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BIODIVERSITY LETTER

Conservation in Brazil needs to include non-forest ecosystems

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ABSTRACT

In the past decades, Brazil made important progress in the conservation of forest ecosystems. Non-forest ecosystems (NFE), in contrast, have been neglected, even though they cover large parts of the country and have biodiversity levels comparable to forests. To avoid losing much of its biodiversity and ecosystem services, conservation and sustainable land use policies in Brazil need to be extended to NFE. A strategy for conservation of Brazil's NFE should encompass the following elements: (1) creation of new large protected areas in NFE; (2) enforcement of legal restrictions of land use; (3) extension of subsidy programs and governance commitments to NFE; (4) improvement of ecosystem management and sustainable use in NFE; and (5) improvement of monitoring of land use change in NFE. If Brazil managed to extend its conservation successes to NFE, it not only would contribute significantly to conservation of its biodiversity, but also could take the lead in conservation of NFE world-wide.

Keywords

biodiversity, grassland, land use change, megadiverse country, savanna.

INTRODUCTION

In the past decade, Brazil made important advances to reconcile biodiversity conservation and economic development and has emerged as a strong player in the international conservation debate (Loyola, 2014). Despite increases in the very recent past,[1] deforestation in the Amazon declined dramatically overall (Hansen *et al.*, 2013; Lapola *et al.*, 2014; Nepstad *et al.*, 2014), and restoration in the Atlantic Rainforest progressed (Calmon *et al.*, 2011). At the same time, Brazil consolidated its position among the largest global producers of agricultural goods. Whereas continued attention to deforestation is of high importance, the focus of the conservation debate only on forest ecosystems obscures the staggering pace of agricultural conversion of Brazil's native non-forest ecosystems (NFE, including: grasslands, savannas, shrublands and open woodlands). NFE historically covered large areas of the country, harbour high biodiversity, with significant rates of endemism and provide key ecosystem services (Table 1). The rapid loss of Brazil's NFE has attracted little attention relative to forests, although awareness of the plight of Brazil's savanna biome, the Cerrado, is growing (Lapola *et al.*, 2014; Gibbs *et al.*, 2015). To avoid losing much of its biodiversity, conservation and sustainable land use policies in Brazil need to be extended to NFE.

[1]http://www.newsweek.com/2015/04/03/brazils-deforestation-rates-are-rise-again-315648.html.

BRAZILIAN NON-FOREST ECOSYSTEMS

Non-forest ecosystems predominate in four of the six officially recognized biomes in Brazil and even cover considerable proportions of the two forest-dominated biomes, including Amazonia (Fig. 1, Table 1). Their biodiversity is comparable to that of forests (Table 1). The global importance of Brazilian NFE is recognized by several criteria in global assessments. The Caatinga is classified as a centre of plant diversity and a crisis region, the Pantanal as a

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Table 1 Extent of non-forest ecosystems (NFE), conservation status, human development index and biodiversity within Brazil's biomes. See Appendices S2 and S3 for databases and methods

Brazilian biomes (according to IBGE)	Main ecosystem types	Biome area (10^3 km^2)	Original extent of NFE within the biome (%, year 1500)	Present extent of NFE within the biome (%, year 2002)	Potential area of NFE in permanent protection areas and legal reserves (10^3 km^2)	Potential area of NFE under land use conversion permission mechanism (10^3 km^2)	Human development index	Gross domestic product (per cap.)	Plant species richness (entire biome)	Bird species richness (entire biome)
Forest biomes										
Amazonia	Rainforest	4196.9	15.8	4.2	294.12	54.37	0.646	4.6	13,214	1300
Atlantic Forest	Rainforest	1110.2	11.7	5.2	20.05	13.34	0.730	9.8	17,741	1020
Non-forest biomes										
Caatinga	Dry woodland	844.5	93.7	38.4	175.81	244.53	0.607	2.8	4967	510
Cerrado	Savanna	2036.4	89.5	23.7	492.90	340.43	0.701	7.9	13,137	837
Pampa	Grassland	176.5	86.3	35.9	28.97	30.07	0.731	6.6	1957	476
Pantanal	Wet grassland and savanna	150.4	86.0	81.7	46.95	61.86	0.646	4.6	1557	463

wilderness area and the Cerrado as a biodiversity hotspot (Brooks *et al.*, 2006). Poorly known outside and even within Brazil, the Pampa grasslands are among the most species-rich grasslands in the world (Overbeck *et al.*, 2007).

In addition to their unique biodiversity, NFE provide essential ecosystem services, including provisioning of water, production of livestock forage and carbon storage. Rivers originating in the Cerrado contribute to eight of the twelve major watersheds in Brazil. Intact savannas and grasslands are critical to both the quality and quantity of water supply of major cities and hydroelectric energy production (Lima & Silva, 2008). Livestock grazing is one of the few land uses that can be reconciled with NFE biodiversity. For example, natural grasslands in the Pampa biome enable large-scale sustainable cattle production (Overbeck *et al.*, 2007). Finally, although carbon sequestration policies typically emphasize forests (e.g. REDD+), globally NFE store as much carbon as forests (White *et al.*, 2000).

FOREST BIAS IN BRAZILIAN CONSERVATION

Brazilian conservation policies, strongly biased towards forests (Fig. 1), have been effective in curbing deforestation. In particular, the expansion of the protected area network and additional forest conservation policies have reduced Amazonian deforestation, with further improvements expected (Nepstad *et al.*, 2014). Supply-chain governance commitments such as the soya bean and beef moratoria on Amazonian products (Nepstad *et al.*, 2014; Gibbs *et al.*, 2015) have significantly contributed to the deceleration of land conversion in the Amazon. Other successes include initiatives that integrate forest conservation with poverty alleviation and livelihood improvements, through establishment of extractive reserves and payments for ecosystem services (Magrin *et al.*, 2014).

In contrast to Brazil's forest conservation successes, conversion of Brazil's NFE proceeds at alarming rates in all biomes (Table 1), similar to NFE throughout the world (Bond & Parr, 2010). The Cerrado lost 92,712 km^2 of natural ecosystems to agricultural conversion from 2002 to 2009, a decline of 8.1% compared with 3.1% in the Amazon (Fig. 1). Recent conversion in the other NFE biomes is of similar magnitude to loss of Amazon forest, but the percentage of NFE formally protected is strikingly lower, resulting in much higher Conservation Risk Indices in NFE biomes (Fig. 1). As in forest regions, conversion in NFE is heavily driven by the global demand for commodities. Agriculture is the single largest driver of land conversion in Brazil (Magrin *et al.*, 2014). Yet, other important non-agricultural land-conversion drivers, like opencast mining in mountain regions in the Cerrado, the partial diversion of the São Francisco river in the Caatinga, proposed infrastructure projects in the Pantanal wetlands, and, unfortunately, attempts to sequester carbon by increasing tree cover in NFE (Veldman *et al.*, 2015b) contribute to the current threat to NFE.

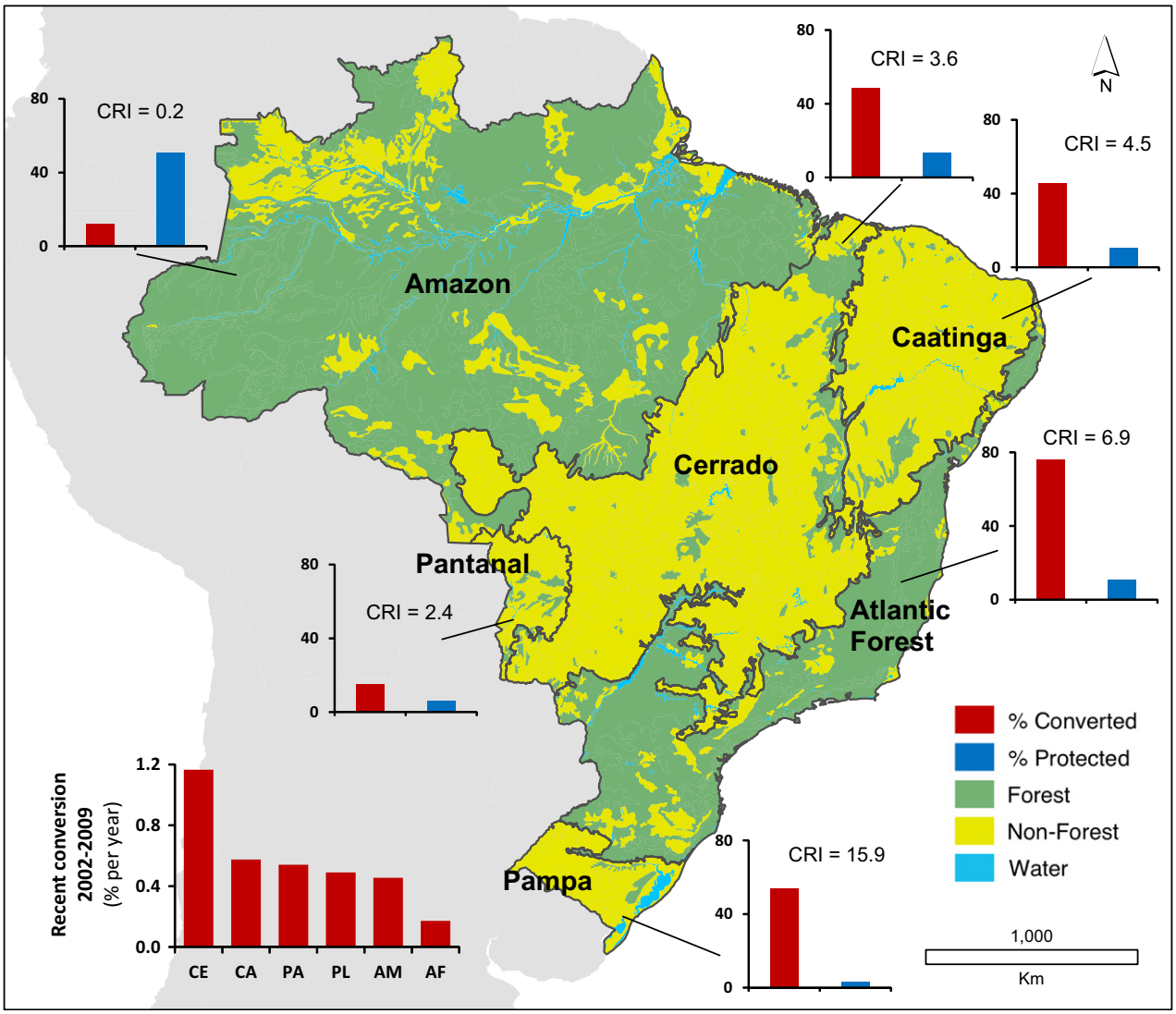

Figure 1 Map of original vegetation cover in the Brazilian biomes. Original forest area is depicted in green and original non-forest vegetation area in yellow. Small inset graphs indicate the proportion of converted (red) and protected (blue) areas in 2009. Protected areas include IUCN categories I–VI and Indigenous Reserves. The Conservation Risk Index (CRI) given for each biome is the ratio of converted to protected percentages. At the bottom left, recent conversion rates (2002–2009) for each biome are shown (CE = Cerrado, CA = Caatinga, PA = Pampa, PL = Pantanal, AM = Amazon, AF = Atlantic Forest). See Appendix S4 for data sources and methods.

POLICY FOR BETTER PROTECTION OF NON-FOREST ECOSYSTEMS

In 2015, the UN Sustainable Development Goals (Griggs *et al.*, 2013) will be announced and a new global climate agreement negotiated, both of which will demand commitments and targets capable of reconciling the protection of life supporting systems with poverty reduction. Brazil's NFE are breadbaskets of the world as much as they are home for a wealth of biodiversity and ecosystem services that include, for instance, alleviation of climate change effects through provisioning of water. Because of the ecological distinctness of NFE (Bond & Parr, 2010; Veldman *et al.*, 2015a), their conservation often requires different strategies than that of forests (e.g. prescribed fire, grazing), but also offers many opportunities for sustainable use and economic benefits. In the following, we highlight five important elements of an integrated policy for the effective protection of Brazil's NFE:

1. Create new large protected areas in NFE, based on existing maps of conservation priority areas developed for the Brazilian Ministry of Environment.[2] These maps provide a scientifically sound basis for the establishment of protected areas in NFE, even though they should be updated. It is important to realize that the window of opportunity to establish large protected areas is closing fast as agricultural conversion advances rapidly. When establishing new protected areas, the respective protection category must be carefully chosen. The highest categories are not necessarily the

[2]Available at: http://mapas.mma.gov.br/mapas/aplic/probio.

most adequate for NFE. In many cases, their biodiversity and ecological processes depend critically on disturbances, that is, management (Veldman *et al.*, 2015a). Thus, often only categories allowing sustainable use can ensure conservation on the long run, in a way that can also integrate local population and bring economic and social benefits (see also item 4, below).

2. Enforce existing legal restrictions on land use (Appendix S1). If properly enforced, the erroneously nicknamed 'New Forest Code' would promote large-scale conservation of NFE, despite some reductions in conservation and restoration requirements in the last revision (Metzger *et al.*, 2010; Soares-Filho *et al.*, 2014). By law, at least 20% (35% in Amazonian savannas) of the native vegetation of any private property has to be registered as Legal Reserve (LR) for sustainable use, and a variable amount of ecologically critical areas has to be designated as Permanent Protection Areas (PPA). Further, any new conversion of native vegetation outside of LR and PPA now requires a permit. In the predominantly NFE biomes, large 'surplus' areas to LR and PPA requirements still exist (Soares-Filho *et al.*, 2014; Table 1, Appendix S2). Up to now, the implementation of LR and PPA has considered forest vegetation more than non-forest vegetation, even in predominantly NFE biomes. Their enforcement could protect an estimated area of almost 1.1 million km^2 of NFE in Brazil (Table 1 and Appendix S2). The requirement of a permit for conversion of native vegetation, if combined with information on regional biodiversity and supported by zoning plans, has the potential to foster conservation by limiting uncontrolled conversion of an estimated area of 745 thousand km^2 of NFE (Table 1 and Appendix S2). Currently, this new regulation faces implementation problems, and no criteria exist to decide when conversion of NFE can be allowed and when not, and according to which reference data.

3. Further promote the Brazilian green subsidy programme 'Bolsa Verde' and extend the soya bean moratorium to NFE. Started in 2011, the 'Bolsa Verde' provides financial incentives for the sustainable use of natural resources by rural poor in areas of high conservation value. Addressing biodiversity conservation and poverty alleviation is also critical in NFE, especially for the Caatinga and the Pantanal (as evidenced by HDI and per capita GDP values lower or as low as in the Amazon; Table 1). Yet, to date, the programme is applied mostly in the Amazon (MPOG/MDA/MDS/MMA, 2013). Similarly, success of the soybean moratorium in the Amazon should be extended to NFE in the Cerrado (Gibbs *et al.,* 2015) and Pampa.

4. Improve management of NFEs in ways that maintain biodiversity, provide economic outputs and reduce the financial incentives for conversion to grow crop agriculture (Strassburg *et al.*, 2014). Traditional ranching practices can maintain biodiversity particularly in Brazil's native grasslands, but also in its savannas (Overbeck *et al.*, 2007; Carvalho, 2014); policy in these biomes should foster initiatives in sustainable production, which can be linked to sustainable development reserves, community management and payment for ecosystem services (Magrin *et al.*, 2014). In many NFE areas under grazing, current stocking rates are above carrying capacity, negatively affecting biodiversity and/or productivity (overgrazing, Mysterud, 2006; Carvalho & Batello, 2009), and increasing occurrence of invasive species (Fonseca *et al.*, 2013). Both problems are severe and need to be addressed by proper management in order to increase biodiversity and to turn affected areas more productive and profitable. Unconverted and well-conserved areas currently not protected in LR and PPA in the NFE (Appendix S2) represent a unique opportunity to promote large-scale conservation combining improved management, financial incentives for sustainable use and expansion of the system of protected areas to counteract land conversion.

5. Improve monitoring and facilitate access to data on land use change in NFE. Amazonian deforestation has been monitored monthly since 1988 by the PRODES project, which has proven indispensable for enforcement of forest conservation. By comparison, data on conversion of NFE are difficult to access (e.g. Lapola *et al.*, 2014; Soares-Filho *et al.*, 2014), thereby contributing to the biased enforcement of conservation policy in forest biomes rather than NFE. For a national monitoring programme to have the greatest potential impact, it must include all biomes and be capable of detecting all types of native vegetation conversion, not just deforestation.

A WORLD-WIDE ISSUE TO BE TACKLED IN BRAZIL

Conservation policy in Brazil has prioritized forests and largely forgotton NFE. Changes in Brazil have world-wide impact, first, because of the sheer absolute extent of NFE in that country; second, because they can establish good precedents applicable to other countries with extensive NFE areas. Better enforcement of current laws for the protection of native vegetation could remedy this imbalance, but first the importance of NFE to biodiversity conservation and ecosystem services in Brazil must be recognized by the public, policymakers and stakeholders in the agricultural, cattle and forestry industries. Brazil's record of reconciling forest conservation and human well-being gives us hope that similar policies can reverse the loss of NFE. If Brazil were to enact new NFE-focused conservation policies and enforce current laws on native vegetation in NFE, the country would establish itself as world leader in the effort to achieve UN Sustainable Development Goals, which must also consider the values of the world's many native NFE.

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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article:

Appendix S1 Non-forest ecosystems (NFE) and the Brazilian legislation for protection of native vegetation.

Appendix S2 How much of non-forest ecosystems (NFE) can be potentially protected by the different legal mechanisms?

Appendix S3 Data basis and methods for Table 1.

Appendix S4 Data bases and methods for Fig. 1.

Appendix S5 References in the Supplementary Material.

Table S1 Total estimated area of non-forest (NFE) and forest ecosystems that may be potentially protected by the different mechanisms defined by the provisions of the Brazilian Native Vegetation Law.

BIOSKETCH

The TUMBRA workshop where this paper was conceived brought together scientists from Brazil and Germany with ample working experience on conservation of Brazilian non-forest ecosystems.

Author contributions: All authors contributed to the general ideas, the specific contents and the overall structure of the manuscript. G.E.O. led the writing and E.V.-M. conducted the analyses.

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