Last of the green: identifying priority sites to prevent plant extinctions in Brazil

Milena F. Diniz, Tatiel V. Gonçalves and Daniel Brito

Abstract The identification and protection of Alliance for Zero Extinction sites at the national level is of great importance to safeguard biodiversity and achieve the targets of the Convention on Biological Diversity for 2020. Here we identify priority species and sites for the Brazilian flora. We evaluated the protection status of each site, taking into account whether or not it was located within a protected area, and the anthropogenic pressure on the site, using human density and gross domestic product as surrogates. We identified a total of 234 trigger species at 140 sites. Most of the sites are located in the Atlantic Forest and the Cerrado; only 21 are within protected areas. There was no relationship of human density and annual gross domestic product per capita with the level of site protection. The low proportion of Alliance for Zero Extinction sites protected shows that Brazil is lagging behind in global conservation efforts to protect such sites.

Keywords Alliance for Zero Extinction, BAZE, Brazil, conservation priorities, plants, protected areas, threatened species

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Introduction

Only 7% (c. 20,755 species) of known plant species have had their conservation status evaluated, and approximately 54% of these are categorized as threatened on the IUCN Red List (IUCN, 2015). Given the number of plant species that have not yet been evaluated for the Red List, and the estimates of significant numbers of plant species that have not yet been discovered or described by science (Purvis & Hector, 2000; Scotland & Wortley, 2003; Joppa et al., 2011; Scheffers et al., 2012), the current estimate of c. 9,000 threatened taxa is an underestimation. The goals of the Global Strategy for Plant Conservation include completing the evaluation of the conservation status of plants by 2020 (target 2) and protecting 75% of all threatened plant species in situ (target 7; SCBD, 2009).

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Brazil harbours c. 45,000 plant species (c. 19% of global plant diversity; Giulietti et al., 2005), with c. 19,000 endemics (Forzza et al., 2010); a new plant species is described there every 2 days (Sobral & Stehmann, 2009). The conservation status of 4,617 plant species have been evaluated and 2,118 (c. 46%) are categorized as threatened and 554 (c. 12%) as Data Deficient (Martinelli & Moraes, 2013).

Conservation efforts are generally targeted to identify and safeguard priority species and sites at various spatial scales: global (e.g. biodiversity hotspots; Mittermeier et al., 2005), regional (e.g. key biodiversity areas; Eken et al., 2004; Langhammer et al., 2007) and local (e.g. Alliance for Zero Extinction; Ricketts et al., 2005). The Alliance for Zero Extinction, an international initiative to identify and protect sites of global relevance to biodiversity conservation, suggests that threatened species that are restricted to a single site or population should be a priority for conservation (Ricketts et al., 2005), based on the concepts of irreplaceability and vulnerability (Pressey, 1994; Margules & Pressey, 2000; Pressey & Taffs, 2001).

The identification and protection of Alliance for Zero Extinction sites is among the metrics used to evaluate ongoing efforts to achieve the Convention on Biological Diversity targets for 2020 (as a subindicator for target 11). The Convention also recommends the implementation of national-level initiatives to identify priority species and sites (CBD, 2015). This is a critical time for conservation in Brazil, and the importance of leading by example has been highlighted on a number of occasions (Scarano et al., 2012; Ferreira et al., 2014; Loyola, 2014). Because of its rich biodiversity Brazil is at the forefront of the global conservation agenda, and actions taken at the national level will influence global decision making. Our objective was to identify and map Alliance for Zero Extinction species and sites for the Brazilian flora.

Methods

The methodology used to identify priority species and sites for the Brazilian flora is similar to that used globally (Ricketts et al., 2005). A shortlist of candidate species was obtained from Brazil's national red list of threatened flora (Martinelli & Moraes, 2013). To qualify for Brazilian Alliance for Zero Extinction status a species must be categorized as Endangered or Critically Endangered on this list (Martinelli & Moraes, 2013), with a majority of the population or distribution (c. 95%) confined to a single site with a definable boundary (Ricketts et al., 2005). Distribution and population data were obtained from published databases (Giulietti et al., 2009; Plantas Raras do Brasil, 2009; Martinelli & Moraes, 2013; Biodiversitas Foundation, 2015; List of Species of the Brazilian Flora, 2015; speciesLink, 2015). We also consulted the *Catalogue of Plants and Fungi of Brazil* (Forzza et al., 2010).

To evaluate the protection status of sites we overlaid them with the World Database on Protected Areas (Protected Planet, 2015). Sites were defined as protected if they overlapped with an existing protected area; otherwise they were defined as unprotected. To evaluate human pressure on sites, we obtained human density and gross domestic product data for the municipalities where the sites are located (IBGE, 2010). Statistical analyses were performed in *R v. 2.15.2* (R Development Core Team, 2012). Brazil has identified priority areas and conservation actions to protect its biodiversity (Ministério do Meio Ambiente, 2007). To evaluate the congruence between these priority areas and the Alliance for Zero Extinction sites for the Brazilian flora, we estimated the overlap between the existing conservation agenda and the newly identified Alliance for Zero Extinction sites.

Results

We identified a total of 234 trigger species located in 140 Alliance for Zero Extinction sites (Fig. 1). The Atlantic Forest hosts the largest number of such sites for the Brazilian flora (78), and two oceanic sites are particularly important: Fernando de Noronha and Trindade (Figs 1 & 2). Most trigger species belong to the families Asteraceae (38 species), Bromeliaceae (24) and Cactaceae (16; Supplementary Table S1).

The status of the sites is a cause for concern as only 21 are located within protected areas (Figs 1 & 3); of these only eight are in strictly protected areas and 13 are in sustainable-use protected areas. Most of the protected sites are in the Atlantic Forest (10 sites, or 13% of the Alliance for Zero Extinction flora sites in the Atlantic Forest), whereas the Pampa and the Pantanal do not have a single protected site within their boundaries (Fig. 1; Supplementary Table S2).

Neither human density ($t = -1.020$, df = 22.347, P = 0.31) nor annual gross domestic product per capita ($t = -1.239$, df = 22.319, P = 0.22) has a relationship with the level of protection of the sites analysed. Unprotected sites had a mean human population density of 181 inhabitants per km^2 and a mean annual gross domestic product per capita of USD 6,363.80, whereas protected sites had a mean human population density of 489 inhabitants per km^2 and a mean annual gross domestic product per capita of USD 9,314.50 (Supplementary Table S2).

Only 74 (53%) of the identified Alliance for Zero Extinction sites for flora were located within an official priority area identified by the Brazilian government (Fig. 4). Of these, 56 (76%) were categorized as extremely high priority, three (4%) as very high priority, 11 (15%) as high priority and four (5%) sites were included within the Data Deficient category (Fig. 5). It is important to note the large number of single-site species categorized as Vulnerable on the Brazilian Red List (285 species, 108 sites; Supplementary Table S3); although they do not trigger the designation of Alliance for Zero Extinction sites (Ricketts et al., 2005; Alliance for Zero Extinction, 2010), changes in their conservation status could dramatically increase the number of such sites for the Brazilian flora.

Discussion

National-level analyses may speed up the identification and protection of globally sensitive species and sites, particularly in the case of endemics. Mexico has the highest number of sites in the global Alliance for Zero Extinction scheme, with 151 trigger species and 68 sites (Alliance for Zero Extinction, 2010). Currently, Brazil has 28 trigger species and 27 sites overall (Alliance for Zero Extinction, 2010), substantially fewer than our calculations of 234 trigger species in 140 sites. Our calculations are, however, significant underestimations, as only 15% of the Brazilian flora has been assessed (Martinelli & Moraes, 2013), and do not take into account the 12,000 animal species recently assessed in Brazil, of which 1,173 are categorized as threatened (Ministério do Meio Ambiente, 2014).

The high number of Alliance for Zero Extinction sites in the Atlantic Forest and in the Cerrado may be attributable to the high levels of habitat destruction and endemism in these regions (Myers et al., 2000; Mittermeier et al., 2005), suggesting urgent reactive conservation strategies are needed to safeguard such sites (Brooks et al., 2006). The trends in the policy of protected area creation in Brazil (Cabral & Brito, 2013) and the low human occupation of the Amazon should facilitate the adoption of a proactive conservation strategy to safeguard Alliance for Zero Extinction sites in the Amazon (Brooks et al., 2006).

Our results highlight the need for protection of currently unprotected sites. At the global level, 22% of Alliance for Zero Extinction sites are protected (Butchart et al., 2012), whereas only 15% of the sites designated for the Brazilian flora are protected, and thus Brazil is lagging behind the global efforts to protect such sites (CBD target 11). Although protected areas have been created in the Atlantic Forest and in the Cerrado they are small, and therefore the increase in the total area protected within these biomes is insignificant (Cabral & Brito, 2013). The present political scenario for improving and expanding the national protected area

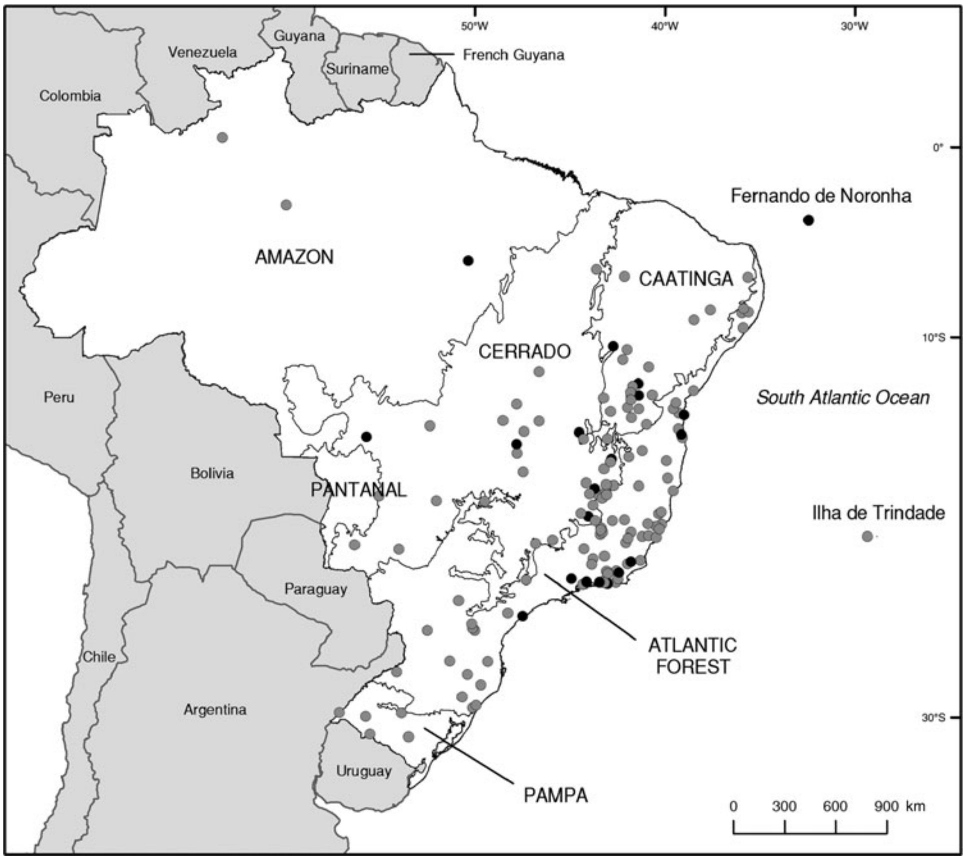

FIG. 1 Protected (n = 21; black filled circles) and unprotected (n = 119; grey filled circles) Alliance for Zero Extinction sites for the Brazilian flora.

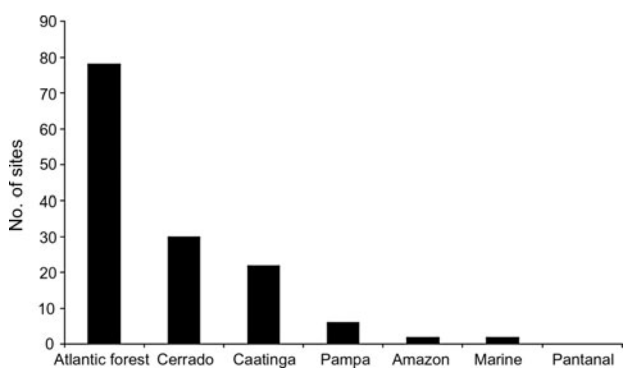

FIG. 2 Number of Alliance for Zero Extinction sites for the Brazilian flora, by biome.

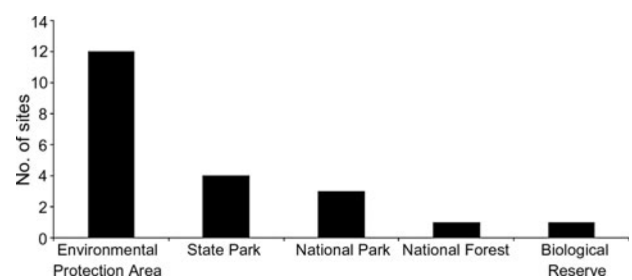

FIG. 3 Number of Alliance for Zero Extinction sites for the Brazilian flora in each category of protected area.

network is not promising (Bernard et al., 2014; Marques & Peres, 2015). None of the sites identified here, however, overlap with protected areas that were recently downgraded, downsized or degazetted (Bernard et al., 2014; Marques & Peres, 2015); the Alliance for Zero Extinction sites are the top candidates for complementing Brazil's existing protected area network. It has been noted that species occurring within Alliance for Zero Extinction sites have had less deterioration of their conservation status than species outside these sites (Butchart et al., 2012). The protection of priority sites for biodiversity also provides significant benefits for people, and improvements in ecosystem services (Larsen et al., 2012). However, given the high number of Alliance for Zero Extinction sites in Brazil, and the country's unstable protected area policy (Bernard et al., 2014; Marques & Peres, 2015), legally protecting all of the sites is not feasible.

Implementation of strategies to protect biodiversity on private lands, complementing the existing protected area networks, is therefore required (Norton, 2000; Jenkins et al., 2015; Kamal et al., 2015). In Brazil, Private Natural Heritage Reserves (Reservas Particulares do Patrimônio Natural) are a successful strategy, with landowners receiving

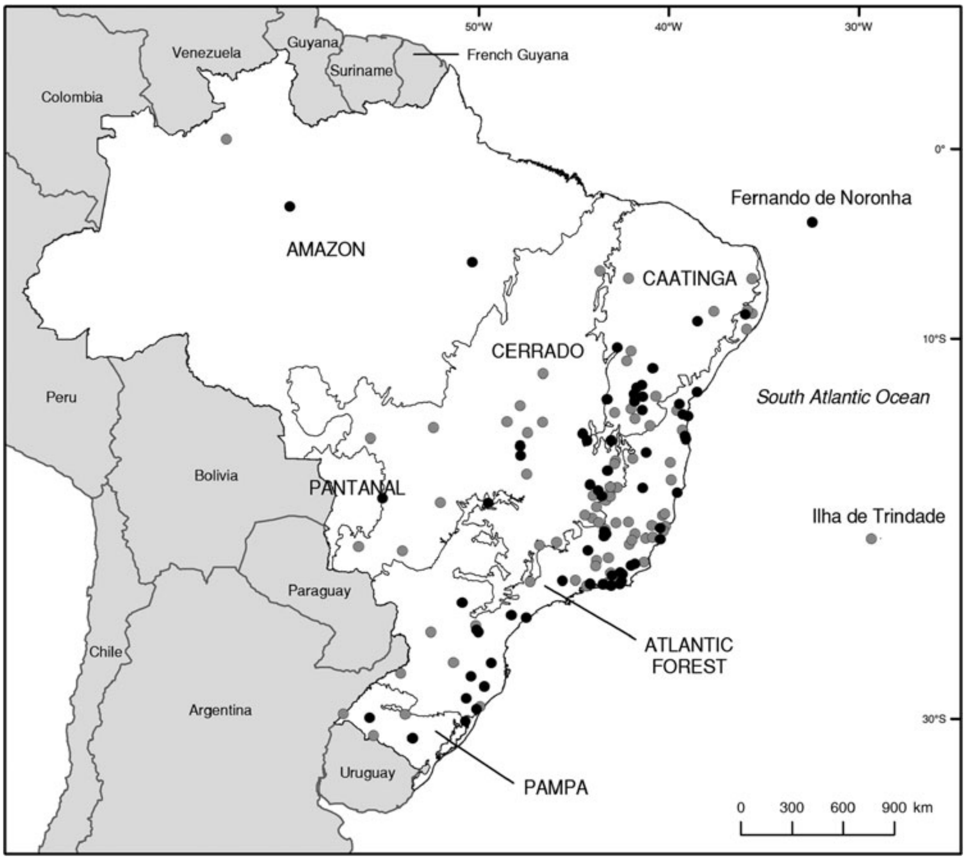

FIG. 4 Alliance for Zero Extinction sites for the Brazilian flora in government-defined priority areas for conservation action (n = 74; black filled circles) and non-priority areas (n = 66; grey filled circles).

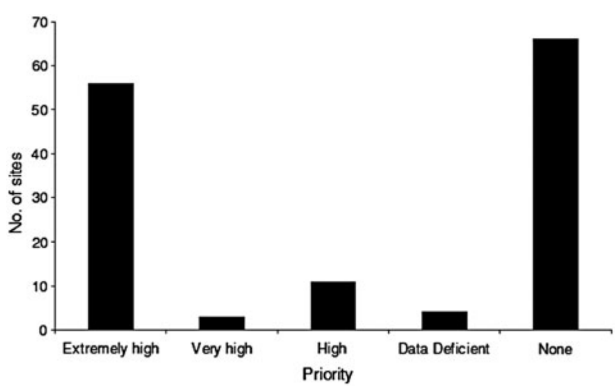

FIG. 5 Number of Alliance for Zero Extinction sites for the Brazilian flora in each priority category.

economic incentives from the government if they create a private protected area. The coverage of protected land is increased at only a small cost to the government (Rambaldi et al., 2005; Crouzeilles et al., 2013). Incentives to create Private Natural Heritage Reserves could support short-term biodiversity conservation while new strategies are tested and implemented to ensure long-term efficiency and stability of conservation outside governmental protected areas (Young, 2005; Kamal et al., 2015). In situ and ex situ population management could also complement the strategy of protecting sites (e.g. Hoffmann et al., 2015), and the role of herbaria and botanical gardens in conservation should be promoted (Wyse Jackson & Sutherland, 2000; Maunder et al., 2001a,b; Schatz, 2002; Callmander et al., 2005).

Our results represent an underestimation of the number of Alliance for Zero Extinction sites for the Brazilian flora, for four main reasons: (1) Brazil's red list includes many Data Deficient species (Martinelli & Moraes, 2013), some of which may be threatened (Sousa-Baena et al., 2014); (2) the Linnean shortfall (Whittaker et al., 2005; Possingham et al., 2007), where species that are not yet formally described by science are overlooked in strategies devised to safeguard biodiversity; (3) there are many single-site species categorized as Vulnerable whose conservation status may worsen, triggering new Alliance for Zero Extinction sites for the Brazilian flora (Supplementary Table S3); and (4) our analysis is based on only a partial assessment of the conservation status of Brazilian plants, as Martinelli & Moraes (2013) provided assessments for only 4,617 of c. 45,000 species. The number of species that trigger Alliance for Zero Extinction sites is likely to increase substantially when the assessment of all Brazilian endemics is completed.

This work is an example of how science can help inform public policies, using the national plant red list as a scientific guide for the development and allocation of scarce conservation resources (Scarano & Martinelli, 2010). The use of red lists as a conservation tool in Brazil is gaining momentum (e.g. Morais et al., 2012, 2013; Moraes et al., 2014). In the national flag the green colour symbolizes the country's forests and abundant biodiversity but it will fade if the native flora is not effectively protected.

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Biographical sketches

Milena Diniz's main research interests are in evaluating the effectiveness of protected area networks in Brazil, and prioritizing areas for conservation. Tatiel Gonçalves' interests lie in the use of Red Lists as conservation tools to advance the protection of biodiversity and in the influence of conservation policies on conservation actions. Daniel Brito's research focus is on comprehending the extinction process, identifying conservation priorities, advancing Red Lists as conservation tools, and estimating the consequences of knowledge gaps in conservation.