

Essays and Perspectives

Bird Conservation in Brazil: Challenges and practical solutions for a key megadiverse country



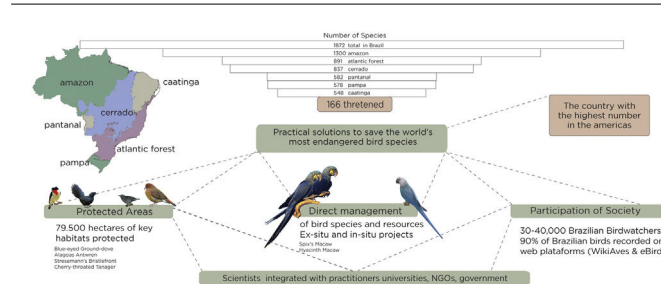
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HIGHLIGHTS

- Brazil is among the three countries with the highest diversity of bird species in the Americas, but it is the first in number of threatened birds with 166 species.
- Greatest number of endangered species are recorded in the Atlantic Forest.
- 79,500 ha of new areas officially protect the most endangered bird species in Brazil.
- 30–40,000 Brazilian birdwatchers generating information for bird conservation.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 25 September 2020
Accepted 6 February 2021
Available online 3 March 2021

Keywords:
Birds
Conservation
Brazil
Red List
Protected Areas
Civil Society

ABSTRACT

Brazil is among the three countries with the highest diversity of bird species in the Americas. However, it ranks first in number of threatened birds with 166 species. Changing this troubling scenario is not an easy task and requires the active involvement of society and engagement in practical conservation measures, besides gathering quality scientific information. Measures such as the implementation of protected areas, conservation initiatives on privately-owned lands and the direct management of certain species have contributed to reverse this status of threat to Brazil's birds. In the last two decades public and private protected areas encompassing 79,500 hectares have been created specifically to protect some of the world's most endangered bird species such as the Blue-eyed Ground-dove (*Columbina cyanopis*), Alagoas Antwren (*Myrmotherula snowi*), and Cherry-throated Tanager (*Nemosia rourei*). The integration between ranchers and environmental sectors has also resulted in positive outcomes for the grasslands of southern Brazil, where 242 bird species (six of them globally threatened) are being conserved on private lands. Direct management was key to foster population growth in species such as the Hyacinth Macaw (*Anodorhynchus hyacinthinus*) in the Pantanal region. Population recovery is also the only hope for the Spix's Macaw (*Cyanopsitta spixii*) to return to nature, through a reintroduction program led by the Brazilian government in association with international partners. The active participation of society is also crucial and is bolstered by the recent growth in the number of Brazilian birdwatchers, currently estimated at between 30 and 40 thousand people. New web tools such as *WikiAves*, a community science website that provides access to over 3 million photographs of Brazilian birds, as well as eBird,

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are being used to store all the information generated by birdwatchers. Thanks to their contribution, many knowledge gaps regarding the distribution of Brazilian birds are being filled, while we nurture a society that is much more attentive to the cause of bird conservation. Even considering the inefficient and detrimental environmental policy of the current government, integrated practical actions backed by good scientific knowledge and civil society participation can help Brazil to reverse this alarming title of being the Americas' number one country in number of endangered birds.

Introduction

Reversing bird population declines and improving the threat status of birds require working with people to conserve habitats and manage species directly. Effective outcomes depend on the cooperation of multiple actors to achieve a balance between biodiversity conservation and human development, going far beyond biological issues (Fitzpatrick and Rodeald, 2016).

Brazil and the Neotropical region are of global importance as regards bird diversity and the number of endangered species. The high number of endemics in the Neotropics further raises the responsibility of the region's countries for maintaining one of the most diverse avifaunas in the world. In the first part of this article, I present a brief review to highlight the importance of Brazil for the conservation of birds in the Neotropical region in comparison with other countries. Then, acknowledging that effective bird conservation involves multidisciplinary solutions including human aspects, I discuss practical solutions for the conservation of Brazilian birds along with recent results and future challenges.

The birds of the Neotropical region and Brazil's relevance

The Neotropical region stands out when compared to other regions of the planet as regards bird diversity. According to data from the Cornell Lab of Ornithology (2018), a total of 4194 species of birds are found in the region, corresponding to almost half of all the bird species on Earth. The 10 richest countries in bird species are: Colombia, Brazil, Peru, Ecuador, Bolivia, Venezuela, Mexico, Argentina, Panama and Costa Rica (Table 1). These 10 countries also have the highest numbers of globally-threatened and endemic birds - and Brazil is the country with the highest numbers in both respects (Table 1). To compare different countries considering the number of endangered species presents some limitations since countries that have higher diversity are expected to have more threatened species. The Red List Index

Table 1

Total number of bird species, number of globally-threatened species and number of endemic species in neotropical countries with the highest diversity of birds.

Country	Number of species ^a	Number of threatened species ^b	Number of endemic species in the country ^c
Colombia	1962	120	91
Brazil	1872 ^d	166	264
Peru	1855	108	137
Ecuador	1621	99	41
Bolivia	1416	54	20
Venezuela	1408	53	56
Argentina	1004	53	16
Mexico	1054	69	80
Panama	978	23	10
Costa Rica	905	28	9

^a del Hoyo et al. (2018).

^b BirdLife International (2020).

^c del Hoyo et al. (2018).

^d According to the Brazilian Ornithological Records Committee (*Comitê Brasileiro de Registros Ornitológicos - Piacentini et al., 2015*), there are 1919 bird species in Brazil. Here, however, the estimates and taxonomy of the Handbook of the Birds of the World were adopted to facilitate comparisons with other countries.

(RLI) would be a better indicator in this case, however, there is no available information at a national level considering just birds. RLIs for a group of species (mammals, birds, amphibians, corals and cycads) at global and regional levels can be accessed at <https://www.iucnredlist.org/assessment/red-list-index>. Even so, the number of endangered species is a critical indicator of the health of one country's biodiversity, adopted in different policy contexts and helping to guide funding priorities.

Because birds are considered to be excellent indicators of environmental quality (Gardner et al., 2008), the large number of endangered birds reflects the problematic situation of the conservation of the Neotropical region. In fact, according to Phalan et al. (2013), in the early 2000s, the expansion of agriculture in South America, Africa and Tropical Asia was considerably higher when compared to other world regions, with Brazil being one of the countries with the highest expansion of crops; mainly soybean and sugar cane. Forests, savannas and grasslands are the environments most impacted by agriculture in Brazil (Foley et al., 2005), while the conversion of natural lands into pastures is the single largest cause of deforestation (Graesser et al., 2015). Even though certain bird species may be able to adapt to new habitats, expansion of croplands and pastures represents one of the greatest threats to global biodiversity, accounting for the decline in the populations of 74% of all the globally-threatened birds in the world (BirdLife International, 2018). Other threats that affect a substantial percentage of all globally-threatened bird species are selective logging (50%), invasive species (39%), hunting and capture (35%) and climate change/severe weather (33%). According to the World Wide Fund for Nature (WWF/Dalberg, 2012), illegal hunting and trafficking alone affect about 1.5 million birds in Brazil annually.

Unfortunately, Brazil is not only the country with the largest number of globally-threatened birds in the Neotropical region, but also the second in the world (Indonesia ranks first with 170 species). The importance of Brazil in relation to endangered birds is also clear when considering the categories of the greatest threat concern alone, as defined by the International Union for Conservation of Nature (IUCN), i.e. Critically Endangered (CR), Extinct in the Wild (EW) and Extinct (EX). In Brazil, there are 24 species in these three categories, with Colombia coming next with 16 species, and then Ecuador with 9 species (BirdLife International, 2020). If we then add all the species in the Near Threatened (NT) category (i.e. 123) to the number of endangered birds (166), we have a total of 289 bird species of concern for conservation in Brazil, which makes the country a top priority for bird conservation globally.

The general distribution of birds in the different Brazilian biomes, as well as the distribution of species under threat of extinction, is not uniform (Table 2). Considering the six Brazilian biomes (following the Brazilian classification of IBGE, 2004) and Coastal and Marine Zones, both the greatest diversity of species and the number of endangered species are observed in the country's two largest tropical forests, the Amazon and the Atlantic Forest (Table 2). The high number of endangered birds in the Atlantic Forest is explained by the long history of human occupation through European colonialism and associated environmental degradation across the entire region (Ribeiro et al., 2009). In the Amazon Rainforest, comparing the data presented in this article (57 endangered species) with data provided by Marini and Garcia (2005) (20 endan-

Table 2

Total number of species and number of threatened species in the six different Brazilian biomes and in the Coastal/Marine Zones (see note 1).

Biome	Species	Threatened Species ^h
Amazon	1300 ^a	57
Atlantic Forest	891 ^b	84
Cerrado	837 ^c	48
Caatinga	548 ^d	24
Pantanal	582 ^e	9
Pampa	578 ^f	13
Coastal/Marine Zones	130 ^g	13

Note 1: It is important to emphasize that the number of bird species found in a given region varies according to the calculation criteria used, mainly in the definition of the biome's limits. New discoveries and increased research also lead to variations in numbers. Differences in methods and lack of systematization make comparisons difficult.

^a Marini and Garcia (2005).

^b Lima (2013).

^c Silva (1995).

^d Araujo and Silva (2017).

^e Nunes (2011).

^f Bencke et al. (2009).

^g Marini and Garcia (2005).

^h The author himself by overlapping the area of occurrence of each threatened species with the area of the biome.

gered species), we observe a worrisome increase in the number of threatened bird species. Part of this increase is explained by habitat loss, combined with the number of new species described to science in recent years that are already threatened at the time of their discovery. Although around 80% of the Amazonian forests are conserved, and progress was made in reducing deforestation in the first part of this century (Nepstad et al., 2014), deforestation rates have systematically risen in the last years (2013–2019), with a slight decline in 2017, but with a new significant increase in 2019 and 2020 (INPE, 2020). Deforestation is concentrated in the north of Mato Grosso state and eastern Pará; regions of occurrence of many bird species with restricted geographical distributions and, therefore, high vulnerability. These more threatened regions of the Amazon also house several of the new species recently described (Elliott et al., 2013), which have already been classified as threatened. The situation of Amazonian forests may worsen in the coming years due to a *savannization* process (synergistic effect between extreme droughts, forest fragmentation, selective logging and fire, making the forest drier). According to Lovejoy and Nobre (2018) a further decrease (20–25%) in the forest cover in eastern, southern and central Amazonia may reach a tipping point when moist forests would irreversibly transform into savannas. The significant increase in fires in the region recorded in the dry seasons of 2019 and 2020 and the lack of a government coordinated plan to fight these fires make the scenario even worse. Unfortunately, the increase in fires and rates of deforestation are direct results of the current government's detrimental policy towards the environment, not only in the Amazon, but also throughout the country.

The general pattern of species distribution per biome, as well as the number of endangered bird species, are strong criteria to define where the greatest conservation efforts should be focused in the country. The orientation of bird conservation efforts can also be based on the identification of Important Bird and Biodiversity Areas (IBAs), the largest and most comprehensive global network of sites that are significant for the persistence of biodiversity in the country. In Brazil, 237 IBAs have been mapped (see <http://datazone.birdlife.org/country/brazil/ibas>) based on four criteria: 1 – number of threatened birds, 2 – number of endemic species *per* biome, 3 – number of restricted range species, 4 – high concentration of congregatory species (Bencke et al., 2006; De Luca et al., 2009). The goal of creating IBAs is to protect and manage a network of sites that are important for the long-term viability of

naturally occurring bird populations across the geographical range of those bird species. IBAs are a practical tool for on-the-ground conservation actions (Bencke et al., 2006). Of the total IBAs identified in Brazil, 123 (nearly 52%) are in the Atlantic Forest, which reflects the high number of threatened and endemic taxa thereof. After the identification of these priority sites in Brazil, a total of 348 protected areas were established in these IBAs, representing the protection of approximately 2.5 million hectares of key habitats for birds (Develey et al., 2020). IBA identification is a dynamic process and ideally should be reviewed and updated according to the availability of new information and changes to species' status and occurrence. Future climate scenarios should also be considered in IBA identification, since according to model projections some bird species of conservation concern for which IBAs have been identified may not remain in these sites as climate changes (BirdLife International and National Audubon Society, 2015).

The number of endangered species and diversity of species puts Brazil as a priority country for biodiversity conservation, and urgent practical actions are required. Even considering the current situation of great concern regarding environmental policy in the country, fortunately, there are already good examples of actions which are directly contributing to habitat protection and the recovery of the populations of many endangered bird species, as discussed next.

Results and challenges for conservation in practice

1. Designation of Protected Areas and Indigenous territories

The designation of protected areas is considered one of the most efficient tools for the conservation of biodiversity (Possingham et al., 2006). In Brazil, many public protected areas were designated in the first decade of the new millennium (2000–2009), especially in the Amazonian region, which currently has a total of 120 million hectares in protected areas representing 27% of the entire biome (CNUC, 2018). When indigenous territories are added to this total, more than 45% of the Amazon forest is under some form of protection.

While the Amazon has the largest extension of public protected areas in Brazil (120 million hectares/351 areas), the Atlantic Forest harbors the highest number (1224) of protected areas (strict protection reserves and sustainable use reserves). Although many of the latter protected areas are small, the total area adds up to 11 million protected hectares (CNUC, 2018).

In the Atlantic Forest, although the overall number of hectares under some form of protection is high, only 2.8 of the 11 million hectares are areas of strict protection (with the rest being areas of sustainable use or other designation) (CNUC, 2018). This creates an element of concern regarding bird conservation priorities. In addition, there is no available data on how many threatened birds in Brazil have populations inside protected areas, and such information should guide future systematic conservation planning. Even so, recently created protected areas represent a concrete gain for the conservation of some of the most threatened birds in the country, which were previously not officially protected. In 2010, a creative partnership among scientists, NGOs and public authorities resulted in the implementation of the 27,000-hectare National Park and Wildlife Refuge of Boa Nova (Bahia). This Park protects 400 species of birds (10 globally-threatened species), including the Endangered Slender Antbird (*Rhopornis ardesiacus*) (Albano, 2010; Bencke et al., 2006). Also established in Bahia, Serra das Lontras National Park protects 330 bird species, 16 of which are globally threatened (Develey and De Luca, 2009). In both cases the whole process of protected area creation began with the publication of scientific articles highlighting the unique ornithological impor-

tance of these regions (e.g. [Gonzaga et al., 1995](#)). Further North, in Alagoas, the 6116 hectares of Murici Ecological Station protects one of the last remnants of the Northeastern Atlantic Forest, with 16 globally-threatened species and the only recent occurrence site of the Critically Endangered Alagoas Antwren (*Myrmotherula snowi*) ([Bencke et al., 2006](#)). Murici is also the location of the last known sighting of the recently described Cryptic Treehunter (*Cichlcolaptes mazarbarnetti*), which is already extinct, along with the Alagoas Foliage-gleaner (*Philydor novaesi*). Unfortunately, for these two species, conservation initiatives arrived too late to prevent their disappearance. In the Brazilian Cerrado, a State Park established in 2018 with 35,682 hectares is preserving the only known population of the Blue-eyed Ground dove (*Columbina cyanopsis*).

Although legally established, most Brazilian Protected Areas are still not fully implemented or resourced. In other words, they are “paper parks”. The main reasons for this are the lack of funding for land regulation, the complexity of land tenure and lack of community support. According to [Silva et al. \(2021\)](#), the Brazilian government only allocates 15.5% of the total cost estimated for an adequate management of all federal protected areas, consequently there is a large and increasing funding deficit for proper implementation of these areas. Protected areas in the Amazon are mostly underfunded in comparison with the Atlantic Forest and Brazilian Cerrado. All of the five areas mentioned above are affected by this problem to some extent. Despite this scenario, the official designation of a protected area constitutes an important step to prevent certain threats such as large-scale mining or agribusiness; in addition, it provides a mechanism for adding the region into the Brazilian Ministry of the Environment’s responsibility and annual budget. As an example, in the case of Amazonia, all protection regimes contribute significantly to reducing deforestation rates in the region and areas for strict protection and indigenous reserves are more efficient in resisting deforestation than areas for sustainable use ([Nolte et al., 2013](#)).

2. Conservation on Private Lands

The creation of public protected areas is fundamental, but private protected areas also make a substantial contribution to the conservation of threatened bird species. Because they are private, these areas are usually much smaller. According to the *Confederação Nacional de RPPNs*, in the entire country there is a total of 807,602 hectares of private reserves (mean = 490.05 SD +/- 2.394). Some of the rarest species in Brazil are safeguarded in private protected areas owned by NGOs. While remaining in private ownership, these protected areas are legally endorsed by the federal or state governments as Private Natural Heritage Reserves (i.e. *Reservas Particulares do Patrimônio Natural*), which share the responsibility with the owner for conserving the areas. An extremely positive example of a private protected area contributing to bird conservation is the case of the Critically Endangered Blue-eyed Ground-dove (*Columbina cyanopsis*). The rediscovery of this species after 75 years was a relevant recent event in the ornithological world. By the end of 2017, two years after the species’ rediscovery, the spot where it was found (in a Cerrado location in northern Minas Gerais state) was protected, providing a refuge for the tiny population of just 27 individuals (SAVE Brasil, unpublished data). Brazilian NGO SAVE Brasil (BirdLife International in Brazil) purchased and established a private reserve of 593 hectares with support from Rainforest Trust, a US-based organization. This effort leveraged the state government to create the state park in the same region, as mentioned above.

Another good example is the protection of the Critically Endangered Araripe Manakin (*Antilophia bokermanni*) in a 135-hectare Atlantic Forest reserve belonging to Brazilian NGO Aquasis, purchased with support from American Bird Conservancy (ABC). Alongside NGOs, there are also examples of private companies that

have created their own reserves, such as the 1200-hectare reserve established in an Atlantic Forest area in Espírito Santo state, which represents one of the only occurrence sites of the Critically Endangered Cherry-throated Tanager (*Nemosia rourei*).

The creation of private protected areas is not always a viable solution, especially areas with a high economic potential for agribusiness. In regions of high agricultural potential that also harbor high biodiversity, there is a need to devise ways to integrate agricultural production with environmental conservation – one of the greatest challenges facing the conservation community.

An example of a successful initiative has been implemented in the South American Pampa. The grasslands of southern South America originally spanned an area of one million square kilometers, divided between Argentina (60%), Brazil and Uruguay (18% each) and Paraguay (4%). According to [Bencke et al. \(2009\)](#), 120 species of birds are adapted to open grassland habitats in the Brazilian South. In 2004, concerned with the high rates of habitat loss in the grasslands caused by the expansion of soybean farming and exotic trees plantations, BirdLife International created the “*Alianza del Pastizal*” (www.alianzadelpastizal.org). The main objective was to bring together the different local stakeholders in the conservation of the Pampa’s biodiversity, working directly with cattle producers. One of the main economic activities in the Pampa is cattle ranching, a traditional and profitable activity in the region for centuries. The high diversity of grass species is an excellent source of food for livestock, while also providing habitat for a high diversity of grassland birds. *Alianza del Pastizal* has been seeking to integrate biodiversity conservation and livestock production in a win-win process.

The main activity of the *Alianza del Pastizal* is to work with cattle producers to promote livestock production in native grasslands (rather than fertilized grasslands planted with non-native grasses). To be a member of the *Alianza*, cattle producers need to certify their farms. Certification establishes environmental and production criteria. One of the main requirements is the presence of native grasslands on at least 50% of the property. As an added incentive, meat produced from native pastures is not only more environmentally friendly, but also more beneficial to human health when compared to meat produced in feedlots or non-native grass production systems ([Freitas et al., 2014](#)). From the moment cattle producers become part of *Alianza*, they receive a package of benefits, which includes:

- a - A best management practices for grasslands training program to increase profitability while supporting a healthy habitat for birds and other wildlife;
- b - A “bird-friendly” beef program, meaning that the meat produced in member farms receives a quality seal of the *Alianza del Pastizal*. Consumers can look for this seal when purchasing meat, and producers are able to charge more for this option that is friendlier to the environment and birds.
- c - Low interest lines of credit and other financial mechanisms for producers who agree to adopt best management practices to improve native pastures while also benefitting cattle production (e.g. construction of fences or restoration of degraded pastures). The credit lines are available through a partnership with a rural bank which provides socio-environmental responsibility programs focused on agribusinesses. About 10% of the loans taken by producers are subsidized by the *Alianza*, using funds donated by conservation organizations.

The Pampa is an environment that allows for traditional economic activity to be integrated with biodiversity conservation without the need for major changes in production methods. But, even under these circumstances, the dialogue between producers and conservationists is not easy and requires a lot of flexibility,

patience and pragmatism on both sides. Despite the challenges, the outcomes in recent years have been positive. Two of the main environmental indicators used to evaluate the effectiveness of the initiative were the number of hectares of preserved grasslands and changes in bird diversity on the properties. Considering all four countries (Argentina, Brazil, Uruguay and Paraguay), *Alianza* currently works with 560 private properties. In the state of Rio Grande do Sul (Brazil) alone, there are 139,000 hectares of native grasslands preserved in 241 properties. The bird surveys in 20% of these properties recorded 242 species of which 58 are typical grassland birds (Bencke in litt.), representing 53% of the species associated with the temperate grasslands of southeastern South America (Azpiroz et al., 2012). Some of these species are dependent on tall grasses such as the Sharp-tailed Tyrant (*Culicivora caudacuta*), Sedge Wren (*Cistothorus platensis*) and Chestnut Seedeater (*Sporophila cinnamomea*) and six are globally-threatened, such as the Saffron-cowled Blackbird (*Xanthopsar flavus*), and Black-and-white Monjita (*Xolmis dominicanus*).

Requirements for the conservation of native vegetation on private lands in Brazil is established by the Forest Code law ('Código Florestal', or Law No. 12.651/2012). The law determines two instruments for this purpose: the Legal Reserve ('Reserva Legal') and the Permanent Preservation Area (*Área de Preservação Permanente* - APP). Legal Reserves require the preservation of a percentage of the property with native vegetation cover which varies depending on the biome where the property is located (80% of forests in the region known as *Amazônia Legal* - i.e. the states of Acre, Amapá, Amazonas, Pará, Rondônia, Roraima and Tocantins, as well as part of Mato Grosso and most of Maranhão; 35% of areas located in the Cerrado within *Amazônia Legal*; 20% in other areas of Cerrado; and 20% of areas in the Atlantic Forest and other biomes). APPs ensure the preservation of areas that play key roles in the maintenance of water resources and geological stability, such as bodies of water and hillsides/slopes. Considering that 17 globally-threatened bird species depend on the forests located along rivers to survive (e.g. Brazilian Merganser - *Mergus octosetaceus*, Araripe Manakin - *Antilophia bokermanni*, Bahia Tapaculo - *Eleoscytalopus psychopompus* and Cone-Billed Tanager - *Conothraupis mesoleuca*), the recovery and maintenance of APPs represent an important contribution to the survival of these species (Develey and Pongiluppi, 2010). According to the law, all rural properties in Brazil are required to declare Legal Reserve areas and Permanent Preservation Areas (APPs) through the *Cadastro Ambiental Rural* - CAR (Rural Environmental Registry). When all Brazilian rural properties complete this process, this will represent an effective way to control and enforce the legislation.

If this environmental legislation were fully respected (rural properties conserving the Legal Reserves and APPs) the amount of native vegetation in the country would be much greater with far more biodiversity-friendly farms, representing a complement to public protected areas, especially in the buffer zone of protected areas. For example, according to Rezende et al. (2018), landowners should restore 5.2 million hectares of forest to comply with the legislation, thus increasing native vegetation cover in the Atlantic Forest up to 35%.

3. Direct management of bird species

In many cases, habitat protection is not enough to reverse the threat status of a certain species, especially when the population size has already reached very low levels. In these cases, direct interventions are needed via the management of key resources for breeding or feeding the species or predator control, especially when dealing with invasive predators. In Brazil there are still few examples of species whose populations have been recovered through direct management actions. One of the limitations for the direct

management of species is the lack of knowledge about the basic biology of Brazilian birds, especially small Passeriformes, which makes the planning and execution of management measures difficult.

One successful case is represented by the Hyacinth Macaw (*Anodorhynchus hyacinthinus*) in the southern region of the Mato Grosso Pantanal. Since 2003, Instituto Arara-azul (Hyacinth Macaw Institute) has worked to raise awareness of this species among rural landowners, obtaining support for the installation of nest boxes to increase the availability of nesting cavities. They have also manually moved eggs and chicks between nests to maximize reproductive success in the wild (Guedes and Harper, 1995; Guedes, 2002). The project has achieved a significant increase in Hyacinth Macaw populations through these interventions, but also through raising landowners and rural workers' awareness of the importance of the species' conservation, greatly reducing the illegal trapping for trafficking. As a result, the species was removed from the list of threatened birds in the last Brazilian review conducted by the Ministry of the Environment in 2014 (Portaria No. 444/2014). However, this positive scenario may change due to the large fires that severely hit Pantanal in 2019 and 2020, destroying important breeding and feeding sites for the species. Future monitoring will be necessary to understand the impact of these recent fires in the Hyacinth Macaw population in short- and medium-term.

In more extreme cases, when local extirpation of a species has already been confirmed, or when the number of individuals is so small that natural recovery becomes unfeasible, release projects (reintroduction, translocation or population reinforcement) are the only hopes for recovery. In the Atlantic Forest of southern Brazil, a project to reintroduce the Endangered Vinaceous-breasted Amazon (*Amazona vinacea*), which began in 2010, has already rehabilitated and released 76 individuals, most of them recovered from the illegal trade (Kanaan, 2016). Through post-release monitoring (2011–2014) flocks of 2–15 individuals have been frequently recorded and breeding was confirmed with the birth of nine parrot chicks, demonstrating that, with the appropriate methods, it is possible to return birds that had been living in confinement to the wild.

Another parrot species, the Spix's Macaw (*Cyanopsitta spixi*), is already Extinct in the Wild. Thus the only hope for this species is to return it to its natural habitat in the Caatinga through the reintroduction of captive individuals (Donald et al., 2010). Since 2013, the Chico Mendes Institute for Biodiversity Conservation (Instituto Chico Mendes para a Conservação da Biodiversidade - ICMBio) has been working to implement the Action Plan for the Conservation of the Spix's Macaw in association with private bird breeders, NGOs and the local community where the species originally occurred (Curaçá-Bahia). The action plan describes management of the species in captivity and protection of the habitat where the birds should be released in the next few years. According to the ICMBio, there are currently 189 individuals in captivity currently kept by two entities in Germany and Brazil, with 26 chicks born in 2017 and 11 more in 2018. In June 2018 the federal government established a 28,000-hectare protected area in the Curaçá region where the last wild Spix's Macaws lived before being captured for the illegal trade. The existence of an integrated group working towards the return of Spix's Macaws to the wild and the positive involvement of the local community, combined with the growth in the number of birds in captivity, gives us hope that these birds will be flying free again in the coming years.

For some birds, conservation efforts arrive too late. Seven Brazilian birds are listed as globally Extinct, Extinct in the Wild or CR - Probably Extinct, of which five are from the Atlantic Forest. Two species endemic to the Atlantic Forest of Brazil's Northeast Region, the Cryptic Treehunter (*Cichlocolaptes mazarbarnetti*) and the Alagoas Foliage-gleaner (*Philydor novaesi*), are considered offi-

cially extinct (Pereira et al., 2014; Lees et al., 2014; Butchart et al., 2018). The biology of these species is little known and there are no individuals in captivity for potential reintroduction. For species on the brink of extinction, such as Stresemann's Bristlefront (*Merulaxis stresemmani*) and the Alagoas Antwren (*Myrmotherula snowi*), the challenge for scientists and conservationists is to develop and test protocols for captive breeding. Concurrently, the development of research on the basic biology of these birds in the wild is also crucial for understanding habitat needs and conserving the best areas for future reintroductions. Investing in these lines of research and management should be one of the priorities of research-funding agencies working in an integrated manner with conservation organizations.

4. Participation of Society

Humans are the main cause of the biodiversity crisis in Brazil and worldwide. But if we are the main problem, we are also the solution. There is no effective conservation program that does not involve people. Conservation initiatives should focus on understanding people's attitudes and behaviors, seeking positive changes for nature. Affecting human behavior is one of the greatest challenges faced by conservationists and is one of the fundamental pillars for the conservation of biodiversity (Verissimo, 2013). Effective education and outreach programs can increase public support for conservation, reduce hunting and capture of species and other harmful activities, and influence public policies and decisions that affect the environment.

A healthy environment is also important for human beings. According to Aerts et al. (2018), the benefits of the contact between people and nature on mental health are well documented, but the evaluation of biodiversity effects on human health still need further studies. However, recent studies demonstrated that bird richness and composition (e.g. songbirds, species most easily detected) have important contributions to positive effects on human well-being (Cox and Gaston, 2015; Cox et al., 2017).

Because of birdwatchers, Brazil is experiencing a positive moment of interaction between humans and biodiversity. In addition to the health benefits for people, this new trend has substantially contributed to promoting bird conservation and increasing knowledge about Brazil's birds. In a country the size of Brazil, the participation of birdwatchers is an efficient and viable way to generate information and fill knowledge gaps. Community science programs seek the active participation of people to generate scientific knowledge. There are many examples of community science efforts throughout the world (Ellenbogen, 2007; Bonney et al., 2009) and more recently in Brazil. With the development of internet tools, citizen participation in science has greatly increased, recruiting thousands of volunteers worldwide and actively contributing to knowledge of birds including aspects such as geographical distribution, new bird records, breeding and feeding behavior and migration routes (Lees and Martin, 2015). Collaborative science programs are most commonly led by universities or conservation organizations, which provide the necessary technical inputs and guidance for data collection and analysis and generate reports that influence the application of practical conservation measures (McCaffrey, 2005; Greenwood, 2007).

Until a few years ago, it would have been difficult to imagine Brazilian birdwatchers contributing significantly to conservation and the participatory generation of knowledge about Brazilian bird species. The reason is that the practice of birdwatching was poorly developed in the country, and mostly limited to a few groups of foreigners. Fortunately, this scenario has recently changed with a considerable growth in the activity of birdwatching. An important milestone for birdwatching in Brazil was the first Avistar Brasil (Brazilian Birdwatching Meeting) in 2006. This encounter led to the

creation of several birdwatching clubs and established organized field trips and outings in different cities across the country. Since its first meeting, the event has grown considerably and currently attracts some 5000 people each year, making it the largest birdwatching fair in Latin America. Three other important initiatives that stimulated the increase of birdwatching in Brazil are: (1) the creation of the WikiAves website (<http://www.wikiaves.com.br>) in 2008. This website gathers information on birds, as well as photographic and sound records, making it an important source for research on Brazilian birds and a space for the exchange of experiences among those who enjoy the activity. Currently, the website has 36,940 registered users; 3,274,875 photos; and 200,954 sound files between them covering 1891 registered bird species (according to the CBRO list). (2) the Cornell Lab of Ornithology's eBird web platform that showed significant growth in use between 2013 and 2019 when the number of people submitting checklists in Brazil rose from 244 to 10,070, and a total of 1758 bird species were recorded (94% of the total number of bird species in Brazil). (3) the platform managed by the Brazilian Federal Government (<http://ara.cemave.gov.br/>) with 1864 birds recorded including records in 215 federal protected areas. These numbers reflect the enormous amount of information that private citizens can provide to the conservation and scientific communities, helping to fill ornithological knowledge gaps in Brazil and contributing to the conservation of the country's birdlife.

Although precise estimates are lacking, there are currently between 30 and 40 thousand observers (and photographers) of birds in Brazil. On the other hand, the number of "formal" ornithologists, defined as professionals trained in Biological Sciences or related areas with some specialization in ornithology, is much smaller. The average number of participants in the last Brazilian ornithology congresses was approximately 300 people, many of them students, and the Brazilian Ornithological Society (*Sociedade Brasileira de Ornitologia* - SBO) has maintained an average of 100 members in recent years (Höfling et al., 2017). This underscores the importance of community science for supporting bird conservation in Brazil, while also pointing to the need to increase professional scientific capacity.

Conclusions

Finding workable solutions for the serious issues surrounding the decline of bird populations in Brazil is not a simple task. In recent years the knowledge on ornithology in Brazil has grown considerably with new information being generated in behavior and habitat use, systematics, description of new species and distribution of Brazilian birds. Birdwatchers in Brazil have made critical contributions to filling gaps in scientific knowledge, while also building interest and involvement in conservation. Nevertheless, despite recent scientific advances, there are still many knowledge gaps – particularly information needed to support the conservation of critically endangered species. To narrow this science-practice gap, efforts in establishing partnerships between scientists and practitioners is crucial and should be promoted by agencies and foundations that support research and conservation.

However, scientific information is only the first step in a long process. As the scientific knowledge about Brazilian birds advances and new species are discovered (mainly in the Amazon), we are also losing others (in the Atlantic Forest). Practical conservation actions are crucial and involve social, economic and political issues, and, therefore are generally complex and time-consuming. The human-human conflicts between different groups of scientists, practitioners, and governments is another factor that sometimes jeopardizes the development of a positive agenda for conservation. Most of the threats to avian biodiversity in Brazil require immedi-

ate action. However, solutions are not so immediate and the results are seen in the medium- and long-term. This mismatch of timing is already a challenge and can be a bit distressing for those working in conservation.

To add to this challenge, the policy currently adopted by the federal government has been proving to be highly prejudicial to environmental conservation, with the constant attempt to weaken and relax environmental legislation, the protected areas system, the patrolling agencies and surveillance division. The continuous attacks on scientists, NGOs and environmentalists further intensify the biodiversity crisis in Brazil.

We already know our problems and many of our conservation priorities. Fortunately, in spite of the bad political scenario, just as knowledge about our birds is increasing, conservation projects led by committed individuals and nongovernmental organizations have also grown through action plans focused on endangered species or groups of species. As another example of the civil society engagement, a recent movement led by some of the largest private companies in the country and financial institutions has been pushing the government to implement concrete actions for environmental conservation. This movement is added to a massive media coverage focused on the environment and biodiversity. Even so, integration, communication, planning and investment in applied biodiversity conservation are still urgently needed to reverse the severe decline in the populations of many Brazilian bird species.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

I would like to thank Tatiana Pongiluppi for her work in compiling the data presented in the first part of this article, and colleagues Carla Morsello and Ben Phalan who kindly reviewed the first version of the manuscript. I also want to thank the entire SAVE Brasil team for their constant support, especially Alice Reisfeld, Albert Aguiar and Karlla Barbosa for their help with certain references and information, and Laura Develey who contributed suggestions that improved the final structure of the text. Guto Carvalho kindly helped with the graphical abstract. Thanks to Jeffrey A. Stratford for the initial suggestion to write this article. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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