



Brazilian efforts towards achieving a comprehensive extinction risk assessment for its known flora

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Abstract

Brazil houses nearly 36,400 native terrestrial plant species. The country is a signatory of the Global Strategy for Plant Conservation (GSPC) and has to develop tools to achieve GSPC targets. Target 2 states that countries must undertake risk assessments of its entire known plant species by 2020. Here, we offer a panorama on how far has Brazil gone towards achieving this target. We compiled data on all risk assessments for plant species ever made in the country and produced the first synthesis of results with respect to these assessments. We found that the Brazilian Red List Authority for plants has assessed the extinction risk of 5,646 species so far, which corresponds to 15.5% of all known flora in Brazil. Among these species, 2,738 (48%) are currently threatened. Those species are distributed across all Brazilian Biomes and states. Families with the highest number of threatened species are Asteraceae and Bromeliaceae. We conclude that Brazil is far from achieving GSPC target 2 by 2020. However, given the enormous flora of the country and the huge amount of effort and resources put into this particular task, Brazil is following a good path towards a reliable assessment of its entire flora.

Key words: Aichi targets, biodiversity outlook, Convention on Biological Diversity, IUCN red list, threatened species.

Resumo

O Brasil possui cerca de 36400 plantas nativas terrestres. O país é signatário da Estratégia Global para a Conservação de Plantas (GSPC) e tem desenvolvido ferramentas para alcançar as metas da GSPC. A meta 2 estabelece que os países devem conduzir a avaliação de risco de extinção de toda sua flora até 2020. No presente trabalho, nós apresentamos um panorama sobre o quanto falta para alcançarmos a meta. Nós compilamos os dados de todas as avaliações de risco de extinção feitas no Brasil e produzimos a primeira síntese de resultados relacionadas a essas avaliações. Nós já avaliamos o risco de extinção de 5.646 espécies, o que corresponde a 15,5% de toda a flora terrestre nativa conhecida. Dentre essas espécies, 2.738 (48%) estão ameaçadas de extinção. Essas espécies estão distribuídas em todos os biomas e estados do Brasil. As famílias com o maior número de espécies ameaçadas são Asteraceae e Bromeliaceae. Nós concluímos que o Brasil está longe de alcançar a meta 2 da GSPC até 2020. Entretanto, dado o alto número de espécies da flora do país e o grande esforço e recursos empregados para essa tarefa, o Brasil está seguindo um bom caminho para avaliar toda a sua flora.

Palavras-chave: metas de Aichi, panorama da biodiversidade, Convenção da Diversidade Biológica, Lista Vermelha da IUCN, espécies ameaçadas.

Introduction

Plant species worldwide are threatened with extinction. The Sampled Red List Index for Plants indicates that more than 20% of all known plants are currently threatened with extinction (Brummitt *et al.* 2015). Other estimates point out that 27 to 33% of all plant species (including those likely to be described) are possibly threatened (Pimm & Joppa 2015). This is a critical issue given that

plants play a key role in supporting the planet's environmental balance, and are an irreplaceable component of animal habitats. Habitat loss, biological invasion, pollution, and climate change are the main processes responsible for such a dismal scenario (Sharrock 2012). In tropical developing countries, such as Brazil, main threats to plants are habitat loss and fragmentation arising from land-use change (Martinelli & Moraes 2013).

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Extinction risk assessment and the publication of Red Lists of threatened species are paramount tools to summarize the overall state of biodiversity and for mapping out strategies to address ongoing biodiversity loss. In fact, extinction risk assessments inform and catalyze action for biodiversity conservation (Collen *et al.* 2016). As a reflection of the importance of extinction risk assessments, Target 2 of the Global Strategy for Plant Conservation (GSPC) calls for “an assessment of the conservation status of all known plant species, as far as possible, to guide conservation action”, which follows upon Target 1 of the GSPC, a catalogue of all known plant diversity (Martins *et al.* 2017). Other GSPC targets clearly depend on knowing which plants are threatened, as it should be starting point for conserving threatened species both *in situ* (target 7) and *ex situ* (target 8) and for defining priority areas for conservation (targets 5 and 10) (Bachman *et al.* 2017; Mounce *et al.* 2018; Loyola *et al.* 2014).

Currently, nearly 25% of all accepted terrestrial plant species (excluding algae and freshwater plants) have had their extinction risk already assessed in different parts of the world, although only 6% of them were included in a global assessment (Mounce *et al.* 2018). In Brazil, the National Center for Flora Conservation – CNCFlora acts as the Red List authority for plants and adopts the standards and procedures for risk assessment analysis recommended by the International Union for the Conservation of Nature (IUCN 2001; Martinelli & Moraes 2013). Brazil harbors nearly 36,400 native species of terrestrial plants, of which 53% of them are endemic (Brazilian Flora 2020 under construction 2018). In 2014, as a result of risk assessment undertaken by CNCFlora, Brazil updated its Official National List of Threatened Species of Flora, which now has 2113 species assigned to different threat categories at the national level (MMA 2014). Since then, several other species were (and continue to be) assessed by CNCFlora.

Here, we synthesize the results of extinction risk assessment of the terrestrial flora in Brazil and discuss progress towards achieving a comprehensive response to GSPC Target 2. We also pinpoint gaps in taxonomic and geographic coverage of risk assessments and provide an overview of progress towards the achievement of GSPC Target 2 in Brazil.

Methods

We included in this study data on all risk assessments undertaken by CNCFlora from 2010 to 2018. These assessments were carried out following different thematic approaches, resulting in three published Brazilian Red Books on Threatened Flora (Martinelli & Moraes 2013; Martinelli *et al.* 2014; Martinelli *et al.* 2018).

The first red book (Martinelli & Moraes 2013) comprised a reassessment of 4617 species that were part of seven Brazilian state lists, all threatened and data deficient species encompassed in the former official national list (MMA IN n° 06/2008) and the Brazilian species included in the IUCN red list. In the second red book (Martinelli *et al.* 2014), risk assessment was undertaken for 578 rare species (*sensu* Giulietti *et al.* 2009) occurring in the Cerrado, the Brazilian tropical Savana. In the third red book (Martinelli *et al.* 2018), 884 species endemic to the state of Rio de Janeiro were assessed. Lastly, other risk assessments were carried out for newly described species.

Extinction risk assessment followed the IUCN system of categories and criteria (IUCN 2001). Our definition of plants included only terrestrial plants, *i.e.* consist of all vascular plants and bryophytes, excluding Algae. For each risk assessment, different literature sources were consulted. For each species, we compiled data on taxonomy, autecology, pressure arising from human threats, current conservation actions directed toward the species, and other data relevant to species extinction risk assessment.

We matched all plant names evaluated by CNCFlora to names deposited in the Brazilian Flora 2020 under construction (2018), which is our adopted reference for taxonomic validation. We filtered out all taxa recognized as a “synonym” or “no accepted name”, which left assessments with only “accepted” names. Further, all data used in the assessments were validated by botanical experts. Such data validation guaranteed the quality and consistency of the assessments, with correction of possible errors related to the determination of the species and its occurrence, thus avoiding erroneous estimates of its spatial distribution.

Finally, non-endemic species have been assessed at the national level applying the IUCN criteria and categories (IUCN 2001). After that we applied the red list criteria at the sub-global level (IUCN 2003). Hence, we have assessed 1091 non-endemic species and 4,468 endemic species.

Results

The Brazilian National Center for Flora Conservation carried out initially 6029 assessments. However, after matching these species to names on Brazilian Flora (Brazilian Flora 2020 under construction 2018) and filtering out “synonyms”, “non accepted names” and eliminating duplicate species names, the total species with accepted names totaled 5646, which represents 15.5% of all accepted plants in the Brazilian flora. Among these 5646 species, 2738 (48%) are currently threatened in Brazil: 606 Critically Endangered (CR); 1518 Endangered (EN); and 614 Vulnerable (VU) (Fig. 1). Among non-threatened species, 360 are Near Threatened (NT), 1537 have a list Least Concern (LC) status, and 1011 are Data Deficient (DD), which precluded any classification of threat. The majority of plants included in these categories are endemic to Brazil (Fig. 1).

Over the last eight years, plant species inhabiting all phytogeographic domains in Brazil were assessed. The Atlantic rainforest had the highest number of species assessed followed by the Cerrado (Fig. 2). These biomes also had the highest percentage of threatened species (44% for both), followed by the Caatinga (35%) and the Pampa (34%) (Fig. 2).

Plant species also had their extinction risk assessed throughout the states of Brazil (Fig. 3). The state of Minas Gerais holds the highest absolute number of threatened species (877 species), followed by Rio de Janeiro (862 species) and Bahia (482 species) (Fig. 3). The higher the

number of species assessed, the higher the number of threatened species ($r=0.97$).

Plant species from diverse life forms have also been assessed. Among threatened species, the vast majority are herbs, followed by trees and bushes (Fig. 4). All these previously shown results highlight how comprehensive Brazilian evaluation has been in terms of the geographical representation of species and their life forms.

With regard to family representation, 216 families had at least one species assessed (Tab. 1). However, 182 families still don't have any species for which risk assessments were undertaken. Among the families assessed (see Tab. 1), Asteraceae and Bromeliaceae have the highest number of threatened species, followed by Orchidaceae, Melastomataceae and Fabaceae (Fig. 5). Among the top 15 threatened families in Brazil, most species were classified as EN, although Bromeliaceae had the highest number of CR species and Gesneriaceae the lowest (Fig. 5). Bromeliaceae, Orchidaceae, and Fabaceae figured as the top three families with the highest number of DD species (Fig. 6). The family Lejeuneaceae had the least proportion of species evaluated so far (Tab. 1), although there was no systematic bias towards a small number of non-vascular plants being evaluated (*i.e.* this is a by-product of the thematic approaches taken by CNCFlora).

Discussion

We produced the first synthesis on extinction risk assessment for plants in Brazil. Over the last eight years, 15.5% of the known flora inhabiting Brazil has been assessed, which is a clear indication that the country will not achieve GSPC target 2 by 2020, as we had already suggested (see Martins *et al.* 2017). Why is that the case in Brazil?

First, Brazil has an enormous flora, with the number of known species continually increasing because of the description of new species (Sobral & Stehmann 2009) and taxonomic recircumscriptions (BFG 2015). Hence, the number of species to be assessed is ever increasing while the velocity of such assessment is currently steady. To avoid subjectivity, risk assessments undertaken in Brazil follow strict procedures based on taxonomic databases and geographical validation of species occurrence records (Martinelli & Moraes 2013; Martins *et al.* 2015; 2017). While all these steps are important given that the Red List is a powerful instrument to support the government's publication of the official list of threatened flora in Brazil

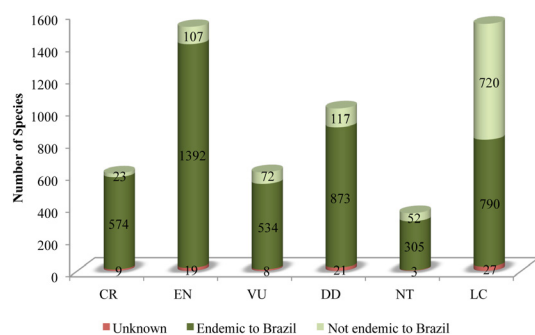


Figure 1 – Number of species of the Brazilian flora included in each IUCN category of risk along with an indication of the number of species endemic to Brazil or with unknown endemism. CR – Critically Endangered, EN – Endangered, VU – Vulnerable, NT – Near Threatened, LC – Least Concern and DD – Data Deficient.

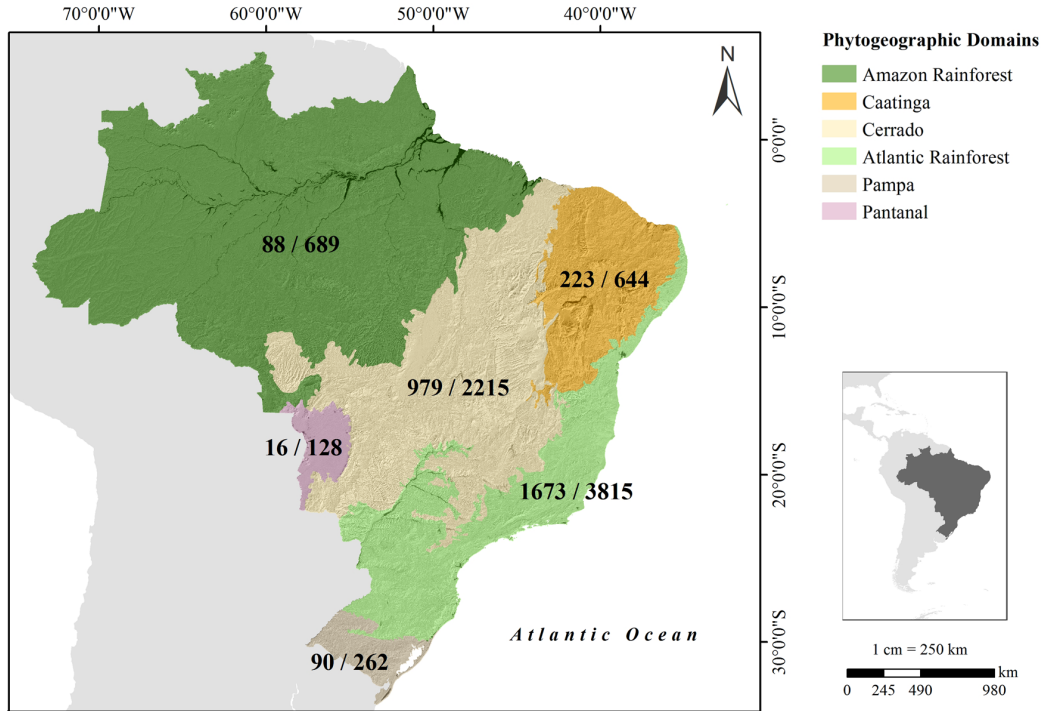


Figure 2 – Number of threatened plant species followed by the number of species with extinction risk assessment, respectively, across all phylogeographic domains in Brazil.

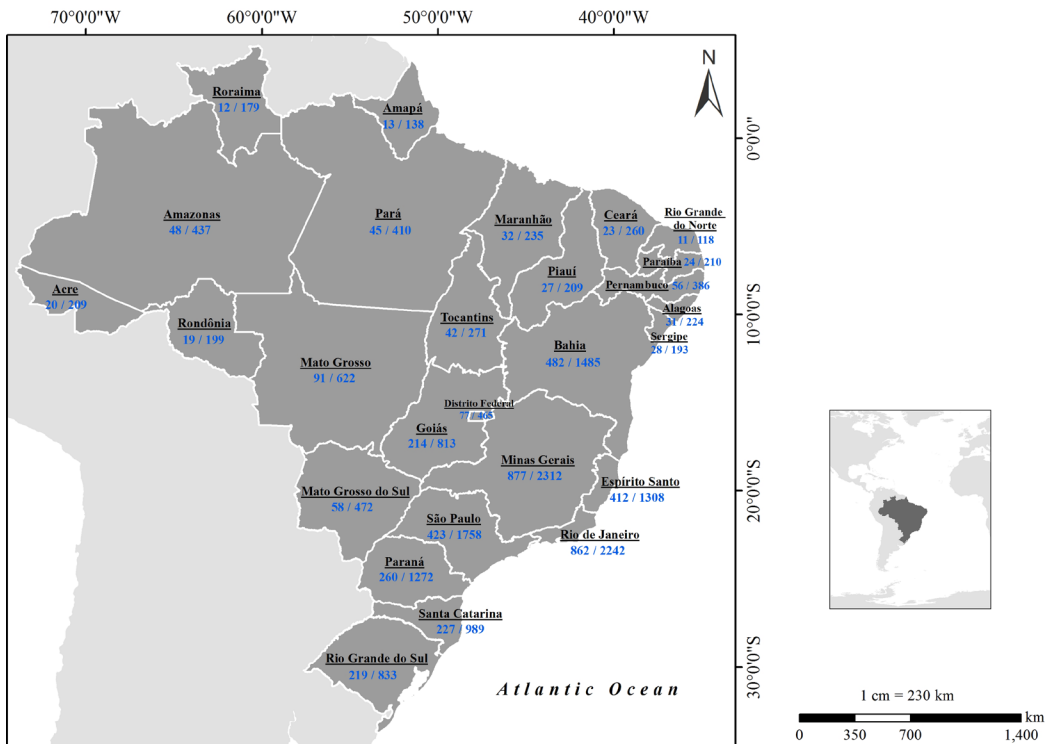


Figure 3 – Number of threatened plant species followed by the number of species with extinction risk assessment, respectively, across all states in Brazil.

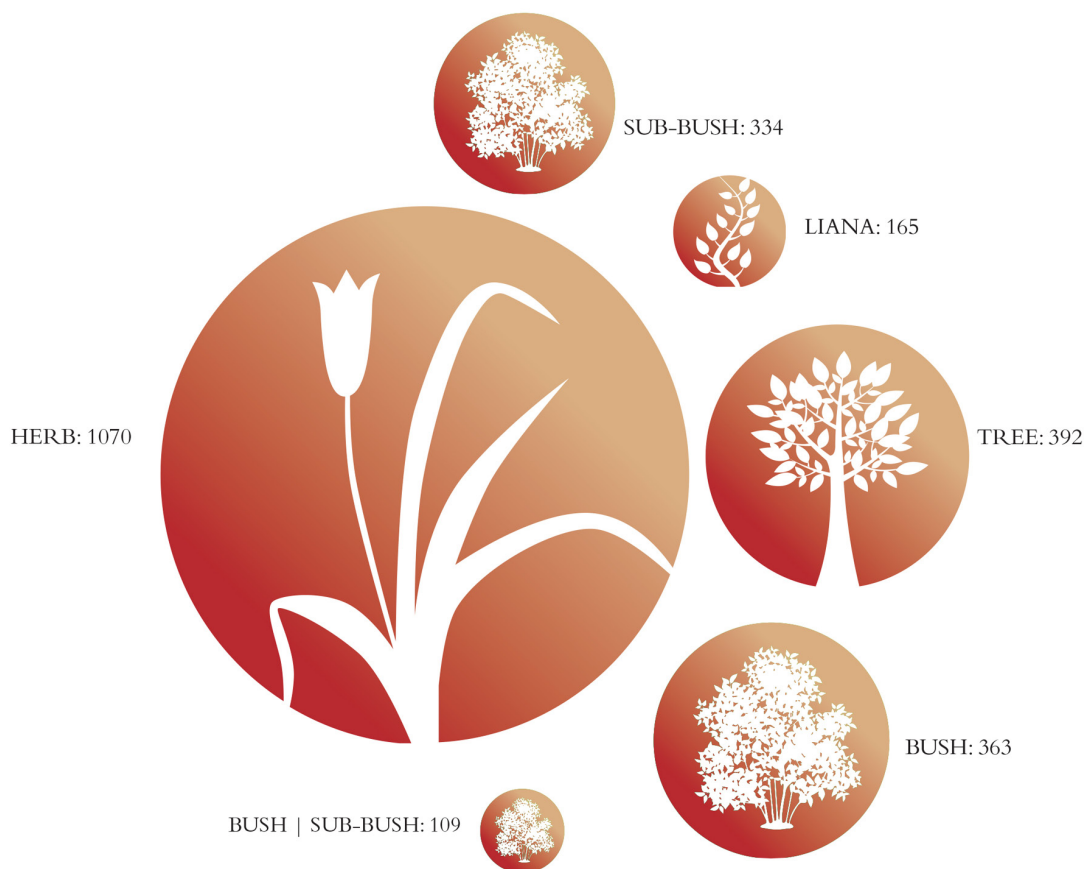


Figure 4 – The most representative life forms (*i.e.* those with more than 100 species assessed) found among threatened species in Brazil.

(Martins *et al.* 2017), it also results in a relatively slow process.

Second, while the CNCFlora is developing tools and applying pilot protocols for rapid assessments of species extinction risk (Souza *et al.* 2016), those protocols have not been used officially until now. When South Africa launched their Red Book on threatened plants in 2009 (Raimondo 2009), it was the first time that a megadiverse country achieved GSPC target 2. However, they did rapid assessments by sorting out which species were clearly not under threat, and therefore Least Concern, which significantly sped up the process (Raimondo *et al.* 2013). The use of such technologies by trained professionals to make decisions on the final classification of species is now an essential trend that has been growing (Souza *et al.* 2016; Krupnick *et al.* 2009; Bachman *et al.* 2011; Cardoso 2017; Dauby *et al.* 2017).

Over the last years, we have witnessed large investments to make scientific collections digitally

accessible all over the world (Beaman *et al.* 2012; Blagoderov *et al.* 2012). Brazil has recently promoted the digitalization and provided access to data from collections from different national herbaria (Gadelha *et al.* 2014; SiBBR 2016). This was an important step to achieve GSPC Target 1 (Martins *et al.* 2017) and now aids in the pursuit of GSPC Target 2. We firmly believe that using new techniques that rely on implementing computing solutions capable of manipulating and analyzing a massive amount of data is a new paradigm in extinction risk assessment (*e.g.* Bachman *et al.* 2011; Cardoso 2017; Dauby *et al.* 2017) and, therefore, should be fostered by the Brazilian Plant Red List authority (Martins *et al.* 2017).

Rapid assessments of extinction risk are not a panacea, however. Financial stability to allow for investments in permanent Human capital, and training programs for taxonomists to work in a more integrated way with risk assessments are also essential (Martins *et al.* 2017). As in many

Table 1 – The 50 more diverse botanical families in Brazil (sensu Brazilian Flora 2020 under construction 2018) along with the number of species they hold, the number and percentage of species already assessed for them, and the number of threatened species relative to total assessments per family in Brazil.

Botanical family	# of species	# of species assessed	% of species assessed	% of threatened species
Fabaceae	2893	336	11.6	42.3
Orchidaceae	2636	437	16.6	34.1
Asteraceae	2143	426	19.9	62.9
Rubiaceae	1496	176	11.8	46.0
Poaceae	1487	135	9.1	48.1
Melastomataceae	1448	248	17.1	59.3
Bromeliaceae	1379	466	33.8	55.2
Myrtaceae	1022	210	20.5	43.8
Euphorbiaceae	965	52	5.4	40.4
Malvaceae	812	65	8.0	21.5
Apocynaceae	803	132	16.4	48.5
Cyperaceae	720	42	5.8	45.2
Eriocaulaceae	657	114	17.4	58.8
Malpighiaceae	575	127	22.1	59.1
Lamiaceae	551	57	10.3	61.4
Araceae	510	54	10.6	46.3
Solanaceae	507	55	10.8	50.9
Piperaceae	464	100	21.6	36.0
Acanthaceae	458	71	15.5	38.0
Lauraceae	456	99	21.7	38.4
Convolvulaceae	429	37	8.6	45.9
Sapindaceae	427	31	7.3	45.2
Bignoniaceae	417	48	11.5	52.1
Annonaceae	371	53	14.3	34.0
Arecaceae	312	48	15.4	37.5
Lejeuneaceae	311	11	3.5	36.4
Verbenaceae	293	38	13.0	68.4
Cactaceae	286	144	50.3	58.3
Chrysobalanaceae	284	27	9.5	66.7
Sapotaceae	246	112	45.5	23.2
Marantaceae	225	16	7.1	43.8
Gesneriaceae	224	81	36.2	59.3
Lythraceae	224	75	33.5	60.0
Velloziaceae	221	63	28.5	82.5
Rutaceae	218	27	12.4	66.7
Moraceae	212	54	25.5	16.7
Iridaceae	211	21	10.0	61.9
Polygalaceae	208	32	15.4	56.3
Begoniaceae	207	90	43.5	60.0
Pteridaceae	204	26	12.7	76.9
Dryopteridaceae	201	23	11.4	17.4

Botanical family	# of species	# of species assessed	% of species assessed	% of threatened species
Ochnaceae	200	22	11.0	81.8
Xyridaceae	191	54	28.3	75.9
Polypodiaceae	179	23	12.8	60.9
Primulaceae	168	10	6.0	30.0
Vochysiaceae	164	13	7.9	92.3
Cucurbitaceae	160	9	5.6	22.2
Amaranthaceae	159	51	32.1	31.4
Turneraceae	159	23	14.5	47.8
Passifloraceae	158	21	13.3	42.9

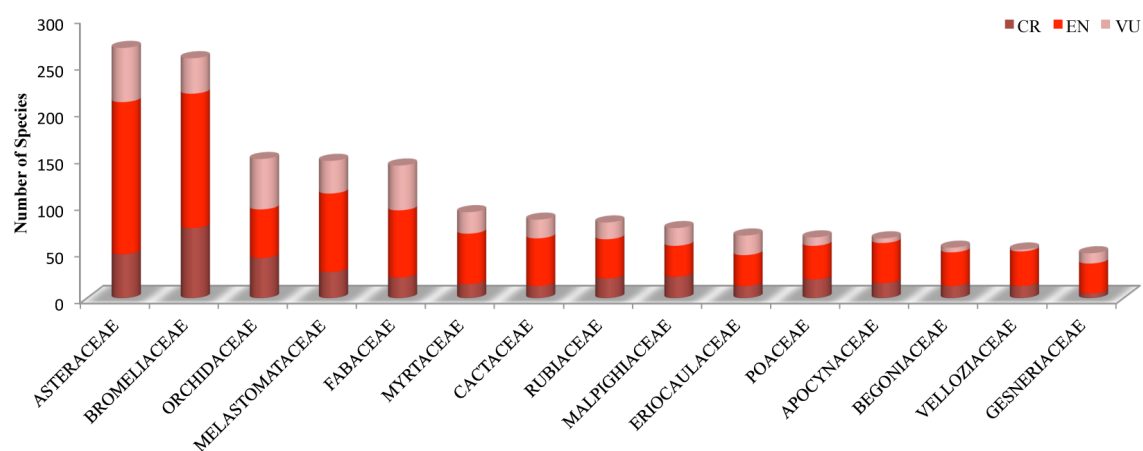


Figure 5 – Number of threatened species in each threat category for the top 15 threatened families of the Brazilian flora. CR – Critically Endangered, EN – Endangered, VU – Vulnerable.

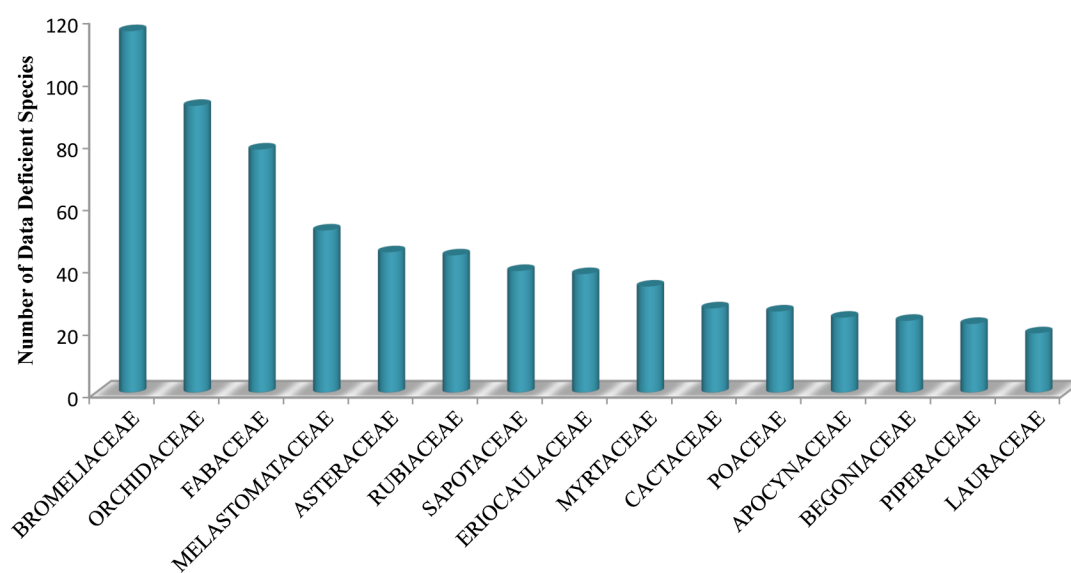


Figure 6 – The top 15 botanical families with data deficient plant species in Brazil.

developing countries, Brazil's challenge to achieve the GSPC targets depends on the government's commitment to investment in the necessary human and financial resources.

In summary, only 15.5% of Brazil's flora has been assessed for its conservation status thus far, with nearly half of those species classified as threatened. While this is not enough to ensure the achievement of GSPC target 2 by 2020, we are confident that this target is important to guide many other efforts and tools for plant conservation (e.g. Loyola *et al.* 2014; 2018; Pougy *et al.* 2015). If assessments follow the same pace as the last eight years, then an estimated 31% of the Brazilian flora will have been assessed by 2020 (Martins *et al.* 2017). However, if assessments start being conducted in a faster way using currently available technology and more funds are delivered towards such assessments, GSPC Target 2 might well be achieved by 2030. Such an achievement would constitute a milestone for the Brazilian national biodiversity strategy.

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