to 50% of its species are predicted to be lost in the next 50 years (Pimm & Raven 2000, Thomas *et al.* 2004). Rapid population declines and extinctions following the widespread destruction of natural habitats have been reported across the globe (Brook *et al.* 2003). Humans have altered roughly half of the habitable surface of the Earth, impairing and destroying several ecosystems (Daily 1995). The majority of the species that have not gone extinct yet will either lose populations, or will experience a decrease in their geographical range (e.g., Ceballos & Ehrlich 2002).

The establishment and effective management of comprehensive protected-area networks is vital for the protection of biodiversity (Pimm *et al.* 1995, Bruner *et al.* 2001, Balmford *et al.* 2002, Rodrigues *et al.* 2004a, b). Historically, protected areas have been the backbone of biodiversity conservation actions and strategies (Rodrigues *et al.* 2004a, b, Chape *et al.* 2005, Loucks *et al.* 2008), and they are effective even in the face of anthropogenic pressures (Bruner *et al.* 2001). According to the Convention on Biological Diversity, at least 17% of the world's terrestrial ecosystems should be conserved through effective protected area networks (CBD 2010). In the last three decades, there has been an increase in the establishment of protected areas around the world (Zimmerer *et al.* 2004, Naughton-Treves *et al.* 2005, Jenkins & Joppa 2009, WDPA 2012), and the total terrestrial area protected has increased from approximately 3.5% in 1985 (Zimmerer *et al.* 2004) to approximately 12.2% in 2008 (WDPA 2012).

Brazil has three Wilderness Areas (Mittermeier *et al.* 2003a, b) and two Biodiversity Hotspots (Myers *et al.* 2000, Mittermeier *et al.* 2005a) within its borders, and it harbors approximately 14% of the world's known biota (Lewinsohn & Prado 2005). Therefore, it is no surprise that it is listed as a megadiverse country (Mittermeier *et al.* 2005b) and it is always in the forefront of global biodiversity issues. Brazil alone is responsible for the great majority (approximately 75%) of new protected areas created since 2003 (Jenkins & Joppa 2009). Given the country's importance in the biodiversity scenario and its global leadership in the establishment of protected areas, our objective is to analyze Brazil's temporal and spatial investments on a nationally protected area network. More specifically, we want to identify biases and trends in the coverage and establishment of protected areas, and help guide future decisions to maximize the representation and preservation of the country's biodiversity. To achieve this goal we will address the following issues: 1) what is the temporal and spatial investment of the

Brazilian government in the establishment of protected areas? 2) Are there differences in investments between strict protection and sustainable use protected areas in Brazil?

MATERIAL AND METHODS

Brazil has a national agency responsible for the national protected areas network (Instituto Chico Mendes de Proteção a Biodiversidade). This agency manages a database on the nationally protected areas (ICMBio 2012). Using it, we compiled the following data for each protected area: 1) year it was created; 2) total area; 3) classification of its terrestrial biome (Amazon, Atlantic Forest, Caatinga, Cerrado, Pampa and Pantanal); and 4) management category (strict protection or sustainable use). We analyzed the temporal establishment of protected areas (both in number and in total area) countrywide and on a biome level per decade, according to the date each protected area was created. We also included analyses separating the protected areas among their management categories in order to evaluate if there is a temporal or spatial difference in the allocation of national resources among these categories of use, which would reflect a philosophical/strategic societal change on the role of protected areas within the country's development strategies.

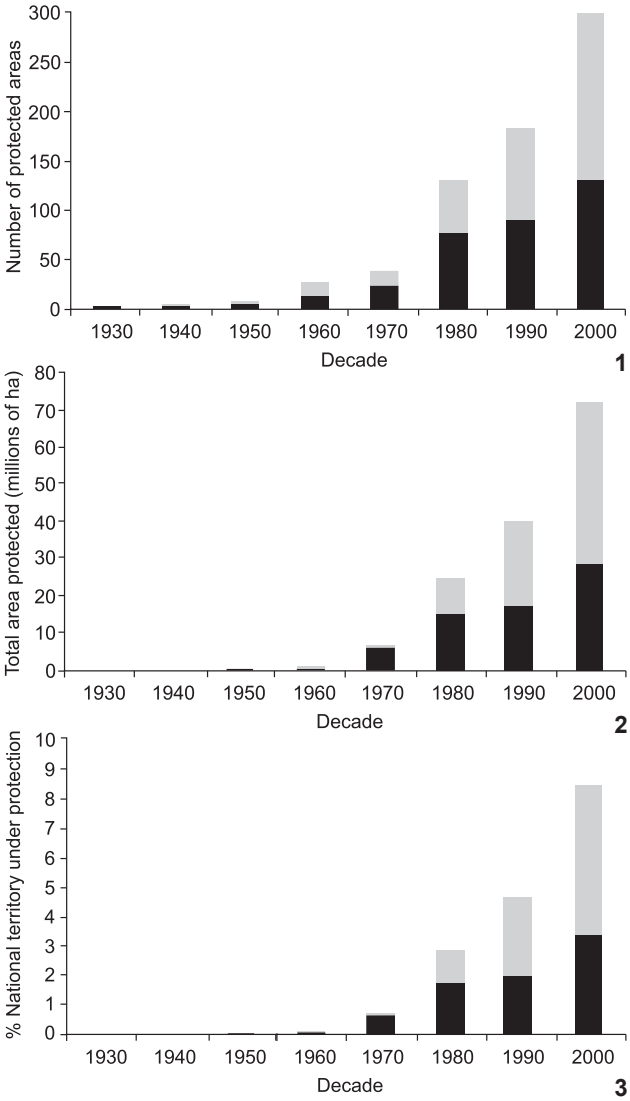
RESULTS

National-level investments in protected areas

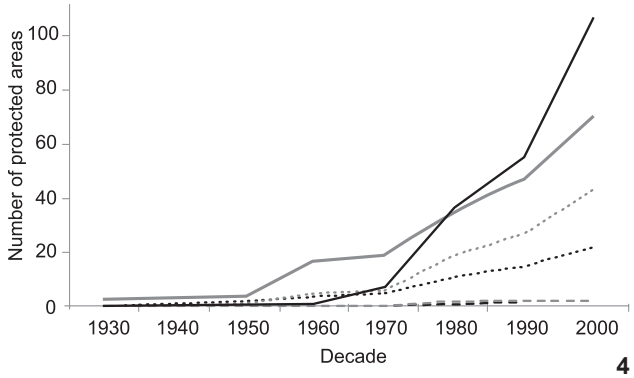
Brazil has 300 national protected areas (Fig. 1), protecting a total of 73,211,483 ha (Fig. 2), covering 9.1% of the country's territory (Fig. 3). The first protected areas in Brazil were created in the 1930's, but the investment in the national network was timid until the 1960's, both in number of sites and in total area under protection (Figs 1 and 2). From the 1970's on, we observed a marked increase in the creation and implementation of protected areas. (Fig. 1).

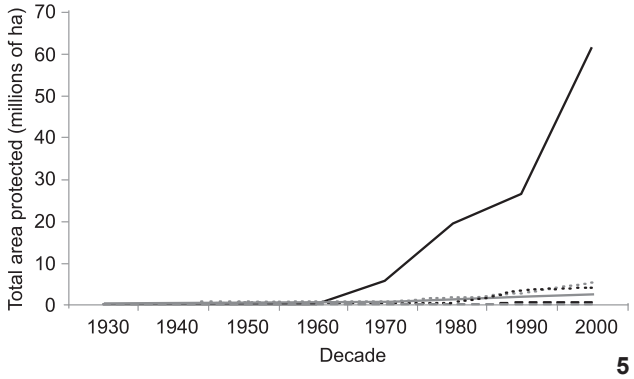
Biome-level investments in protected areas

The Brazilian biomes are unevenly protected (Figs 4-6). The Amazon, which has the largest area, is also the best protected, with 106 protected areas (Fig. 4) covering 14.8% of its area (Fig. 6). Even thought the number of strict protection areas is relatively small (37), they correspond to the majority of the area under legal protection in the biome (10.0% out of the 14.8%). The Amazon has the largest mean size for protected areas (Figs 7 and 8). The Pampa has 8.4% of its area protected (Fig. 6). However, there is not a single strict protection site within the biome. The only two protected areas for sustainable use were established in the 1980's and 1990's, and the conservation investments on this biome have stalled in the last decade (Figs 4-6). The Caatinga has 22 protected areas (Fig. 4), half of which represent strict protection sites. However, the protected areas in the Caatinga are relatively small and cover only 4.2% of the biome (1.8% under strict protection) (Fig. 6). The Cerrado has only 3.9% of its area under legal protection (Fig. 6), but most of it (3.2%) corresponds to strict protection areas. The Cerrado network is comprised of 43 protected areas (20 under the strict protection category) (Fig. 4). The Atlantic Forest has a total of 70 protected areas, 38 of which under strict protection categories (Fig. 4). However, the majority of these protected areas are small (Figs 7 and 8) and this confers only 2.4% of its original cover under protection (0.9% of which under strict protection) (Fig. 6). The Atlantic Forest is the biome that has the network with the smallest mean size for the existing protected areas (Figs



Figures 1-3. Temporal investments in the Brazilian protected areas network: (1) number of protected areas; (2) total area protected; and (3) percentage of the national territory under protection. Black bars represent strict protection protected areas and grey bars represent sustainable use protected areas.





Figures 4-5. Temporal dynamics in the establishment of protected areas per biome in Brazil: Amazon (solid black line), Atlantic Forest (solid grey line), Caatinga (dotted black line), Cerrado (dotted grey line), Pampa (dashed black line) and Pantanal (dashed grey line).

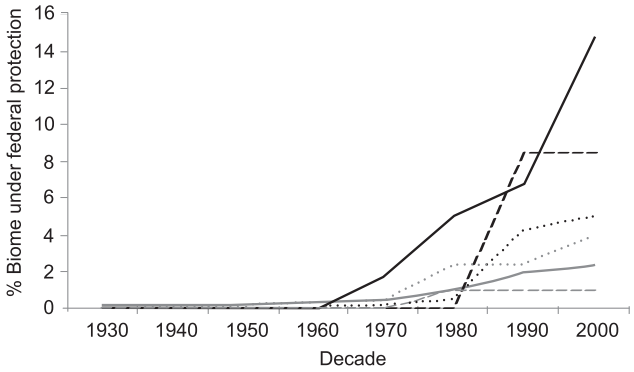


Figure 6. Temporal dynamics in the percentage of area protected in each biome. Amazon (solid black line), Atlantic Forest (solid grey line), Caatinga (dotted black line), Cerrado (dotted grey line), Pampa (dashed black line) and Pantanal (dashed grey line).

7 and 8). Similar to the Pampa, the Pantanal also has only two protected areas (Fig. 4), and as a consequence it has a small area under protection (1.0%) (Fig. 6), but in this case the two sites are strict protection areas. The Pampa and the Pantanal need urgent investment in their protected networks, both in the number of protected areas and biome coverage.

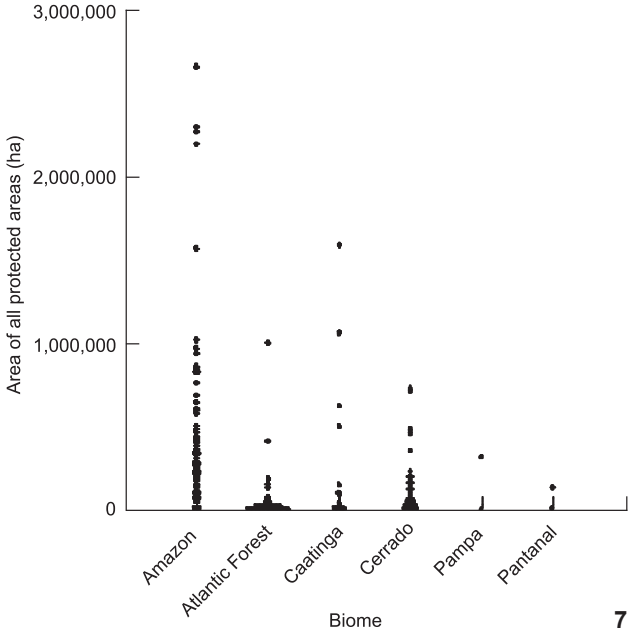
Strict protection vs sustainable use

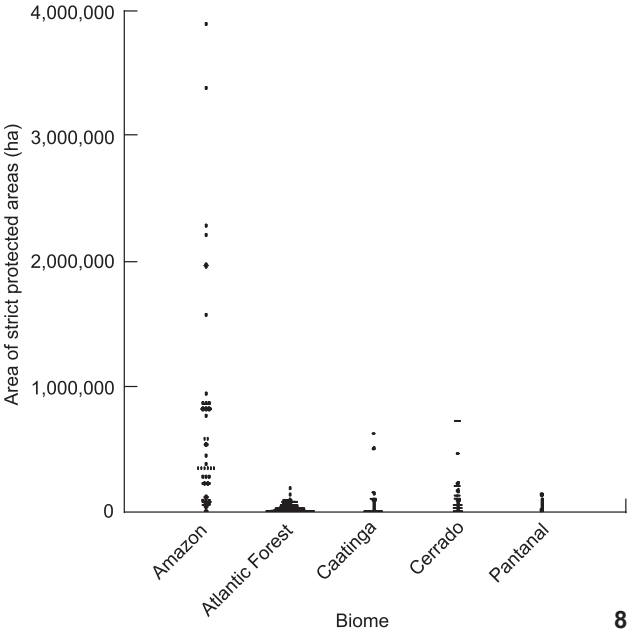
Even though the national investment in the establishment of protected areas shows a steady increase, we have observed a shift in the management categories that sustain this growth (Figs 1-5). Until the 1980's, most protected areas created in Brazil were strict protection sites, but from 1990's on, the government continued to increase the national protected areas network mainly through the establishment of sustainable use sites (Figs 1-5). This represents a change in the philosophy behind the role of protected areas, and a strategic change in how environmental issues relate to the development agenda of the country.

DISCUSSION

Globally, the spatial distribution of protected areas is uneven, particularly in the case of strict protection areas (Chape *et al.* 2005, Brooks *et al.* 2004, Hoekstra *et al.* 2005, Soutullo *et al.* 2008, Jenkins & Joppa 2009). Brazil is no exception, suggesting that the establishment of the national protected areas network has been historically driven by opportunity rather than by strategic planning. Even though the national temporal investments in the protected areas network has increased over time, Brazil is still far from the international targets established by the Convention on Biological Diversity, according to which 17% of a country/biome should be formally and legally protected (CBD 2010). Brazil is far from achieving that target. Also, there is not a single biome under the level of protection recommended by the CBD (CBD 2010).

Most countries fail to protect their biodiversity efficiently, and Brazil is no exception (Brooks *et al.* 2004, CBD 2010). The global protected area network is far from complete (Brooks *et al.* 2004), as is the national network of Brazil. The 17% national goal for protected areas may turn out to be impossible to achieve in the face of recent changes in the national politics regarding biodiversity (e.g., Metzger *et al.* 2010, Martinelli 2011, Nazareno & Lovejoy 2011, Tollefson 2011), when even existing protected areas are ignored, downsized or downgraded (from strict protection to sustainable use) to give way to development. For example, the shift in the types of protected area that are created (strict protection before the1980's and sustainable use from the1990's on) represents a change in the philosophical role of protected areas and a strategic change in how environmental issues fit in the development agenda of the country. Originally, the main objective of the network was biodiversity protection, whereas now it is part of the country's development strategy. Economic and social roles have been also introduced into the network, a trend that is also observed worldwide (Dearden *et al.* 2005). The alarming issue is that areas in the sustainable use categories are usually closer to and more prone





Figures 7-8. Size distribution for: (7) all protected areas in each biome; and for (8) strict protection protected areas in each biome.

to threats than strict protection (Locke & Dearden 2005, Naughton-Treves *et al*. 2005).

The establishment of protected areas is only the first step towards an effective network. After that, funding, infrastructure and personnel must be secured on a long-term basis, otherwise the parks composing the network remain only on paper. There is evidence that globally, the funding of protected areas has increased (Dearden 2005). Some of it is due to the growing participation of the private sector and Non-profit organizations (Dearden 2005). However, the budget is still below the basic needs for approximately 66% of the protected areas (Dearden *et al*. 2005), and in Brazil particularly, governmental investment is usually limited to the delimitation of new sites. The consequence is that much of the country's current network has remained only on paper and their true effectiveness for biodiversity conservation is uncertain. Protected areas are considered the backbone of conservation strategies. Brazil needs to seriously plan and manage its network, which is actually an important component of the global network, since Brazil is a megadiverse country.

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