Chapter 20
Conservation Initiatives in the Brazilian Atlantic Forest

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Abstract With a wide distribution across eastern South America, the Brazilian Atlantic Forest is a mosaic of lowland and montane vegetation types, such as evergreen forest, semideciduous and deciduous forest, mixed forest (e.g., *Araucaria*), mangroves, and restingas. It has long been recognized as having one of the most diversified biotas on the planet, with high levels of endemism of plants and animals. Due to its location, European colonization and exploration began six centuries ago in the coastal areas, spreading to the interior and increasing over the last 70 years.

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In response to long-standing deforestation, many conservation actions have been planned and performed by federal and state governments, NGOs, and universities. Here, we compiled some of these initiatives, showing the conservationists' goals and multi-institutional actions to save species and ecosystems across the Brazilian Atlantic Forest. Furthermore, we confirmed here that with a dialogue among government, NGOs, and universities, it is possible to design and perform actions to the conservation of the Brazilian Atlantic Forest.

Keywords Action plans for conservation · Landscape connectivity · Protected areas · Reintroduction · Spatial analysis of prioritization · Threatened species

20.1 Introduction

Two centuries ago, the Prussian explorer and naturalist Carl F. P. Von Martius launched the term dryad to describe the splendid evergreen forest that occurs along the coast of Brazil. The name dryad, in honor of a Greek nympha, represents how von Martius saw the splendid Brazilian Atlantic Forest. Nowadays, after studies of phytogeographers and botanists, such as Helmut Hueck and Henrique P. Veloso, we know that the Brazilian Atlantic Forest is a mosaic of evergreen forest (mostly along the coast), semideciduous forest, deciduous forest, mixed forest (*Araucaria* forest), mangroves, and "restingas." Oliveira-Filho and Fontes (2000) described a gradient of species composition but definitively stated that all these phytophysonomies formed a unique biome known as Brazilian Atlantic Forest. The limits of the Brazilian Atlantic Forest are hard to unravel and depend on the approach and question to be answered (Muilaert et al. 2018).

With around 1,200,000 km^2 of extension and dynamic climatic fluctuations during the Quaternary era, the Brazilian Atlantic Forest harbors an impressive number of species – many of them endemic to the Biome – of trees (Zwiener et al. 2021), epiphytes (Ramos et al. 2021), social insects (Feitosa et al. 2021), fishes and aquatic invertebrates (Padial et al. 2021), and tetrapods (Figueiredo et al. 2021). Human exploration of Brazilian Atlantic Forest began in the sixteenth century but increased in the last 50 years (Fonseca 1985; SOS Mata Atlântica and INPE 2017), and this biome is recognized as a world biodiversity hotspot (Myers et al. 2000). Nowadays, this biome remains as one of the most deforested areas in Brazil with the remaining vegetation cover comprising 28% of the original (Rezende et al. 2018) distributed mainly in small and isolated fragments, where long-term survival without direct human intervention is controversial (Fundação SOS Mata Atlântica, INPE and Instituto Socio Ambiental 1998).

Due to this long-standing deforestation and its expected consequences on plants (e.g., Lima et al. 2015) and vertebrates (e.g., Brooks et al. 1999; Grelle et al. 1999, 2005), the Brazilian Atlantic Forest is the place of many conservations initiatives, including the creation of national and state protected areas (categories I to VI of

IUCN), private protected areas (RPPNs in the Portuguese acronym), corridors, and actions plans for protected species (e.g., Galindo-Leal and Câmara 2003; Pinto et al. 2006; Rocha et al. 2006; Joly et al. 2014). Furthermore, some analyses of spatial prioritizations were already performed in the Brazilian Atlantic Forest using a systematic conservation planning concept, although with few taxa (Pinto and Grelle 2009; Loyola et al. 2014) or focusing on restoration ecology (Crouzeilles et al. 2015; Zwiener et al. 2017; Strassburg et al. 2019).

Herein, we compiled some of the pioneering and large-scale initiatives for the conservation of the Brazilian Atlantic Forest, including initiatives and studies of the Brazilian government, NGOs, and universities. The initiatives described in this chapter allow the implementation of conservation strategies to extensive biodiversity threats such as changes in land use and land cover (Lira et al. 2021 – Chap. 11), climate change (Vale et al. 2021 – Chap. 12), and defaunation (Galetti et al. 2021 – Chap. 14). Note that along with this chapter, we have not included a comprehensive list of all conservation initiatives, but a selection done by the first author following criteria of potential application for all the Brazilian Atlantic Forest.

20.2 Priority Areas for Biodiversity Conservation in the Brazilian Atlantic Forest

In 2017 and 2018, the Brazilian Ministry of the Environment coordinated the second update process to establish "Priority areas for Conservation, Sustainable Use and Benefit Sharing of Brazilian Biodiversity." The establishment of priority areas for biodiversity conservation is a public policy designed to support decision-making in the planning and implementation of conservation measures. These areas are used to direct protected area siting, licensing, and inspection of activities that may cause significant environmental harm and to foster the sustainable use of the nation's territory. Guidelines for the identification of priority areas and actions were established in Brazil by Decree No. 5092 of May 21, 2004 (http://www.planalto.gov.br/ccivil_03/_Ato2004-2006/2004/Decreto/D5092.htm) within the scope of the Ministry of the Environment's responsibilities.

Like previous efforts, the second update process of priority areas was carried out respecting the limits of biomes in Brazil. For the Brazilian Atlantic Forest biome, the process was carried out with the support of a Brazilian conservation think tank and nongovernmental organization, the Instituto de Pesquisas Ecológicas (IPÊ), which was selected through a public bid to conduct the priority areas process.

Beginning with the first updating of priority areas, done in 2006–2007, the process has been based on the use of the systematic conservation planning methodology (Margules and Pressey 2000). This method seeks to identify and select a set of priority areas for the conservation and sustainable use of different features of biodiversity and conservation targets, such as species, habitats, landscapes, ecosystem services, and ecological processes. This approach selects areas considering not only biological and environmental criteria but also anthropogenic variables that may affect the conservation of biodiversity. The objective is to establish a system of areas that contribute to the achievement of conservation goals while considering socioeconomic constraints.

The process follows some key principles, including (i) representation, wide representation of biodiversity components; (ii) functionality, preservation of conservation objects in the long term while maintaining their viability and ecological integrity; (iii) efficiency, maximum biodiversity protection through a solution that achieves conservation goals with the best possible cost-benefit; (iv) complementarity, consideration of existing protected areas so as to maximize the total number of protected objects when adding new areas; (v) flexibility, achieving conservation goals by various combinations of priority areas; and (vi) irreplaceability, identification of areas indispensable for achieving conservation goals.

20.2.1 Participatory Process

Systematic conservation planning is meant to be a highly participatory process, one that includes the opportunity for feedback, revision, and iteration where needed (Margules and Sarkar 2007). The process consists of six stages (Margules and Pressey 2000):

1. Measure and map biodiversity: an extensive review of existing data locates the most suitable datasets to represent biodiversity, identifying similarities and differences among areas. These data can include the locations of species, species assemblages, habitat types, or other desired conservation targets.
2. Identify conservation goals for the planning region: the overall objectives of the process (representativeness and persistence) are translated into quantitative goals for species, vegetation types, and other important features in the planning region.
3. Review existing conservation areas: analyze how much of the goals set in stage 2 are already achieved by existing conservation areas and so what the gaps are.
4. Select additional reserves: with the information on the gaps in the existing conservation areas, new areas are identified to achieve the set of goals established in stage 2. This identification is usually made using selection algorithms or decision-support software considering constraints such as costs, opportunities, and the land use of the planning area.
5. Implement conservation actions: the set of conservation actions to be implemented in each individual priority area is decided.
6. Management and monitoring of reserves: as in stage 2, the management must be monitored based on goals and targets. This monitoring requires the definition of indicators that reflect the success of the conservation actions and drive adaptive management with a continued review of proposed actions.

The second update of priority areas for the Brazilian Atlantic Forest focused on stages one to five and proceeded in the following five broad steps.

20.2.2 Step I: Assessment of the Previous Priority Area Update

The first step's aim was to evaluate the results generated and impacts achieved with the first updating of the priority areas of the Brazilian Atlantic Forest biome, published by MMA Administrative Ruling No. 09/2007. This included a public consultation of 229 representatives from government agencies, educational and research institutions, civil society organizations, and businesses, among others.

The first priority areas revision, done in 2007, indicated a total of 880 priority areas for biodiversity conservation in the Atlantic Forest, distributed over 428,409 km^2. This corresponded to 37.9% of the biome, with 30.6% of the areas lacking protection and 7.3% of areas somehow protected by conservation units or indigenous lands. According to the public consultation, the results of this process were adequate or satisfactory for several activities, including directing research, projecting further planning, creating new protected areas, and directing financial resources, although there was a need for improvement.

In the period between 2007 and 2018, 551 new protected areas were created that have their limits partially or totally overlapping the priority areas established in 2007. This corresponds to 9239 km^2 of protected areas established in areas identified as priorities. Only 240 protected areas were created outside the priority areas, corresponding to 4460 km^2. This is about half the number and extent compared to areas that intersect priority areas, demonstrating a positive effect of this prioritization and an advance in biodiversity conservation in the Brazilian Atlantic Forest over the last 10 years.

20.2.3 Step II: Definition of Targets and Goals

The second step was to gather and systematize spatial data on potential conservation targets. This was followed by a consultation of experts during the "Workshop for the Definition of Targets and Goals for Biodiversity Conservation," held in Atibaia, São Paulo, between April 11 and 13, 2018. The workshop was attended by 40 participants, mainly specialists in various taxonomic groups. During the workshop, the specialists chose the best databases to use for the analysis and defined the specific targets and goals for biodiversity conservation.

To be selected, the targets had to represent the overall biodiversity and have adequate spatial data across the Brazilian Atlantic Forest. Targets chosen included birds, reptiles, amphibians, fish, mammals, and datasets related to plants. Additional species information used was the status of endangerment, whether species had restricted distributions or were endemic to the Brazilian Atlantic Forest, the level of evolutionary distinctiveness, the presence of rare functional traits, overall rarity (for plant species), and plants used for extractive purposes. In addition, conservation targets related to speleological heritage, vegetation physiognomy, and ecosystem services were considered as targets.

For all targets, quantitative conservation goals were assigned using a range of criteria to establish how much of the distribution of each target should be conserved. Among the criteria considered were the vulnerability or biological importance of the target, as well as its spatial distribution (broad or restricted). In total, there were more than 2500 conservation targets selected, distributed in these groups: mammals, birds, reptiles and amphibians, fishes, humid environments, caves, plants, and targets related to ecosystem services and vegetation physiognomies. This was more than 10 times the number of targets considered compared to the last update of the priority areas and was a much wider diversity of targets.

20.2.4 Step III: Definition of the Cost Layer

The third step included the compilation of available spatial data on economic activities or biophysical conditions that are potentially harmful to the environment or somehow incompatible with biodiversity conservation. This step was part of the process of constructing what is known as a cost surface, which would enter later analyses jointly with the biodiversity data. The cost surface indicates areas with relative difficulty to implement conservation and sustainable actions. Such information helps in choosing priority areas while considering both the reduction of conflicts with the productive sector and the achievement of the biodiversity conservation goals.

The data organizing process was followed by a consultation with specialists and representatives of several economic sectors operating in the biome. The "Workshop for Cost Analysis for the Conservation of Atlantic Forest Biodiversity" took place in the city of Florianópolis, Santa Catarina, between June 19 and 21, 2018. It was attended by 45 participants, including experts and representatives of economic sectors that develop activities in the biome.

Of the variables that contributed to the definition of the cost surface, standing out in descending order (from higher to lower incompatibility): urbanization, major ports, refineries, potentially polluting industrial activities, paved roads, agriculture, airports, petroleum distribution terminals, aquaculture, reservoirs (hydropower reservoirs and others), unpaved roads, pasture areas, thermoelectric power generation, wind power generation, mining-related dams, hydrocarbon exploration wells, railways, plantation forestry, smaller ports, hydropower units, biodiesel production, production of ethanol, transportation waterways, power transmission lines, gas pipeline, solar energy capture, and production of biogas.

20.2.5 Step IV: Definition of the Opportunity Layer

The fourth step was the creation of an opportunities layer for conservation and sustainable use, including the production of a georeferenced database of the information. The opportunity layer represents the information about activities and uses of the territory that are more compatible with biodiversity conservation and that promote or facilitate the maintenance of areas for conservation. The “Workshop on Opportunities for the Conservation of Atlantic Forest Biodiversity” took place in Porto Seguro, Bahia, between August 27 and 29, 2018, with 59 participants. Among them were a series of professionals and representatives of groups and institutions working with Brazilian Atlantic Forest conservation, sustainable use, and indigenous and traditional peoples.

Among the variables contributing to the definition of the opportunities layer, standing out in descending order (from higher to lower favorability), is highlighted: the presence of state and municipal conservation units – not yet officially included in the National Register of Conservation Units (CNUC), the proportion of natural vegetation remaining, the presence of restricted use areas and permanent preservation areas (APPs in Portuguese) legally defined based on slope and altitude, landscape connectivity index, governmental proposals for the creation of new protected areas, the presence of quilombo communities and indigenous lands, environmentally differentiated settlements, ecological corridors, birdwatching tourism, and long-distance trekking trails, among others.

The cost and opportunity layers were then integrated to produce the final cost surface, which entered as an input in the analyses to define the priority areas. To join these individual layers, the opportunity layer (resulting from the sum of individual opportunity variables) was subtracted from the costs layer (resulting from the sum of individual cost variables). To avoid a higher weight for one layer in detrimental of the layer, the data layers were each rescaled during the process to vary between 1 and 10.

It is worth noting that other costs and opportunities can be imagined for the Brazilian Atlantic Forest. However, the selection of variables depended on the availability of adequate spatial data that met minimum criteria:

1. Coverage throughout the biome.
2. Needed information in metadata and attribute tables.
3. Accuracy of the location of occurrence.
4. Lack of redundancy with other variables.

20.2.6 Step V: Definition of Priority Areas and Actions for the Conservation of Brazilian Atlantic Forest Biodiversity

The fifth step, the “Workshop on the Definition of Priority Areas and Actions for the Conservation of Atlantic Forest Biodiversity,” was held in Brasília-DF from November 6 to 8, 2018, with 79 participants. They represented 40 institutions linked to educational and research sectors, governmental and nongovernmental agencies, private initiatives, indigenous and traditional peoples, and expert consultants.

Based on the systematic conservation planning approach and the use of the Marxan software, a map of proposed priority areas for biodiversity conservation in the Brazilian Atlantic Forest was presented. With the contribution of workshop participants, it was further refined and adjusted, synthesizing the four previous steps into one final layer. This represented the best set of areas to meet conservation goals, regarding landscape permeability and connection and reduction of conflicts with productive activities. During the workshop, the participants also discussed the best set of actions to recommend for each priority area.

20.3 Outcomes of the Participatory Process

In December 2018, MMA Ordinance No. 463 of December 18, 2018, was published, recognizing the new priority areas for the conservation, sustainable use, and sharing of benefits of Brazilian biodiversity (Fig. 20.1). The maps, databases, and associated information were made publicly available for consultation on the MMA website: http://areasprioritarias.mma.gov.br.

Priority areas for the Brazilian Atlantic Forest biome covered a total of 246,893 km^2, representing 22.3% of the biome and a reduction compared to 2007, which selected 346,191 km^2 (30.6% of the biome), excluding areas already having

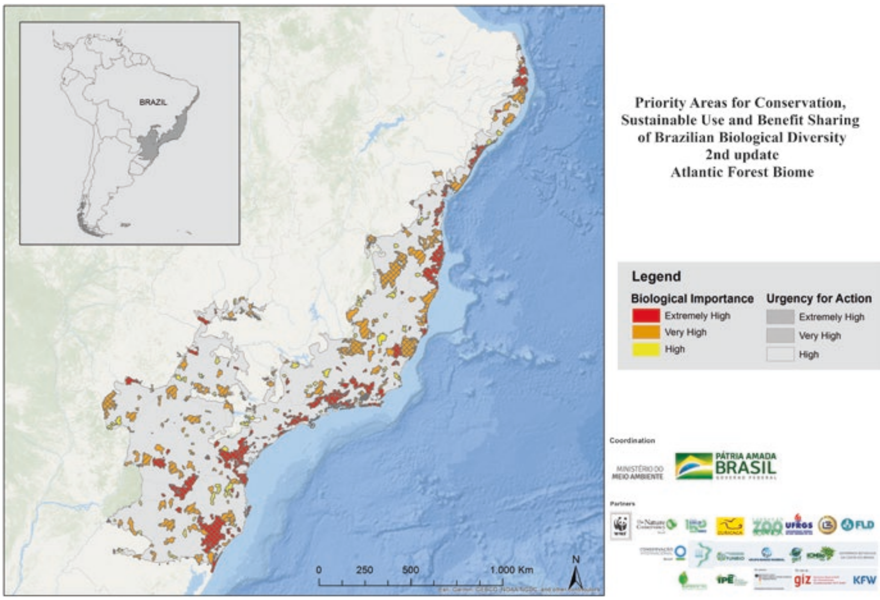

Fig. 20.1 Priority areas for Conservation of Brazilian Atlantic Forest biodiversity, recognized by MMA Ordinance No. 463, of December 18, 2018

protection. This decrease is a result of an exercise that used more consistent databases and georeferenced information, as well as the use of the Marxan system that allowed the selection of areas that, although smaller in number and area, managed to reach 99.5% of the goals for the more than 2500 targets chosen.

Actions and measures that were most frequently cited as the main conservation action for priority areas were limitation/regulation of degrading activities, recovery of degraded areas, integrated and participatory management of protected areas, establishment of ecological corridors and recognition of territories of traditional peoples and communities, creation of conservation units, creation and strengthening of territorial management, measures targeting the protection of species, and monitoring, inspection, and control of illegal activities (e.g., deforestation, hunting, predatory fishing).

Going forward, it is recommended that the priority areas and recommended actions be periodically reviewed by MMA, within a period not exceeding 5 years. During this period, the MMA will disseminate the instrument to subnational governments such as state and municipal regulators, as well as other public and private bodies and institutions that work with biodiversity conservation. The aim is to guide specific actions that can be effectively implemented, achieving results and not just being recommendations on paper.

Throughout the updating effort, the careful elaboration of spatial databases and detailed records of the priority areas process brought more reliability to the results. Now, it is possible to understand which elements have stood out in the choice of each priority area. In addition to greater transparency, this allows the tool to be incorporated for use in other environmental management actions, such as prioritization of research and licensing of development or environmental activities. The extensive involvement of many segments of society in this search for better conservation strategies was a major contribution. Such broad involvement makes the results more likely to be viable for practical application in one of the most threatened biomes on the planet.

20.4 The Brazilian National Centre for Flora Conservation (CNCFlora in the Portuguese Acronym)

The colossal Brazilian plant biodiversity imposes overwhelming difficulties in terms of setting up coordinated efforts regarding the implementation of effective conservation actions. This question becomes even more complex to overcome when it is clear that the amount of newly described species annually in a given country is similar to the number of species that have their extinction risk assessed, and ways to scale up in the detection of species at risk sharply contrast with the ever-increasing rate of natural ecosystems depletion. Although this conundrum remains only partially addressed, two major steps of effective conservation strategies are (i) knowing the identity of *foci* subjects, e.g., name and taxonomic description of all organisms in a given area, and (ii) estimating the extinction risk of the present organisms using the best information available in order to deliver sound conservation actions.

Brazil is a signatory of the Convention on Biological Diversity (CBD) and follows the Global Strategy for Plant Conservation (GSPC) objectives to set integrated conservation actions to guarantee the perpetuation of plant diversity in the country. Acknowledging the need to identify and detect which plants are facing elevated risk of extinction, the GSPC defined 16 essential targets to put forward conservation actions and bring back plant species from the brink of extinction. Among these, Target 1 calls for "a widely accessible working list of known plant species as a step toward a complete world flora," while Target 2 calls for "an assessment of the conservation status of all known plant species, as far as possible, to guide conservation action." Nationally, Target 1 is almost complete due to efforts undertaken to prepare the list of species of the Brazilian flora (2008–2015) and the Brazilian flora 2020 (2016–present). Knowledge of plant conservation status is currently available because of the establishment in 2008 of the National Centre for Flora Conservation (CNCFlora).

CNCFlora was created within the infrastructure of the research Institute of Rio de Janeiro's Botanic Garden (JBRJ in Brazil acronym) that is a federal autarchy subordinated to the Brazilian Ministry of the Environment, with the purpose of conservation of the Brazilian flora. Its main responsibility is to provide, to the Ministry of the Environment and other governmental agencies, technical and scientific information in order to support decisions related to the conservation of the Brazilian flora. Since its creation, CNCFlora supported REFLORA project in its aim to issue a new list of the Brazilian flora – replacing the previous one, *Flora Brasiliensis*, from 1908 (BFG 2018) – mapping out almost 46,000 species in the country, including all terrestrial plants (angiosperms, gymnosperms, ferns, and lycophytes and bryophytes) and algae and fungi species (Flora do Brasil 2020 *in prep*).

Additionally, the center assessed to date the extinction risk of over 6830 terrestrial plant species. Outcomes of these efforts resulted in the update of the National Red List, where 2113 plant species are considered threatened and therefore are subject to specific regulations by the Brazilian government (MMA 2014).

In summary, CNCFlora's mission is to (i) prevent the extinction of species of the Brazilian flora and coordinate efforts to save those detected as threatened (CR, EN, VU), (ii) meet international commitments assumed by the country in the CBD through the GSPC, and (iii) meet the national goals expressed in the Brazilian Biodiversity Policy. In practice, CNCFlora is responsible for the preparation of red lists and action plans (National Action Plans) of Brazilian plants, as well as the coordination of ex situ conservation efforts and the execution of scientific expeditions in priority areas for plant conservation and research.

Although the national scope of the center's work, many initiatives focusing on the Brazilian Atlantic Forest were conducted in previous years. Considering the importance of this iconic biome of both regional and global conservation relevance, here, we synthesize the main activities of CNCFlora for the conservation of the Brazilian Atlantic Forest flora, targeting initiatives that the organization directly or indirectly conducted or promoted in order to secure a healthy destiny for unique flora assemblages contained in this biome and its marginal ecosystems.

The incredible plant diversity in the Atlantic Forest is revealed by substantial increase in knowledge verified in recent years, as since 2010, at least 1471 seed plant species have been added to the national list (Martinelli and Moraes 2013). From this rate, it is evident that many areas within the Atlantic forest remain poorly botanized, and some highly diversified taxonomic groups still neglected from robust scientific investigations (Sobral and Stehmann 2009). Many additions to this ever-growing species list are constantly being made, and nowadays, the most up-to-date tally indicates the occurrence of nearly 18,200 terrestrial species occurring in the biome, of which 8720 (48%) represent single-biome endemics (Flora do Brasil 2020 *in prep*). However, regarding the whole flora conservation status detection and actions to save them, we still have a long way to go.

Over the last 8 years, 19% of the flora inhabiting Brazil had its conservation status assessed by CNCFlora. These assessments deal with plants distributed throughout the whole country and across all Brazilian biomes and were assessed in different initiatives: the first Brazil's Flora Red Data book comprised reassessments of 4617 species previously included in regional red lists published by governmental or nonprofitable agencies (Martinelli and Moraes 2013) and is the baseline of the Brazilian Official List of Threatened Species (MMA 2014), from which 1212 (57%) are (not exclusively) Atlantic Forest species.

Martinelli et al. (2018) also assessed the conservation status of 884 plant species endemic to the state of Rio de Janeiro, thus occurring inside the biome's limit. Additionally, risk assessments were also carried out for newly described species within the biome, and lastly, risk assessments of 800 endemic trees were conducted in a partnership with the Global Tree Assessment (GTA) from the Botanic Garden Conservation International (BGCI), out of which 406 (51%) were pointed as Atlantic Forest species. All assessments which are not yet included in the National Red List (MMA 2014) are being submitted constantly toward the Ministry of Environment and will eventually be included in such a crucial normative tool.

As expected, the Brazilian Atlantic Forest had the highest number of species assessed to date, followed by the Cerrado. From almost 18,200 plant species occurring in the Atlantic Forest, 4350 species have their risk assessments undertaken by CNCFlora. From these, 1875 (43%) are considered threatened, and 1675 (38%) correspond to single-biome endemics. From those identified under a given threat category, 415 (22%) are considered critically endangered (CR), 1034 (55%) endangered (EN), and 426 (23%) deemed as vulnerable (VU). Finally, a great deal of species (702% and 16%) were classified as data deficient (DD), as there is not enough information available to robustly define its conservation status. Further studies regarding DD species distribution, population trends, and threats are critical to assess its extinction risk, hence promoting the implementation of accurate conservation measures for species which are frequently disclosed as threatened once further data come out to light (Bland et al. 2017).

20.4.1 Priority Areas for Plant Conservation and National Actions Plans

The implementation of tailored conservation actions is essential to be continued to ensure effective conservation of threatened plants. Conservation planning in Brazil must be compatible with the current socioeconomic reality, considering the great territory, the high biological diversity, the presence of key areas for regional and/or global conservation, and the limited availability of human and financial resources to act directly in the design, implementation, and monitoring of actions (Loyola et al. 2014). Thus, the designation of priority areas for threatened plant species conservation is an efficient tool to select those areas in which conservation actions targeting endangered flora is most urgently needed.

In this scenario, CNCFlora conducts the process of elaboration, implementation, and monitoring of national action plans for the conservation of endangered flora. The design of such a guiding tool can be planned upon different planning units (from species-specific to relevant taxonomic groups or even for entire ecosystems and territories), but usually, a territorial approach is applied as it is among the most cost-effective mechanism to protect simultaneously several threatened species and their habitats. By this means, this approach reduces financial costs and enables the development and implementation of actions consistent with combating and mitigating threats affecting populations of multiple species.

Adopting as a planning unit of micro-watersheds, an initiative was conducted in 2014 by CNCFlora and Biogeography Laboratory of Goiás University with a total of 70 micro-watersheds within the Atlantic Forest which are a priority for plant conservation, where 27 areas are designated as with extremely high priority, 21 with very high priority, and 22 with high priority. The 27 extremely high-priority micro-watersheds are located mainly in the state of Rio de Janeiro and Espírito Santo, as well as off the coastline of São Paulo, a portion in Bahia, and in the transition region between the Atlantic Forest and the Cerrado hotspots in Minas Gerais. In total, priority areas for conservation of endangered flora correspond to 15.7% of the total area of the Atlantic Forest, highlighting the pertinence of these ecosystems for full conservation actions to be taken (Loyola et al. 2014).

Considering the importance to conserve Rio de Janeiro's flora as a whole due to its high concentration of priority areas for plant conservation within the Atlantic Forest, CNCFlora conducted, in partnership with the State Environmental Secretary (SEA), the conservation assessments of all Rio de Janeiro State's endemic plants (Martinelli et al. 2018), also ranking areas of conservation priority for actions targeting these endemics (Loyola et al. 2018; Pougy et al. 2018). The action plan was elaborated in a participatory process with relevant stakeholders that act in the conservation arena in the state, planned upon thematic lines and also indicating actors, specific legislation and public policies, research, and species and habitat management and awareness pertinent to the implementation of outlined mitigation actions.

The arboretum program has been working since 2010 in carrying efforts to conserve, restore, and raise awareness to the importance of the *Hiléia Baiana* Flora (a widely recognized hot-point within the Atlantic rainforest hotspot) and have on CNCFlora a crucial partner so its mission can be achieved and whose technical team has been supporting many of their activities. The program's mission is to conserve and restore forest diversity as a strategy to value forest resources, generating and disseminating sound scientific knowledge. The program spams from threatened plants seed collection, seedling cultivation, and forest restoration in order to support the development of productive chains integrated with the forest and local communities. Both activities revert in economic outcomes for the locals. To date, 1178 tree individuals from 524 species were selected, tagged, and had germplasm gathered by Arboretum staff, to be cultivated in one of the many local nurseries found in the region, including many species threatened with extinction. For instance, Arboretum nurseries produced together 342,556 seedlings of Atlantic Forest native tree species. Further work foreseen by this joint project will produce an action plan for the conservation of threatened trees occurring in southern Bahia, integrating plant conservation and forest restoration programs.

CNCFlora also established in 2017 a partnership with Rio de Janeiro State Secretary of Environment in order to trigger restoration initiatives in the state by selecting and tagging native tree species for prospective germplasm collection, cultivation, and utilization in restoration programs across the state. The project consisted of an innovative approach since it was the first of this kind to mark trees inside protected areas, following the publication of the state Resolution INEA-RJ 139/2016 and, from that, allowing seed collectors and nurseries to gather germplasm inside state's strict protected Areas. In this context, 849 native tree species from distinct ecological succession stages were tagged, geolocalized, and collected for taxonomic identification in five states' strict protected areas and are now included in a database of support for guiding state's nurseries future work in produce seedlings to be used in restoration efforts in Rio de Janeiro. From the species tagged in this work, 21 are considered threatened and are therefore key elements for ecosystem enrichment of restored areas. Additionally, 161 specimens gathered during the work represent the first botanical record held in one of the five protected areas, directly contributing to the consolidation of botanic knowledge inside these protected areas.

Additionally, to the aforementioned contributions, CNCFlora also participated in several conservation initiatives in the Atlantic Forest Hotspot, as described below:

1. National Action Plan of Faveiro-de-Wilson (*Dimorphandra wilsonii* Rizzini)

   An important effort undertaken in 2014 resulted in the publication of the Action Plan of the *Faveiro-de-Wilson*, a critically endangered (CR) tree endemic to transitional forest formations between the Atlantic Forest and the Cerrado in the state of Minas Gerais. The aim of this joint initiative among CNCFlora and the Botanic Garden of Municipal Parks Foundation and Zoobotânica (FPMZB) was to promote the effective conservation of this iconic forest resource, also enhancing the conservation status of further 42 threatened plant species occurring sympatrically. Before the initiative started in 2014, only 246 trees were known from wild populations. To date, the *Faveiro-de-Wilson* is now known 420 mature individuals, highlighting the impact coming from tailored research and action which amplified considerably its known population size, its data availability, and consequently its accurate conservation status and effective protection of its habitat.

2. The “Wanted Campaign”: In Search of Long-Lost Species in Rio de Janeiro State

Along the extinction risk assessment effort undertaken for Rio de Janeiro endemic plant species (Martinelli et al. 2018), half of the 884 taxa considered restricted to the state’s border were assessed as data deficient (DD). To deal with such an obstacle imposed by the lack of robust information, CNCFlora started the “Wanted Campaign,” as a complement to the Project “Protected Areas – PAs of the state of Rio de Janeiro: analyses and strategies for the conservation of threatened endemic flora.” The campaign aimed to obtain more data in the field and in non-digitized herbaria on these DD species and, thus, provide sufficient information for extinction risk assessment. Species collected and identified on DD-targeted expeditions plus exsiccates consulted in herbaria resulted in 44 targeted species found. Of these, 25 are from active searches in the field, 22 are records from non-digitized herbaria and private collections, and 3 were found on two campaign’s areas of action. This result shows the importance of fieldwork targeting gap species and points out the need to encourage research with such species even in areas where collection efforts are often regarded as sufficient. Despite the success of the campaign, what can be spanned throughout the whole country, hundreds of species endemic to the Rio de Janeiro still in need of data to be adequately assessed (Rosa et al. 2018) in order to prevent thousands of DD species slipping unnoticed toward extinction.

20.4.2 Current and Prospective Contributions

It is evident the necessity of adopts a participatory approach, since the beginning until delivery stages of any conservation action. Therefore, it is clear that multiple, committed stakeholders, with the appropriate scientific and political support, can promote sound conservation interventions in this iconic biome. Results and findings herein present would not be feasible without the full adherence of a broad network of scientists, decision-makers, and society as a whole.

With a guiding mission and well-defined and consequential positive outcomes after more than 10 years of innovative conservation measures, CNCFlora is steadily working on several national and international fronts to move forward so its mission can be fully accomplished. Just recently, CNCFlora updated the joint agreement with BGCI and set up new targets to be addressed between 2019 and 2020 regarding the completion of further 1000 trees full conservation assessment, which will double the current figure of evaluated Brazilian trees. We expect that this project represents the much-needed ignition triggering a complete analysis of the current conservation status of Brazilian trees – a step further toward the understanding of the conservation status of the whole Brazilian flora.

Moreover, CNCFlora and partners are also engaged since the end of 2018 with the Global Environmental Facility – GEF PRO-SPECIES project, a multistakeholder initiative aiming to improve tools to prevent extinction, recover populations, and promote knowledge and sustainable use of the Brazilian biodiversity. The project offsets conservation efforts from the simple detection of species likely to be threatened to actually plan concrete strategies to move such species out of red lists.

20.5 Private Protected Areas as Biome-Scale Strategy

Brazil has the largest and one of the best structured private protected area systems in the world. Private Natural Heritage Reserves (RPPNs in Brazil acronym) currently protect almost 780,000 hectares, distributed in 1536 reserves, located in almost 800 municipalities of the 27 units of the federation.

Comparing the total protected area and the average area of the units between public units and RPPNs may lead to the hasty conclusion that RPPNs have little relative importance in the nature conservation scenario. After all, although more than half of Brazilian protected areas are RPPNs, areas where they represent only 0.31% of the total protected by the system or about 0.5% if we exclude all public marine and ocean protected areas. The average area of the RPPNs (508 hectares) is equivalent to 0.37% of the average area of the continental public protected areas (138,563 hectares). Even with their rather modest size, RPPNs have been important in ensuring the protection of endangered species populations, endemic and rare species, and portions of ecosystems that are not adequately protected by the public network (Pinto et al. 2012; Crouzeilles et al. 2013). RPPNs also play a potentially relevant role in protecting ecosystem services, since in many Brazilian municipalities, as well as some river basins that supply small- and medium-sized cities in the country, the only existing PA is an RPPN.

20.5.1 RPPNs in the Atlantic Forest

The Atlantic Forest is the biome with the largest number of RPPNs. Seven out of every 10 RPPNs in the country are located within the Atlantic Forest. Several authors have noted the importance of voluntary initiatives to create private protected areas in the Atlantic Forest, mainly because it is a region where more than 80% of the natural remnants are in private lands (Costa et al. 2004; Rambaldi et al. 2005;

Pinto et al. 2012). As recorded in Mesquita (2014), there are at least four factors that explain the predominance of the biome in RPPN statistics.

The first factor refers to the average socioeconomic profile of biome owners, especially in the states of the Southeast, which house half of the Atlantic Forest RPPNs. According to Mesquita (2004), Vieira et al. (2004) and Oliveira et al. (2010), a significant portion of the rural owners of the region have personal or family income from activities that have no relation to the rural property where the reserve is inserted and even less with the management of the RPPN itself. They are mostly small- and medium-sized entrepreneurs and traders, self-employed or successful career employees, civil servants, executives, or people who have inherited a family property and have been able to ensure the perpetuation of its existing natural heritage. This factor, combined with a higher level of education and greater sensitivity to the planet's challenges to environmental and climate issues, makes it possible to assume that rural owners of the Atlantic Forest are, on average, citizens with a more prominent environmental conservation awareness and culture. Thus, the combination of better informed and more conscious citizens with landowners who are not economically dependent on their land may explain, at least in part, a greater interest in the creation of private protected areas in this biome.

The second factor may be related to the land tenure network found in the Atlantic Forest. In the region, the proportion of micro, small, and medium properties is much higher than in any other biome, which explains the fact that the Atlantic Forest RPPNs present the smallest average area when compared to the reserves of other biomes. A larger proportion of small properties results in a larger number of properties. The existence of more real estate certainly influences the number of RPPNs, although the interest in the creation of reserves was proportionally equivalent to that found in other biomes.

The third fact is related to public policies and state government programs, which were decisive for the growth of the number of reserves in the biome. State environmental agencies in Minas Gerais, Paraná, Rio de Janeiro, and São Paulo – four out of the five states with the most RPPNs – have implemented programs that have encouraged and supported their creation. More than 70% of the Atlantic Forest RPPNs are located in these four states.

The fourth factor, which also explains the existence of various RPPN clusters, is the performance of civil society organizations, which since the last decade of the last century have promoted the creation of RPPNs in priority areas for biodiversity. In Mesquita (2014), we find a detailed analysis of this factor, passing through the Atlantic Forest Central Corridor and the region of occurrence of the golden lion tamarin (detailed later in this section).

Still on the role of these initiatives, we cannot fail to note the impact of the Atlantic Forest RPPN Incentive Program, a pioneering initiative led by the partnership between the SOS Mata Atlântica Foundation and Conservation International. Over the 13 years of this program, more than 200 new RPPNs were created, in addition to supporting the management and protection of another 130 reserves (Costa 2014).

Several authors have highlighted the role of private reserves in complementing government nature protection efforts, allowing in many situations to maintain a higher degree of connectivity of the natural landscape (Lees 1995; Morsello 2001; Langholz 2005; Pinto et al. 2004; Vieira et al. 2004). There is a lot of published evidence about the increased representation of priority conservation areas, not yet covered by the network of public protected areas (Mesquita and Leopoldino 2002; Mesquita and Vieira 2004).

The keyword is complementarity. If we consider the need for the formation of ecological corridors and mosaic landscapes, presenting protected areas combined with different land uses that are permeable to the transit of animals and seeds, the existence of several RPPNs in the interstices of parks and public reserves is undoubtedly one of the most efficient strategies. The public authority has the task of establishing large protected areas that ensure the protection of representative samples of ecosystems and the maintenance of ecological processes. It is incumbent upon the RPPNs, in a complementary manner, to form a network of protection or cushioning of impacts around public areas, promoting ecological permeability in strongly fragmented landscapes, such as the Atlantic Forest.

In some cases and regions, however, the role of RPPNs becomes central and preponderant. There are many river basins and hundreds of municipalities where the only existing conservation unit is an RPPN. Some species of the Atlantic Forest depend very heavily on RPPNs for their survival. This is the case with the muriquis and the golden lion tamarin.

The Feliciano Miguel Abdala RPPN, located in municipality of Caratinga at Minas Gerais state, is home to the largest population of northern muriquis, one of the 25 most endangered primates on the planet. It is estimated that the nearly 1000 hectares of this reserve house one-third of the entire remaining population of this species. In addition to the muriquis, the reserve also protects significant populations of howler monkeys (*Alouatta guariba*) and the rare tamarin (*Callithrix flaviceps*), two other endangered species. Over the past three decades, the owners' effective protection of the area has resulted in a tripling of the muriqui population.

The Mata do Sossego RPPN, located in the municipality of Simonesia at Minas Gerais state, about 80 km from Caratinga, is one of them. Created more than 20 years ago by the Biodiversitas Foundation (a distinguished conservationist NGO), it houses a scientific center that has monitored muriquis. In addition, the organization promotes various actions and partnerships along with the forest fragments between the two RPPNs. The objective is to encourage the adoption of land use practices that favor the formation of an ecological corridor between them, including the restoration of permanent preservation areas.

The golden lion tamarin (*Leontopithecus rosalia*), a highly endangered primate, which has the last habitat in the Atlantic Forest of north central Rio de Janeiro, also has the necessary reinforcement of the RPPN for its protection. Although there are two federal biological reserves in the municipalities of Silva Jardim and Casemiro de Abreu, the nearly 13,000 hectares of Poço das Antas and União is not sufficient to ensure the long-term preservation of the species. Applying the method called "population assessment and habitat viability," scientists estimated that at least 2000 golden lion tamarins would be required to live freely in at least 25,000 hectares of well-preserved and connected forests to ensure the survival of the species.

20.6 NGO SOS Mata Atlântica

SOS Mata Atlântica Foundation is a Brazilian environmental NGO that acts on the development of public policies for the conservation of this biome through environmental monitoring, production of studies, demonstrative projects, dialogue with public and private sectors, improvement of environmental legislation, communication, and society engagement. The SOS Mata Atlântica seeks to engage people, generate knowledge, and mobilize resources for our mission to inspire society in the defense of the Brazilian Atlantic Forest, transforming values and attitudes across the biome.

However, we live in an outdated model of development sustained in the myth of abundance. All the main economic cycles in the country's history followed the logic that growth occurs through territorial expansion and deforestation, from the exploitation of Pau-Brasil (*Caesalpinia echinate*), agriculture, and cattle raising to the industrialization and expansion of cities. Starting at the coast, our society ended up with about 90% of the original Atlantic Forest area. Therefore, in addition to conserving, we need to restore our forests, especially in springs, and riparian forest areas to mitigate the current and future risks of water shortages. There are many initiatives on restoration ongoing in Brazilian Atlantic Forest (De Siqueira et al. 2021 Chap. 18), and SOS Mata Atlântica has already planted more than 40 million seedlings of native Atlantic Forest species in more than nine states and 550 municipalities, helping to remove 6.5 million tons of CO2 from the atmosphere. This corresponds to an area of 23 thousand restored hectares, equivalent to the city of Recife, Pernambuco state. The Forests of the Future program, responsible for this result, brings together organized civil society, private initiative, landowners, and the public authorities in participatory forest restoration projects.

The SOS Mata Atlântica has a nursery that meets the Forests of the Future project with the capacity to produce 750,000 seedlings of 110 native Atlantic Forest species per year. The nursery is located at the SOS Mata Atlântica Forest Experiment Center – Heineken, Brazil, located in Itu, São Paulo state, which is a reference in Atlantic Forest restoration. This restoration initiative consists of not just planting seedlings of native species in the region, but actually reproducing a functional native environment, with the presence of regional biodiversity and providing ecosystem services – such as carbon sequestration, improvement of water and quality and amount, and restoration of natural landscapes – services that the forest exerted in its original state.

With the Atlantic Forest Atlas, SOS Mata Atlântica identifies and monitors the biome constantly update the number of forest remnants and natural areas. Held in partnership with the National Institute for Space Research (INPE in the Portuguese acronym) and with the technical implementation of Arcplan, SOS Mata Atlântica made possible, in the early 1990s, a diagnose of the situation of the Atlantic Forest. This initiative is fundamental for the development of new studies and vital strategies to ensure the protection of the biome, having subsidized, among other things, the construction and approval of the Atlantic Forest Law (11.428/2006).

An achievement of society, this law regulates the protection and utilization of the biodiversity and resources of this forest. It aims to ensure the rights and duties of citizens and public agencies to exploit it consciously and sustainably without harming its ecosystem. In addition, it creates financial incentives for ecosystem restoration, with donations from the private initiative for conservation projects, regulates the article of the Constitution that defines the Brazilian Atlantic Forest as a National Heritage, delimits its domain, prohibits the deforestation of primary forests, and creates rules for economic exploitation.

The Atlantic Forest Atlas contributes to environmental management and the improvement of legislation and public policies aimed at the conservation and restoration of the biome, the protection of water, biodiversity, and associated marine environments. Over the years, the Atlas has evolved with the advancement of information technology and geoprocessing, methodology, and quality of satellite imagery.

The Brazilian Atlantic Forest has is the only biome ensured by a specific law that, associated with other laws, regulates its use and conservation. To avoid setbacks and make improvements possible, SOS Mata Atlântica works with the legislature, executive, judiciary, prosecutors, and various channels of civil society participation – such as councils, commissions, public hearings, and regulatory agencies. Partnerships with other NGOs in networks, movements, observatories, and coalitions are also established. In this policy action, SOS Mata Atlântica seeks to influence and manage opportunities for formulating, implementing, and defending the priority laws and public policies for the Brazilian Atlantic Forest in favor of forest restoration, enhancement of parks and reserves, clean water, and protection of the sea. Also, the Brazilian Atlantic Forest offers services essential for our survival and well-being, as well as for activities important to our economy (Pires et al. 2021 – Chap. 16).

The SOS Mata Atlântica has also initiatives to clean up the Atlantic Forest rivers by collecting water quality data from volunteers and mobilizing civil society. Of the freshwater available in the world, 12% is in Brazil, but the distribution is very uneven, and the main rivers of the country have worrying rates regarding the quality and availability of water. By observing the rivers, SOS Mata Atlântica organizes volunteers and mobilize them to monitor the water quality of the Atlantic Forest rivers. The results are periodically released as a way to alert society and the public power and contribute to the improvement of legislation around this theme.

20.7 Academic Actions

20.7.1 Reintroduction of Vertebrate Populations in the Atlantic Forest Biome

Most of the Atlantic Forest remnants nowadays consist of defaunated forests (sensu Dirzo et al. (2014)). Therefore, the Atlantic Forest biome is badly in need of reintroductions of locally extinct vertebrate populations, in order to recover species in the brink of extinction, to rebuild native faunas, and also to restore ecological interactions (such as seed dispersal and pollination), thus keeping ecosystem health in the remaining forest blocks (Fernandez et al. 2017).

The need for active interventions against the emptying of the Atlantic Forest had been perceived by some of Brazil's pioneer conservationists as early as the 1960s; therefore, the Atlantic Forest has the longest history of animal reintroduction of any biome in Brazil. Adelmar Coimbra-Filho and Antonio Aldrighi tried to restore the impoverished vertebrate fauna of Tijuca National Park, within Rio de Janeiro city, in the early 1970s, reintroducing 25 bird species, seven mammals, and one reptile (Coimbra-Filho and Aldrighi 1971). There was little know-how about reintroductions at that time, the reintroduced populations were not monitored, and most of these reintroductions failed. However, at least two of them, the channel-billed toucan (*Ramphastos vitellinus*) and boa constrictor (*Boa constrictor*), have succeeded.

Other early initiatives concerned two species of lion tamarins, the golden lion tamarin (*Leontopithecus rosalia*) in Rio de Janeiro and the black lion tamarin (*L. chrysopygus*) in São Paulo state. Coimbra-Filho was the one who sounded the alarm that *L. rosalia* was in a critical situation in the early 1970s, leading to the establishment of Poço das Antas Biological Reserve, where its last large population was found. Thereafter, the newly founded Golden Lion Tamarin Association reintroduced *L. rosalia* to several forest fragments in northern Rio de Janeiro state, starting in the 1980s (Kierulff et al. 2012). The reintroduced animals came from international zoos and translocations from remaining populations – including Poço das Antas – in order to improve the species' conservation *status*. The largest area to receive reintroduced goldens became in 1998 an important protected area in its own right (União Biological Reserve), primarily because of its acquired importance for the tamarins. Meanwhile, in the Pontal do Paranapanema region in western São Paulo state, the Ecological Research Institute (IPÊ), led by Claudio Valladares-Pádua, used reintroductions to improve the perspectives of survival of *L. chrysopygus*. Like its golden cousin, the species had been mostly confined to the last stronghold – Morro do Diabo State Park – but it was also reintroduced, to several smaller forest remnants of the region.

Another long-standing, important project is the reintroduction of the vinaceous-breasted amazon (*Amazona vinacea*) to the Guaragueçaba region in Paraná state, part of the largest remaining Atlantic Forest block. This program has been carried out by the Wildlife Research Society (SPVS) and "Instituto Espaço Silvestre" for over two decades now and has successfully blended research, management, and community involvement, increasing considerably the situation of this endangered parrot.

The onset of the new millennium witnessed an explosive worldwide increase in the use of reintroductions and rewilding as conservation tools (Seddon et al. 2007). This global perception of the need for a more active instance toward conservation would sooner or later reach Brazil, and so it happened. Therefore, the pace of reintroductions in the Atlantic Forest has dramatically increased in these last decades.

An important initiative, for example, was the reintroduction of red-billed curassows (mutums, *Crax blumembachii*) and jacutingas (*Pipile jacutinga*) to Reserva

Biológica Guapiaçú (REGUA), a private reserve in northern Rio de Janeiro state, carried out by Christine Steiner São Bernardo and Mauro Galetti. Although the reintroduction stood on the verge of success for several years, it eventually suffered from sponsorship problems and failed. Recently, the idea of reintroducing jacutingas to REGUA has been resuscitated under the guidance of the ornithologist Pedro Develey and SAVE Brasil.

Meanwhile, the Refauna project started in 2010 with a different and even more ambitious initiative: not to reintroduce a single species, but to reconstruct, as far as possible, the whole native vertebrate fauna of an empty forest (Fernandez et al. 2017). The area chosen was Tijuca National Park, a 3953 ha area surrounded by Rio de Janeiro city, a good "natural laboratory" due to its easy access for the researchers and isolation from other natural areas. The reintroduced populations are all monitored post-release, as well as their role in restoring missing ecological interactions. The Refauna project has been carried out by a consortium led by several researchers – Fernando Fernandez, Alexandra Pires, Marcelo Rheingantz, and Maron Galliez – and composed by several partner institutions such as Universidade Federal do Rio de Janeiro, Universidade Federal Rural do Rio de Janeiro, Instituto Federal do Rio de Janeiro, Rio de Janeiro Primatology Center, Rio de Janeiro Zoo, FIOCRUZ, Center for Alocation of Wildlife – Seropédica, and others.

The first species reintroduced to Tijuca National Park by Refauna was the agouti (*Dasyprocta leporina*) in 2010; the animals came from semi-captivity in an urban park and the reintroduction was considered successful (Cid et al. 2014; Kenup et al. 2018). The second species was the howler monkey (*Alouatta guariba*), reintroduced in 2015, from a variety of captive sources. The howlers' reintroduction has run into several problems, mostly from animals getting too addicted to human contact and from health concerns linked to the yellow fever outbreak in Brazil. Although the population persists, success is by no means sure. Both the reintroduced howlers (Genes et al. 2019) and the agoutis have successfully restored ecological interactions in Tijuca National Park. The third species being reintroduced by Refauna, the yellow-footed tortoise *Chelonoidis denticulata*, was brought from captive populations to Tijuca National Park starting in 2019, and the project intends to bring more species in sequence.

A welcome offshoot of the Refauna project was the reintroduction of the lowland tapir, *Tapirus terrestris*, to REGUA. Tapirs had been extinct in Rio de Janeiro state for more than a century, since 1914. TNP would be too small for a viable population of tapirs, but REGUA – with 7000 ha and part of a 70,000 ha block of Atlantic Forest including Três Picos State Park – provides a better option. This initiative has been led by Maron Galliez, and since 2017, 10 tapirs have been brought to REGUA to start the new population and monitored post-release. The population is thriving well, but it is still too early to evaluate the tapir's reintroduction success.

The developments along this last decade have been quite encouraging, and hopefully, population reintroduction will be a very useful tool to mitigate the effects of defaunation in the Atlantic Forest in the foreseeable future.

20.8 Landscape Connectivity and Perceptual Ranges

Landscape connectivity, the degree to which a landscape facilitates or prevents movements of organisms (Taylor et al. 1993), is a central concept to understanding effects of habitat loss and fragmentation (Haddad et al. 2017), viability and conservation of metapopulations (Hatfield et al. 2018), metacommunity dynamics (Monteiro et al. 2017), and ecosystem functioning (Staddon et al. 2010; Thompson et al. 2017). Ultimately, landscape connectivity depends on the successful movements of organisms through the landscape, between habitat patches, generally fragments of native vegetation, and should be used in strategies for conservation in biomes such as Brazilian Atlantic Forest. Recent advances in two recent areas of study have opened new perspectives on predicting probabilities of movement thought the landscape: understanding of perceptual ranges and the use of scattered trees, plantation rows, and matrix elements in general as guiding structures for animals. Prediction allows action and design of landscape management strategies to improve connectivity, biodiversity conservation, and maintenance of ecosystem services in human-altered landscapes.

The perceptual range is empirically defined and measured as “the distance from which a particular landscape element can be perceived as such (or detected) by a given animal” (Lima and Zollner 1996). The success in finding suitable habitat patches when moving in the landscape depends to a great extent on their perceptual range (Zollner and Lima 1999; Vuilleumier and Perrin 2006; Pe’er and Kramer-Schadt 2008). Frequent movements connecting local populations are mainly dependent on perceptual ranges, which may be within the home range of individuals, differing from occasional long-distance dispersal movements beyond their home ranges (Pe’er et al. 2011). Recent studies by perceptual ranges of nonflying vertebrates of the Atlantic Forest have opened a new perspective on predicting probabilities of routine movements between habitat fragments (Forero-Medina and Vieira 2009; Prevedello et al. 2010, 2011).

The general experimental design to measure perceptual ranges involves translocation experiments: individuals are removed from their home ranges and released in an unfamiliar landscape at varying distances from a habitat patch; the maximum distance where most individuals are considered oriented toward the habitat patch when released is considered its perceptual range (Goodwin et al. 1999; Zollner 2000; Forero-Medina and Vieira 2009). More complex designs are possible to separate potential confounding effects, such as innate bias in movement direction (Olden et al. 2004; Fletcher Jr et al. 2013). Empirical estimates of perceptual range based on this basic experimental design were made for small mammals in temperate (Zollner and Lima 1997; Zollner 2000; Mech and Zollner 2002; Schooley and Branch 2005; Flaherty et al. 2008) and tropical landscapes such as Brazilian Atlantic Forest (Forero-Medina and Vieira 2009; Prevedello et al. 2010, 2011). Estimates of perceptual ranges can now be used to simulate loss or gain of patches of native vegetation in landscapes, including corridors, restoration of riparian habitats, and their effects on landscape connectivity (e.g. Pe’er and Kramer-Schadt 2008).

Animals also have other strategies to orient themselves beyond perceptual ranges, frequently using elements of the matrix between forest patches, an information that can be used to manage landscapes to improve connectivity. Animals frequently use natural or man-made linear structures to quickly cross distances in an unfamiliar matrix, such as plantations rows in Brazilian Atlantic Forest (Prevedello and Vieira 2010; Sozio et al. 2013). If these linear structures were established connecting forest patches, populations otherwise isolated could become connected. Scattered trees in pastures or plantations are another matrix element used by forest animals to move between remaining forest patches (Manning et al. 2009; Fischer et al. 2010; Le Roux et al. 2018; Prevedello et al. 2018). The distribution of scattered trees could be managed to improve connectivity between forest patches.

The previous strategies to increase landscape connectivity are implemented within the spatial scale of a river catchment area and can have great impact on a larger geographical scale, a "bottom-up" strategy to enhance biodiversity conservation. A "top-down" strategy is also possible, for example, setting priorities for reforestation throughout the whole Atlantic Forest biome (Banks-Leite et al. 2014). Native species richness is always affected by habitat loss, but there seem to be thresholds of habitat loss beyond which species richness reduces more drastically, at a faster rate (Pardini et al. 2010; Estavillo et al. 2013; De Coster et al. 2015; Roque et al. 2018). These thresholds are points that should not be crossed, beyond which the costs of habitat restoration increase dramatically; thus, efforts and resources should be applied to landscapes whose native forest cover was reduced to levels close to these thresholds (Banks-Leite et al. 2014). Connectivity estimates at such geographical scales, larger than the landscapes of river catchments, can also be used to infer habitat availability and areas that are vital or more effective to reforest, which have a larger importance connecting larger areas, or to decide on the best strategy for forest restoration, active or passive (Crouzeilles et al. 2011, 2015).

20.9 Concluding Remarks

Natural resources can be a plentiful capital in megadiverse countries and important for human welfare (Constanza et al. 1997). It is from this natural resource (hereafter natural capital) that humans derive a wide range of ecosystem services, which make human life possible. Therefore, the conservation of biomes such as Brazilian Atlantic Forest is fundamental, and it is possible with effective environmental policy, including protected areas and conservation planning (Bustamante et al. 2019).

Obviously, to achieve these objectives, a country needs commitment, knowledge, and budget funding for science among other factors. As science-based decisions are crucial, scientific production and an integrated decision between researchers and policy makers are necessary. This dialogue among local communities, companies, and NGOs should be the goals of all megadiverse countries, and the present chapter – with authors from the Brazilian government, NGOs, and universities – shows how it is happening in Brazil. However, to run these initiatives, some budget is needed.

Unfortunately, these recent trends are paralleled by budget cuts in science and conservation funding. However, some authors argue that such cuts may have consequences for the commitments of the Brazilian government, such as sustainable development goals, Aichi targets, and Nationally Determined Contribution (Fernandes et al. 2017; Dobrovolski et al. 2018). Therefore, with potential consequences for global biodiversity and the ecosystem services (Overbeck et al. 2018) but the links between the socioecological science produced in the country and policy-making remain far from established. As expected, sustainable and environmental development depends on investments in science and technology (e.g., Tallis et al. 2008; Scarano 2017).

Recently, a report showed that there was a cut off funding of Brazilian Environmental Ministry, with a drastic reduction of the budget in the last years (WWF 2018). This cut of funding and the drastic reduction in budget for research in Brazil affect all initiatives described above in this chapter.

On the other approach, in the last 20 years, there was a flourish in scientific production in Brazil (Fernandes et al. 2017) that has a 13th position in the global ranking of scientific production (Clarivate Analytics 2017). The period evaluated in this report of Clarivate (between 2011 and 2016) reflects the grew up in budget funding in Brazil, with a peak in 2013 (Fernandes et al. 2017). Besides this and according to the Clarivate report (Clarivate Analytics 2017), environmental/ecology is one of the fields of knowledge in which Brazil can emerge as an international leader. Thus, there are evidences that Brazilian scientists are ready to help in the definition of conservation strategies and resource management.

In this chapter, we list a myriad of conservation initiatives, showing a governmental and nongovernmental concern on the future of Brazilian Atlantic Forest. The good news is a scientific maturity and a wish to work together in the design and implementation of strategies of conservation of the Brazilian Atlantic Forest.

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