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ARTICLE

Agricultural activities and threat to fauna in Brazil: an analysis of the Red Book of Endangered Brazilian Fauna

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Abstract. The recent edition of the Red Book of Endangered Brazilian Fauna brings 1,173 threatened species, 86% of them in terrestrial or freshwater environments. For these species, the main threat vector is agricultural activities that affect 519 species (51%). This information brought by the Red Book is examined in-depth and its consistency is discussed in search of an objective view on the impacts of agriculture, its importance, how they affect the different groups of animals, the different biomes of the country, and the different types of habitats continental. Birds, fish, and invertebrates are the groups with the highest number of species threatened by agricultural activity, accounting for more than 70% of the species. Habitat loss is by far the biggest impact caused by the activity, affecting almost 90% of the species. However, there is a difference between the impact of agriculture and livestock. The work seeks to understand why livestock threatens a smaller number of species, although pastures occupy more than twice the area occupied by crops and forestry. The work brings an objective debate on the relationship between agricultural activities and the conservation of wild fauna in Brazil, without falling into the trap of the useless demonization of human activities, highlighting, instead, the need to define and implement strategies for the conservation of biodiversity in the midst the land use matrix itself, complementary to the conservation units, based on the best available information on the vulnerability of fauna to the impacts of this vector.

Keywords. Endangered Species; Biodiversity Conservation; Habitat Loss; Habitat Fragmentation; Land-use Change.

INTRODUCTION

The evaluation of the degree of threat to a species or ecosystem is a fundamental step in the process of biodiversity conservation. Since the 1950s, the International Union for Conservation of Nature (IUCN) has compiled lists of species at risk of extinction (Mace *et al.*, 2008). Enhanced throughout these years, the IUCN Red List of Endangered Species (IUCN Red List) has become a powerful tool to catalyze biodiversity conservation actions and promote public policies for the protection of natural resources (IUCN, 2019a).

First published in 1968 (IBDF, 1968) and contemporary to the IUCN Red List, the Official List of Endangered Brazilian Fauna was later influenced by the IUCN, as in its third edition published in 1989 the IUCN criteria and categories were partially applied in its updating process (Machado, 2008), and widely used in the following review process in 2002 (Drummond & Soares, 2008).

In the current editions published in 2014 (MMA, 2014a, b), not only did the IUCN assessment model serve as a basis for the review again but for the first time, the national lists started to incorporate the extinction risk categories of the Red List in its official text. For each edition of the official lists of the Brazilian Government, a corresponding scientific version was published, receiving in 2008 the name of the Red Book of Endangered Brazilian Fauna (Machado *et al.*, 2008), in an unequivocal alignment with the evaluation IUCN's risk of extinction model.

The current edition of the Red Book of Endangered Brazilian Fauna (hereafter RBB; ICMBio, 2018a) brings an important innovation compared to previous editions. In addition to the complete list of all 12,254 species evaluated and information on the taxonomy, geographical distri-

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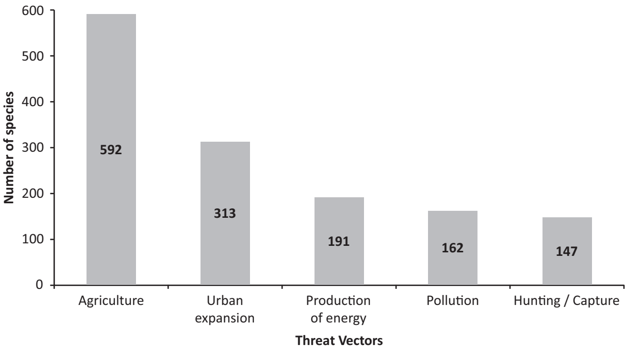

Figure 1. Continental species affected by the main threat vectors (ICMBio, 2018a).

bution, population, and threats of the 1,173 threatened species, there is an effort to identify the human activities that originate the threats. Although the information about the threat vectors, as these human activities are called, needs more precision, the vision that they provide about the conservation of biodiversity in Brazil is undoubtedly all-embracing. Not only do they disclose a much broader picture of threats to species, but also provides more objective perspectives for the formulation and negotiation of effective actions for their conservation.

Agricultural activities are identified by the RBB (ICMBio, 2018a) as the main vector of threats to species, followed by urban expansion by far and even more distant by the generation of hydraulic energy (Fig. 1). Agricultural activities prevail as the main threat vector in almost all Brazilian terrestrial biomes, except in the Amazon Biome, where these activities are surpassed by the generation of hydraulic energy by the narrow margin of a species. In most other terrestrial biomes, the number of species affected by threats from agricultural activities is more than twice as high than the others. From this perspective, this study explores the hypothesis that as a result of the novelty of threat vectors associated to endangered species, although there is a significant degree of inaccuracy in the information that associates agricultural activities with threats to species (which possibly should also occur in other activities), it is possible to construct a reasonable picture of the role of agricultural activities in the risk of fauna extinction and apply it to conservation. The impact of agricultural activities on the environment is a recurrent theme in several technical and scientific documents, either due to the occupation of the land surface and the consequent reduction and fragmentation of the habitat (EMBRAPA, 2018); due to habitat degradation caused by excessive water consumption (Rodrigues & Irias, 2004); by the processes of soil erosion, compaction, and salination (Thomas *et al.,* 2013); or by the use of pesticides and their effects on water (Oliveira-Filho & Lima, 2002) and other environments. The relationship between agricultural activities and the risk of extinction brought by the RBB (ICMBio, 2018a) is supported by extensive bibliography, as well as by the perception and empirical knowledge of scientists that were applied to the evaluation process to assess the status of species. This makes the RBB, although with some limitations, a formidable source for exploring this and other issues regarding species conservation.

METHODS

In the review of the RBB (ICMBio, 2018a), we examined the descriptions of each species, mainly the reasons for its classification as threatened, the threats to which they are subject, and the preferred habitats. We identified and selected species with clear descriptions of threats associated with agricultural activities and, for this selection, we avoided any subjective interpretation of the descriptions and strictly observed what was described by the authors of the species accounts. Based on the selection of species, we sought to identify the type of impact resulting from agricultural activities and highlighted their relevance based on the number of species affected by them. Then, we compared the incidence of impacts between the main groups of fauna, considering all classes of vertebrates separately and all invertebrate phylla as a single group. We also compared the incidence of impacts between biomes, between the types of preferred habitats, and between the modalities of agricultural activities. The term "agricultural activities" adopted in this study included the set of activities that take advantage of the environment and its natural resources for plant and animal production destined for human subsistence, including agriculture, livestock, forestry, and aquaculture (EMBRAPA, 2018). Fisheries, although also part of this set, was not addressed in the study because it is treated in a separate context in the RBB (ICMBio, 2018a). The results are presented in absolute numbers, using percentages to highlight and compare the most relevant aspects.

RESULTS

We found 519 species with threat quotes related to agricultural activities (Table S1), 73 less than the number shown in Fig. 1. For 461 species, agricultural activities are considered the main source of the threat, with birds, invertebrates and fishes appearing as the groups most affected by these activities (Fig. 2). For 167 species, agricultural activities are the only source of threat: proportionally, amphibians and invertebrates are the groups with the highest number of impacted species, with 57% and 48% of their species affected, while mammals and

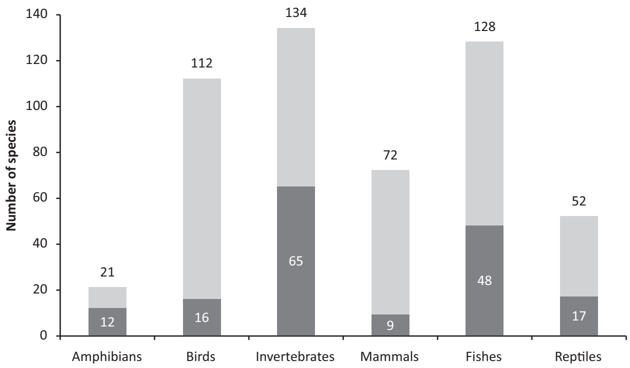

Figure 2. Number of species threatened, in each group, by agricultural activities. Highlight for the darker part of the columns with the number of species that has the only source of threat in agricultural activities.

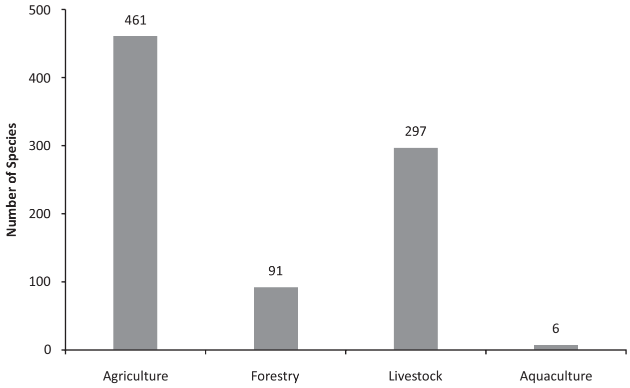

Figure 3. Number of species threatened by the different segments that make up agricultural activities.

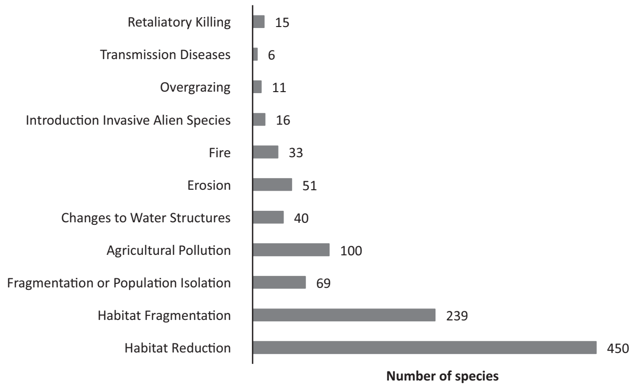

Figure 4. The impacts of agricultural activities and the number of species affected.

birds (with 13% and 14% of species, respectively) are the ones with the lowest number (Fig. 2). Among the agricultural segments (Fig. 3), agriculture is the one with the highest number of citations (461), followed by livestock (297) and, silviculture (91).

Eleven forms of impact arising from agricultural activities were mentioned (Fig. 4). Habitat loss or reduction, as well as habitat fragmentation, are the most relevant impacts, affecting by far the largest number of species compared to other forms of impact that affect a much smaller number of species, the most relevant among them (agricultural pollution), not exceed 20% of the species threatened by the vector of agriculture. These other forms of impact are damage to the environment caused by plantations and the management of domestic livestock, leading to progressive degradation or loss of habitat quality. In addition to this group, there is direct loss of animals as a result of persecution and subsequent slaughter, in addition to diseases introduced by the cattle. For most species, agricultural activities cause more than one impact, only 37% are affected by one of these impacts: habitat reduction (n = 155); agricultural pollution (n = 22); erosion (n = 13); retaliatory death (n = 2); introduction of invasive alien species and overgrazing (both with one species).

Habitat reduction is the most recurrent impact among the descriptions, affecting 87% of the species analyzed in this study, of which 91% have this type of impact as the main form of threat. Habitat fragmentation is cited for 239 species and identified as the main impact for 95% of them. Of the species cited as threatened by habitat fragmentation, the greatest number are invertebrates (Fig. 5), followed by mammals with the highest percentage (72%). It is important to highlight that, in most descriptions, habitat fragmentation is mentioned in association with habitat reduction, not effectively discriminating between one effect and another; in addition, the isolation of populations appears as an additional impact on fragmentation.

According to Haddad *et al.* (2015) and Fletcher *et al.* (2018), isolation is one of the aspects of fragmentation and its citation in the RBB (ICMBio, 2018a) appears

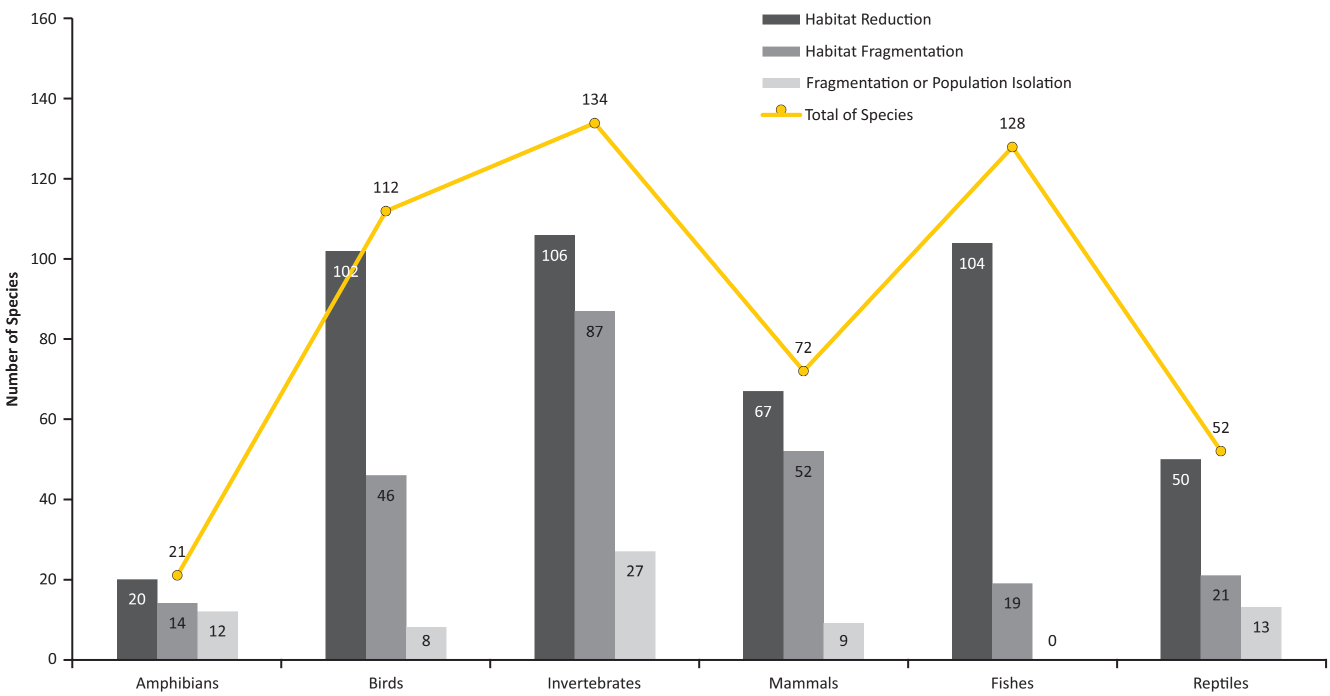

Figure 5. Number of species affected by isolation, in each group, compared to the number of species affected by habitat reduction and habitat fragmentation.

mainly in species that occur in the Atlantic Forest biome (n = 53), representing 31% of species affected by habitat fragmentation in the biome. The Cerrado and Caatinga biomes have similar percentages of isolation citations, 28% and 32%, respectively. In other biomes, this percentage is between 17% (Pampa) and 7% (Pantanal). In the Amazon it reaches 11%, with only three species affected. Population isolation is a type of impact that mainly affects invertebrates (n = 27), although amphibians have the highest percentage of citations (86%) in species threatened by habitat fragmentation, suggesting that almost all amphibians in fragmented habitats have their populations isolated or disarticulated, as is the case of *Bokermannohyla vulcaniae* and *Physalaemus soaresi,* which have practically their entire population isolated in an area of forest fragments with approximately four km² (Haddad *et al.,* 2018a, b). The population isolation also affects a significant percentage of reptiles threatened by habitat fragmentation (62%), with little representation for the rest of the groups: invertebrates (31%); birds and mammals (17%); reaching zero for fish.

Within habitat degradation, agricultural pollution is the one that emerges with the largest number of affected species (n = 100), representing much higher than the species impacted by erosion (n = 51), by burning (n = 33), or by any other form of degradation responsible for the loss of habitat quality. Invertebrates are the group with the highest number of citations of threats of agricultural pollution (n = 37), followed by fish (n = 34) and birds (n = 18). For most species of invertebrates and fish affected by agricultural pollution (76% and 82%, respectively), this form of impact is considered one of the main threats to the species. Unlike birds in which the impact of agricultural pollution is considered one of the main threats for only two species. This reflects the higher volume of descriptions of the impact of agricultural pollution on aquatic environments as one of the main threats: 49 of the 65 citations of aquatic pollution, against nine of the 29 citations of air pollution. Most of the invertebrates are aquatic, mainly decapods. Among the fish, the majority are species of rivulids (annual fish), of extremely restricted distribution, sometimes endemic to a single temporary pond (*Hypsolebias auratus;* Pavanelli *et al.,* 2018a). The greatest predominance of citations of agricultural pollution in aquatic environments refers mainly to the possible toxic contamination of the environment by agrochemicals. The few mentions of water pollution by eutrophication of the environment are related to the carrying of livestock manure (*Aegla brevipalma;* Santos & Bueno, 2018), and fertilizers associated with domestic effluents (*Mergus octosetaceus;* Silveira *et al.,* 2018). In terrestrial environment, species affected by the application of herbicides, insecticides, and fungicides represent less than 30% of the threat citations for agricultural pollution, which predominantly occur through atmospheric propagation with the consequent contamination of individuals (*Aleuron ypanemae;* Camargo *et al.,* 2018) or food on the ground surface (*Circus cinereus;* Dias & Mauricio, 2018). Air pollution is mostly reported for birds (n = 15) and invertebrates (11), while descriptions of pollution from soil contamination are given to a small number of species that feed on decomposers, which are reduced by the action of fungicides (*Gnamptogenys wilsoni;* Delabie, 2018), or by species whose food, composed of ants and termites, are contaminated by insecticides (*Myrmecophaga tridactyla;* Miranda *et al.,* 2018), in addition to a fossorial reptile and a cave pseudoscorpion that occur in an area with intense use of pesticides (*Amphisbaena uroxena* and *Spelaeobochica allodentatus;* Colli *et al.,* 2018; Bichuette *et al.,* 2018c).

Aquatic habitats, besides, being the most affected by agricultural pollution, are also strongly impacted by physical changes directly caused by agricultural activities, whether by direct interventions in water structures or by silting caused by soil erosion. The descriptions of the Red Book (ICMBio, 2018a) point out that 72 aquatic species are impacted by changes related to crop plantation or water use for irrigation. Silting resulting from soil erosion, caused mainly by the suppression of riparian vegetation, affects almost half of the 72 species (n = 35). Thirty-two species are threatened by dams, diversions of watercourses, and, mainly, drainage of flooded environments. For 94% of the 72 species, those threats are considered important. Aquatic invertebrates (n = 16) and, especially, fish (n = 42) are the groups most affected. As with species threatened by water pollution, decapods and annual fish are most representative species in their respective groups.

Species impacted by physical changes in water structures reinforce the predominant role of agriculture as the source of the threat, compared to other types of agricultural activities. Changes in water structures caused by plantations affect 90% of the taxa, against 54% of species affected by water structures changes resulting from pasture management and only 13% of species impacted by changes promoted by forestry. The greatest impact of agriculture results from dams and drainages that affect 31 species, twice as many as those affected by the same water structure changes resulting from pasture management (n = 15).

Considering that irrigated agriculture (ANA, 2017) consumed 67% of the water in the country and that most or all the water extracted in irrigation does not return to the original water sources (Rodrigues & Irias, 2004), it would be reasonable to expect a significant number of aquatic species affected by the exhaustion of water sources or lowering of the water table. However, those two threats are cited only for very few species (seven and two, respectively). Furthermore, the depletion of springs is not brought about in a clearly expressed way, but it is associated with other threats that mainly affect some fish of very restricted distribution (*Pamphorichthys pertapeh;* Pavanelli *et al.,* 2018b). The depletion of the water table is a threat described objectively for two species of troglobial fish (*Stygichthys typhlops* and *Trichomycterus dali;* Bichuette *et al.,* 2018a; Bichuette *et al.,* 2018b).

More than half of the species threatened by erosion and changes in water structures (n = 43) are also threatened by agricultural pollution, mainly fish (n = 26) and invertebrates (n = 12), and to a lesser extent, birds (n = 5).

These results involving fish and invertebrates suggest a possible correlation between these threats, perhaps the transport of pesticides associated with silting.

Erosion, changes in water structure and water pollution are cited as threats to cave species threatened by agricultural activities (n = 24), represented mainly by invertebrates (n = 16), in addition to fish (n = 8). Erosion due to soil exposure after the removal of natural vegetation is the most incident impact (n = 19), resulting in the silting of stretches of watercourses that pass through the interior of the cavities (n = 6). In addition to changes in the structure of the cavities, threats related to agricultural pollution were cited for a small group of species (n = 6), all involving toxic contamination, mostly aquatic species (n = 5).

Among the impacts of habitat degradation, the use of fire as an agricultural practice has little expression, being cited for 33 species, mostly birds (n = 19). It is hardly mentioned for the other groups, only five species of mammals and two species of reptiles. Among invertebrates, there are only seven species, although some studies report a decrease in invertebrate populations after burning (Redin *et al.,* 2011).

The intrinsic impacts on livestock

For a set of 41 endangered species, the descriptions of the RBB (ICMBio, 2018a) present citations of other forms of impact that are intrinsic to livestock, although in some species they also appear associated with agriculture and aquaculture, in case of conflicts with farmers and the introduction of invasive alien species, respectively. The other impacts are represented by cattle overgrazing and the transmission of introduced diseases and are exclusive to livestock. In 16 citations, these impacts were considered among the main risk factors for species extinction, generally as a threat closely associated with habitat conversion.

The introduction of invasive alien species and the chasing and killing of predators are the threats that have the highest number of citations (n = 16 and n = 15, respectively) among the 41 species of this set of threats. The threat posed by the introduction of exotic species refer to the replacement of the native grasslands and savannas with pastures of exotic grasses and the consequent change in habitat, except for two species of fish that are threatened by competition with introduced species; insectivorous and granivorous birds (n = 8) and herbivorous mammals (n = 6) are the groups most affected. Herbivorous mammals, all ungulates, are also the only group with species impacted by disease transmission.

Associated with the management of cattle and other herds, another impact is the preventive or retaliatory killing of predatory species: 15 species, mainly felines (n = 9), becoming an important threat to the jaguar (*Panthera onca;* Morato *et al.,* 2018), puma (*Puma concolor;* Azevedo *et al.,* 2018), and maned wolf (*Chrysocyon brachyurus;* Paula *et al.,* 2018). This list also includes the crowned eagle (*Urubitinga coronata;* CEMAVE, 2018b), and the white-necked hawk (*Amadonastur lacernulatus;* CEMAVE, 2018a), which are the only citations of conflicts with birds involving cattle; all other conflicts (n = 3) are related to the foraging of parrots in corn, rice, and orange plantations (*Amazona vinacea;* Somenzari, 2018). Herd management is also associated with the impact of overgrazing that affects a small number of species (n = 11), the majority of birds (n = 9), in addition to one amphibian and one reptile species.

DISCUSSION

Food production is the human activity that most demands the use of land (EMBRAPA, 2018) largely promoting the conversion of habitats, one of the key factors for the decline of global biodiversity (Newbold *et al.,* 2013, Haddad *et al.,* 2015 and WWF, 2015). In Latin America, between the 1980s and the 1990s, areas converted for agricultural use increased by almost 50 million hectares (Gibbs *et al.,* 2010), the majority on intact (55%) or already degraded (28%) forests. In Brazil, agricultural activities occupy about 30% of the territory (EMBRAPA, 2018), with an estimated direct impact on 519 species of native fauna, which represent 51% of the threatened species on the continent.

Habitat fragmentation

In most of the citations in the RBB (ICMBio, 2018a), habitat fragmentation is mentioned in association with habitat loss or reduction, not effectively discriminating one impact from the other. This view of fragmentation is mentioned by Tscharntke *et al.* (2012) for several studies, leading to the perception that these threats are linked or, as Fahrig (2003, 2013) and Fletcher *et al.* (2018) agree, that concept of fragmentation of the habitat has been used as a simplified term to refer to the general process of changing the quantity and configuration of the habitat over time. However, for caution, when interpreting the use of the term in the descriptions of the Red Book (ICMBio, 2018a), this study preferred Hanski's (2015) understanding that fragmentation poses an additional risk to habitat loss.

Although some authors (Tscharntke *et al.,* 2012; Fahrig, 2017; Fahrig *et al.,* 2019) question the hypothesis that fragmentation per se (in addition to habitat loss) has a significant effect on biodiversity reduction, the number of species affected by fragmentation in the Atlantic Forest seems to support the contrary conclusion of Haddad *et al.* (2015), which advocates the significant role of habitat fragmentation in reducing biodiversity, as a result of its consistent and cumulative effects. The study by Haddad *et al.* (2015) highlights the wide reduction of the Atlantic Forest in the last three centuries, transformed into a landscape dominated by a complex matrix formed by urbanized areas, farming, and several other human activities, with scattered forest fragments, mostly with less than 1,000 ha. It is in this biome that most of the 519 species threatened by the agricultural vector are concentrated (57%), of which 58% are also affected by fragmentation. It is the highest percentage among all biomes, where possibly the cumulative effects of fragmentation are greater, compared to the Cerrado, the second biome in the number of threatened species (36%), where habitat conversion is more recent and, perhaps because of this, the number of species affected by habitat fragmentation reaches the lowest level of 36% of threatened species. It is interesting to note that although most forests in the Amazon biome remain contiguous (Haddad *et al.,* 2015), the percentage of threatened species affected by fragmentation (44%) is higher than that of the Cerrado.

Population isolation due to habitat fragmentation, as recognized by the IUCN (2019b), as a rule, is the type of impact to which species whose adult stages are less efficient in long-distance dispersal are subject. This explains the highest percentage of amphibians in fragmented landscapes affected by isolation (86%) from the other groups. Most of these amphibians (83%) have an area of occurrence smaller than 2,000 km² and for 58% the area of occurrence is less than half this size, evidencing their low dispersal capacity and, consequently, their greater vulnerability to habitat fragmentation. Not coincidentally, 83% of amphibians affected by isolation inhabit the Atlantic Forest and are restricted to forest environments.

Habitat degradation

Other impacts identified in the RBB descriptions (ICMBio, 2018a), namely habitat degradation, are described for 183 of the species threatened by agricultural activities, 42% of which are affected by more than one of these impacts. It is interesting to note that 52 species are affected only by habitat degradation.

However, most impacts related to habitat degradation have, so far, no scientific evidence, as the chemical contamination of wild animals. The RBB (ICMBio, 2018a) mentions this type of impact for 100 species, principally invertebrates (37%), fishes (34%), and birds (18%), but only three articles support this statement, focusing on invertebrates (Brown-Jr, 1993; Santos *et al.,* 2012) and mammals (Rosas, 1994). The impacts by pesticides on RBB (ICMBio, 2018a) are mainly based on the suspected and generalization of the authors and, are likely influenced by the high consumption of pesticides in Brazil, especially in the large soy plantations (Pignati *et al.,* 2017). Faita *et al.* (2020) found, in the laboratory essays, that these herbicides based on glyphosate, can affect the survival of bee colonies when used in large quantities. It is curious to note, however, that the RBB (ICMBio, 2018a) does not mention the impact of pesticides on threatened bee species, despite this being the group of invertebrates likely to be most affected. The RBB (ICMBio, 2018a) also provides little information on the impact of invasive alien species introduced by agricultural activities. Despite the importance of this type of impact for species in altered landscapes (Fischer & Lindenmayer, 2007), only 16 affected species are mentioned by the Red Book (ICMBio, 2018a), mainly birds (56%). This little information available probably reflects the information gaps on the subject in the country, pointed out by Zenni *et al.* (2016). Likewise, there is little information on the impact of fire, which is an agricultural practice widely used in the country to prepare the soil, to suppress vegetation in the forest (Costa *et al.,* 2011), to remove crop residues, to eliminate pests and weeds and to fertilize the soil (Korontzi *et al.,* 2006). Costa & Rodrigues (2015) mention that the high frequency of fire in natural pastures promotes the elimination of sensitive plant species, reducing the floristic diversity and causing changes in habitat. This type of change in open environments possibly affects most bird species (63%), the group with the largest number of species impacted by fire, as well as reptiles. In other groups, most species are possibly impacted by fires in forest environments (57% of invertebrates and 80% of mammals), associated with the installation of crops in the process of advancing the agricultural frontier, mainly in the Amazon (*Cebus kaapori;* Fialho *et al.,* 2018). It is interesting to note that the RBB (ICMBio, 2018a) does not mention amphibian species impacted by fire, although scientific literature reports a reduction in the richness and abundance of anuran species as a result of this type of impact (Ribeiro *et al.,* 2020).

The impacts of overgrazing and the relationship between cattle and wild animals

In addition to the impact described for fire, excessive grazing of cattle also promotes the exclusion of native plant species (Dias-Filho & Ferreira, 2009), as it hinders their regeneration. Birds are the species most affected by this type of impact (82%), causing the degradation of the breeding area (*Sporophila palustris;* Dias & Malaco, 2018) and even the possible crushing of nests and young (*Xanthopsar flavus* and *Xolmis dominicanus;* Dias, 2018a, b). Virtually all species impacted by overgrazing, including reptiles and amphibians, are in open areas, inhabiting fields (n = 4) or humid areas (n = 7), where herbaceous and shrubby vegetation predominates. Livestock management is also strongly implicated in the impacts represented by conflicts between natural predators and farmers. Although conflicts involve a very small number of species, they are important impacts that affect large cats (*Panthera onca;* Morato *et al.,* 2018). The conflicts, as a rule, reflect the reduction and degradation of the habitat that leads to the reduction of natural prey, or the excessive availability of herds, due to the inadequate management of cattle that facilitates the attack of large carnivores (Paula & Boulhosa, 2015). These conflicts have a significant impact on the populations of carnivorous mammals (Balbuena-Serrano *et al.,* 2020), species that generally occupy the top of the food chain in all terrestrial ecosystems. In the case of felines, all species threatened by the agricultural vector are affected by conflicts with farmers. The cattle herd is also a way of introducing diseases that affect practically all ungulates threatened by agricultural activity, except only the small red brocket deer (*Mazama bororo*). This type of impact, although it has been described for species of wide occurrence (*Tapirus terrestris;* Medici *et al.,* 2018), seems to be concentrated in the species that occur in the Cerrado and Pantanal biomes, where there is a great livestock activity, mainly in the Pantanal, where livestock represents the main economic activity in the region.

The possible relationship between habitat and the greatest impact of agriculture

It is interesting to note that livestock is the vector with the greatest diversity of impacts, covering the entire set listed in Fig. 4, including some that are entirely exclusive to it: transmission diseases; and overgrazing. Still, it is the activity with the smallest number of species affected, when compared to agriculture. Crops, along with planted forests, occupy only 9% of the territory (EMBRAPA, 2018), but impacts 89% of the species threatened by the agricultural vector, while livestock, which occupies 21% of the territory, impacts only 57% of species (Fig. 3). This difference is practically repeated in the number of species affected by habitat reduction and fragmentation. Among terrestrial species with available information on habitat preference, it is clear that, except for reptiles, there is a greater predominance of species that inhabit forest environments (Fig. 6). These figures draw attention to the possibility that species of forest habitats may be more affected by the impacts of agricultural activities than species of open habitats, regardless of the type of activity. For birds, this assumption is supported by the results obtained by Newbold *et al.* (2013), which point out that species dependent on forest habitat suffer more adverse effects from habitat loss or degradation than species with a preference for more open habitats. Likewise, Prescott *et al.* (2016) found no significant differences between the Colombian Llanos forest habitats modified by pastures and palm oil crops in terms of richness and phylogenetic distance between individuals in the bird community. Similarly, Boron *et al.* (2019) did not perceive evident effects on mammals in these environments.

Apparently, it is not the type of agricultural activity that provides the greater or lesser number of impacted

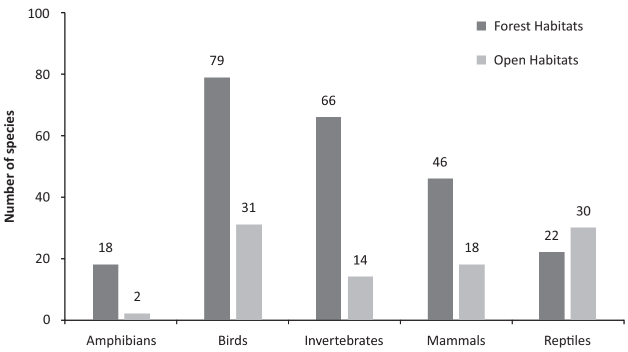

Figure 6. Number of terrestrial species affected by agricultural activities with information available on preference for forest habitats or open habitats.

species, but the type of habitat that is suppressed for its installation. Converting open habitats for agricultural use affects fewer species compared to converting forest habitats. Forest habitats are recognized for a greater diversity of species (Ashton, 1989; Wilson, 1997), therefore, a greater number of species threatened by their suppression is expected, mainly in the Atlantic Forest, where the extensive suppression of habitats began in the century XVI. This scenario explains the smaller number of species impacted by livestock which, despite occupying an area 60% larger than agriculture, has a soil occupation matrix with a higher percentage of open habitats in the Pantanal and Cerrado, reaching 38% of the native pastures in its composition (EMBRAPA, 2018). Besides, the RBB (ICMBio, 2018a) includes descriptions of species of open habitats that apparently are tolerant to the changes caused by livestock, some of which even benefited from the activity, such as the buff-breasted sandpiper (*Calidris subruficollis;* Serafini, 2018), apparently favored by the overgrazing in the natural fields that creates a suitable environment for your shelter. An even more peculiar case occurs in the high-altitude fields of the Atlantic Forest in southeastern and southern Brazil, mostly converted to pastures, where an endangered species of scarab beetle (*Pedaridium hirsutum;* Vaz-de-Mello & Nunes, 2018) has a diet based on horse feces. This diet is probably a change from your original diet that should have been based on tapir feces, animals that are no longer common in the region. Interestingly, the only two areas where the species is currently registered became protected areas and the presence of horses in these areas became incompatible. Without the presence of horses, the scarab beetle's main food source may have ceased in the two areas where there is the current record of the species, and this fact seems to contribute to the threat to the species.

Conservation strategies

In the RBB (ICMBio, 2018a), among the species of mammals and reptiles threatened by the agricultural vector, there are 41 mammals and eight reptiles with citations of movement of individuals in anthropized environments, suggesting some degree of tolerance to altered habitats, against 11 species of mammals and 14 reptiles described as intolerant to habitat change. For another 18 species of mammals and 30 of reptiles, no information is available. Although protected areas are an essential part of any conservation strategy and some authors defend their distribution more coincident with hotspots of endemism (Dalapicolla *et al.,* 2021) or the lands that in the future will house endemic threatened species (Gonçalves-Souza *et al.,* 2020), it is becoming increasingly clear that they will not be enough to maintain species and biodiversity conservation will need to extend beyond them (Fischer *et al.,* 2006; Magioli *et al.,* 2021). This vision highlights the importance of other instruments for the conservation of biodiversity, in addition to protected areas, mainly the strategic planning of actions for the conservation of species, involving the entire range of organizations and individuals interested in species and their habitat (IUCN, 2019a). Until 2017, Brazil had 645 threatened species (55% of the current list) as targets of conservation plans (ICMBio, 2018a). And in 2018, ICMBio published a new type of plan (ICMBio, 2018b), aimed mainly at mitigating the impacts of roads and railways on 462 species of fauna, in addition to other 1,943 species of plants, involving not only threatened species, but also taxa with very restricted distribution (under 5,000 km²). This new modality of planning brought an objective vision of species survival in the midst of economic activity, indicating areas for the development of the activity with less risk of loss of biodiversity, as well as areas suitable for the adoption of compensatory measures, in addition to a set of measures to prevent or mitigate impacts. It is an instrument that optimizes the use of available knowledge about species, and modeling tools, to build objective scenarios of compatibility between economic activity and species conservation, which, transported to agrosystems, bring a perspective of biodiversity conservation close to Daily's (2001) view on the future of species survival.

CONCLUDING REMARKS

The occupation of the landscape in Brazil by crops and pastures impacts 519 endangered species of native fauna, most of which are affected by habitat reduction, associated with fragmentation. In addition to these impacts, the RBB (ICMBio, 2018a) mentions other types of impacts, eight in total, mainly related to habitat degradation. These impacts, however, are putative and have no scientific basis, which urge the need for new research programs, not only to verify whether these impacts occur but to understand how they affect species, to allow the identification of measures that can prevent or mitigate its effects. Mainly on agricultural pollution, which among the impacts of degradation is the one with the greatest number of affected species.

Likewise, it is important to seek to better understand the reason for the greater number of species threatened by agriculture compared to livestock, which occupies a 60% larger territory. We suspect that the land occupation matrix by livestock uses a higher percentage of open habitats, including natural pastures, which leads to considering the possibility that species of forest habitats are more affected than species of open habitats. Understanding this difference, as well as how species are affected and how they respond to changes, is essential for the intelligent management of the agricultural occupation matrix, which reduces its impacts on the environment and provides conditions for the survival of species and the maintenance of the ecosystem service. This is an important issue because we believe that the future of biodiversity conservation will depend on conservation strategies complementary to protected areas. Strategies that should be implemented in the land-use matrix itself, making economic production compatible with the conservation of species and ecosystems.

AUTHORS' CONTRIBUTIONS

MMO: Compilation of information from the Red Book of Endangered Brazilian Fauna, writing, review, and editing. RGM and RSPJ: Writing and review. RCP: Review. All the authors actively participated in the discussion of the results and approved the final version of the document.

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TABLE S1

List of species threatened by agricultural activities and the impacts to which they are affected.

Taxon	Impacts										
	HR	HF	PI	AP	WS	ER	FR	AS	OG	TD	RK
AMPHIBIANS											
Adelophryne maranguapensis	x										
Agalychnis granulosa	x	x	x								
Allobates brunneus	x										
Allobates goianus	x	x	x	x							
Aparasphenodon pomba	x										
Bokermannohyla vulcaniae	x	x	x	x							
Bolitoglossa paraensis	x	x	x								
Chiasmocleis alagoanus	x	x	x								
Crossodactylus dantei	x	x									
Crossodactylus lutzorum	x										
Cycloramphus diringshofeni	x										
Hypsiboas curupi	x	x									
Hypsiboas semiguttatus	x	x	x								
Melanophryniscus cambaraensis	x	x	x								
Phyllodytes gyrinaethes	x	x	x								
Physalaemus caete	x	x	x								
Physalaemus soaresi	x	x	x								
Proceratophrys moratoi	x	x	x		x						
Proceratophrys palustris	x			x					x		
Proceratophrys sanctaritae	x	x	x		x						
Thoropa saxatilis				x							
BIRDS											
Acrobatornis fonsecai	x										
Alectrurus tricolor	x	x		x	x		x	x	x		
Amadonastur lacernulatus	x	x	x								x
Amazona pretrei	x										
Amazona vinacea											x
Anodorhynchus leari	x										x
Anthus nattereri	x			x			x	x			
Anumara forbesi	x			x							
Aratinga solstitialis	x										
Asthenes hudsoni											
Attila spadiceus uropygiatus	x	x	x								
Augastes lumachella	x										
Automolus lammi	x	x									
Calidris pusilla	x				x						
Calidris subruficollis	x			x				x			
Campylorhamphus cardosoi	x										
Caryothraustes canadensis frontalis	x	x									
Celeus flavus subflavus	x										
Celeus obrieni	x	x									
Cichlopsis leucogenys	x										
Cinclodes espinhacensis	x						x				
Circus cinereus	x			x	x						
Conopophaga lineata cearae	x	x									
Conopophaga melanops nigrifrons	x	x									
Coryphaspiza melanotis	x	x		x				x			
Coryphistera alaudina	x										
Cranioleuca muelleri	x										
Cyanocorax hafferi	x				x		x				
Cyanopsitta spixii	x										
Dendrexetastes rufigula paraensis	x										
Dendrocincla taunayi	x	x									
Dendrocolaptes picumnus transfasciatus	x										
Discosura langsdorffi langsdorffi	x	x									
Eleoscytalopus psychopompus	x	x									
Formicivora erythronotos	x										
Geositta poeciloptera	x	x	x			x	x	x			
Glaucis dohrnii	x	x									
Grallaria varia distincta	x	x									
Grallaria varia intercedens	x	x									
Gubernatrix cristata											
Hemitriccus furcatus	x	x									
Hemitriccus griseipectus naumburgae	x	x									
Hemitriccus kaempferi	x	x									
Hemitriccus mirandae	x	x	x								
Herpsilochmus pileatus	x	x									
Hydropsalis candicans	x						x	x			
Lepidocolaptes wagleri	x	x									
Lepidothrix iris	x						x				
Leptasthenura platensis	x						x				
Limnodromus griseus	x										
Lophornis gouldii	x										
Mergus octosetaceus				x							
Merulaxis stresemanni	x	x	x				x				
Momotus momota marcgraviana	x										
Morphnus guianensis	x										
Myrmoderus ruficaudus											
Myrmotherula snowi	x	x									
Myrmotherula klagesi	x										
Nemosia rourei	x	x									
Neomorphus squamiger	x										
Neopelma aurifrons	x										
Nothura minor	x										
Ortalis guttata remota	x										
Pauxi mitu	x	x	x	x							
Penelope jacucaca	x										
Penelope ochrogaster	x										
Phaethornis aethopygus	x	x									
Phaethornis margarettae camargoi	x										
Phylloscartes beckeri	x	x	x								
Phylloscartes ceciliae	x	x									
Picumnus varzeae	x										
Porzana spiloptera	x								x		
Pseudoseisura lophotes	x								x		
Pulsatrix perspicillata pulsatrix									x		
Pyriglena atra	x	x									
Pyrrhura cruentata	x										
Pyrrhura pfrimeri	x										x
Rhopornis ardesiacus	x	x	x				x				
Schiffornis turdina intermedia	x	x									
Sclerurus cearensis	x	x									
Scytalopus diamantinensis	x	x					x				
Scytalopus gonzagai	x	x					x				
Scytalopus iraiensis	x	x		x	x						
Scytalopus novacapitalis	x	x			x		x		x		
Spinus yarrellii				x							
Sporophila beltoni	x										
Sporophila falcirostris				x							

Taxon	Impacts										
	HR	HF	PI	AP	WS	ER	FR	AS	OG	TD	RK
Sporophila frontalis				x							
Sporophila hypoxantha	x										
Sporophila melanogaster	x			x	x			x			
Sporophila nigrorufa	x										
Sporophila palustris	x				x		x	x	x		
Sporophila ruficollis	x			x			x				
Stigmatura napensis napensis	x										
Stymphalornis acutirostris	x	x						x	x		
Synallaxis infuscata	x	x									
Synallaxis kollari	x										
Tangara fastuosa	x	x									
Tangara velia signata	x	x									
Taoniscus nanus	x	x					x				
Terenura sicki	x	x									
Thamnophilus aethiops distans	x	x									
Thamnophilus caerulescens cearensis	x	x									
Tigrisoma fasciatum				x							
Touit surdus	x										
Trogon collaris eytoni	x										
Urubitinga coronata	x			x			x				x
Xanthopsar flavus	x			x	x		x		x		
Xenops minutus alagoanus	x	x									
Xiphocolaptes falcirostris	x										
Xiphorhynchus atlanticus	x										
Xolmis dominicanus	x			x			x		x		
INVERTEBRATES											
ANNELIDA											
Eunice sebastiani				x							
ARACHINIDA											
Ananteris infuscata						x					
Avicularia diversipes	x	x	x								
Avicularia gamba	x	x									
Celaetycheus mungunza	x	x									
Eukoenenia spelunca						x					
Eusarcus elinae						x					
Hadrurochactas araripe											
Iandumoema setimapocu						x					
Metagonia diamantina						x					
Oligoxystre diamantinensis	x	x	x								
Rhopalurus lacrau						x					
Spelaeobochica allodentatus				x		x					
Spelaeobochica iuiu						x					
Speocera eleonorae						x					
Typhochlaena seladonia	x	x	x								
CHILOPODA											
Cryptops (Cryptops) spelaeoraptor											
DIPLOPODA											
Dioplosternus salvatrix	x	x									
Glomeridesmus spelaeus						x					
Odontopeltis giganteus	x	x	x								
ENTEROPNEUSTA											
Willeyia loya				x							
INSECTA											
Aceratobasis cornicauda	x	x									
Aceratobasis mourei	x	x									
Actinote quadra	x										
Adebrotus lugoi	x	x									
Aleuron prominens	x	x									
Aleuron ypanemae				x							
Anochetus oriens	x	x									
Arawacus aethesa	x	x	x								
Arhysosage cactorum	x										
Ateuchus squalidus	x										
Baetodes capixaba	x	x		x		x					
Baetodes iuaquita	x	x									
Camelobaetidius spinosus	x	x		x		x					
Camelobaetidius yacutinga	x	x		x		x					
Canthon corpulentus	x	x	x					x			
Canthon quadripunctatus	x	x	x								
Cartagonum apiuba	x	x	x								
Castoraeschna januaria	x	x									
Charonias theano	x	x	x								
Coarazuphium caatinga					x	x					
Coarazuphium pains						x					
Diaphoromyrma sofiae	x	x									
Dichotomius eucranioides	x	x	x								
Dichotomius schiffleri	x	x	x				x				
Dinoponera lucida	x	x	x								
Doxocopa zalmunna	x										
Drephalys mourei				x							
Drephalys miersi	x			x							
Elasmothemis schubarti	x	x									
Eresia erysice erysice	x										
Fluminagrion taxaense	x	x									
Fulakora cleae	x	x	x								
Gnamptogenys wilsoni				x							
Hamadryas velutina browni	x	x	x								
Heliconius nattereri	x	x	x								
Heraclides himeros baia	x										
Hermanella amere						x					
Hermanella mazama	x	x			x	x					
Hermanella nigra	x	x				x					
Heteragrion petienses	x	x									
Homeoura lindneri	x	x									
Hyalyris leptalina leptalina	x	x	x								
Hypocephalus armatus	x	x	x								
Joiceya praeclarus	x	x	x	x							
Lachnomyrmex nordestinus	x	x									
Leptagrion acutum	x	x									
Leptagrion bocainense	x	x									
Leptagrion porrectum	x	x									
Leptagrion vriesianum	x	x									
Lycomorphon brasiliense	x	x	x								
Magnastigma julia	x	x		x							
Mecistogaster pronoti	x	x									
Melinaea mnasias thera	x	x									
Melipona (Michmelia) rufiventris	x	x									
Melipona (Michmelia) scutellaris	x	x									
Micrathyria borgmeieri	x	x									
Micrathyria divergens	x	x									
Mimoides lysithous harrisianus	x										
Monomorium delabiei	x	x	x								
Morpho epistrophus nikolajewna	x	x	x	x							
Morpho menelaus eberti	x	x	x	x							
Nyceryx mielkei	x	x		x							
Orobrassolis ornamentalis	x	x	x								
Pampasatyrus glaucope boenninghauseni	x						x				
Pampasatyrus glaucope glaucope	x										
Pampasatyrus gyrtone	x						x				
Parelbella polyzona	x	x		x							

Taxon	Impacts										
	HR	HF	PI	AP	WS	ER	FR	AS	OG	TD	RK
Parides burchellanus	x	x					x				
Parides klagesi	x	x									
Parides panthonus castilhoi	x	x	x								
Partamona littoralis	x	x									
Pedaridium hirsutum	x										
Phyllocycla bartica	x	x									
Rhetus belphegor	x	x					x				
Rhionaeschna eduardoi	x	x									
Rhopalothrix plaumanni	x			x							
Scada karschina delicata	x	x	x	x							
Strymon ohausi	x	x	x	x							
Tithorea harmonia caissara	x						x				
Zonia zonia diabo	x										
MALCACOSTRACA											
Aegla brevipalma				x		x					
Aegla camargoi	x	x		x		x					
Aegla franca	x	x				x					
Aegla grisella	x	x		x		x					
Aegla inermis	x			x		x					
Aegla itacolomiensis	x			x		x					
Aegla lata				x			x				
Aegla leachi	x	x									
Aegla leptodactyla	x	x		x		x					
Aegla ligulata	x	x		x		x					
Aegla manuinflata	x	x		x							
Aegla oblata	x	x		x							
Aegla obstipa				x		x					
Aegla plana	x	x									
Aegla perobae	x	x	x	x							
Aegla pomerana	x	x									
Aegla rossiana	x	x									
Aegla spinipalma	x	x		x							
Aegla spinosa	x	x									
Aegla violacea	x	x		x		x					
MOLUSCA											
Lymnaea rupestris	x	x									
Macrodontes dautzenbergianus	x										
Megalobulimus cardosoi	x	x									
Olivancillaria contortuplicata				x							
Olivancillaria teaguei				x							
Plesiophysa dolichomastix	x										
Potamolithus karsticus				x							
Potamolithus troglobius				x							
Spiripockia punctata						x					
Tomigerus (Digerus) gibberulus	x	x									
ONYCHOPHORA											
Epiperipatus adenocryptus	x	x									
Epiperipatus diadenoproctus	x	x									
Epiperipatus paurognostus	x	x									
MAMMALS											
Alouatta belzebul	x	x	x								
Alouatta discolor	x										
Alouatta guariba clamitans	x	x									
Alouatta guariba guariba	x	x									
Alouatta ululata	x	x									
Ateles chamek	x	x									
Ateles marginatus	x	x									
Blastocerus dichotomus	x				x			x		x	
Brachyteles arachnoides	x	x									
Brachyteles hypoxanthus	x	x	x								

Taxon	Impacts										
	HR	HF	PI	AP	WS	ER	FR	AS	OG	TD	RK
Bradypus torquatus	x	x	x								
Callicebus barbarabrownae	x	x	x								
Callicebus coimbrai	x	x									
Callicebus melanochir	x	x									
Callicebus personatus	x	x	x								
Callistomys pictus											
Callithrix aurita	x	x									
Callithrix flaviceps	x	x									
Cebus kaapori	x	x					x				
Cerradomys goytaca	x										
Chiropotes satanas	x	x									
Chiropotes utahickae	x	x									
Chrysocyon brachyurus	x										x
Coendou speratus	x	x	x								
Ctenomys lami	x	x	x								
Eptesicus taddeii	x	x									
Glyphonycteris behnii	x	x									
Gyldenstolpia planaltensis	x										
Kerodon acrobata	x										
Lagothrix cana cana	x	x									
Lonchophylla dekeyseri	x	x									
Leontopithecus chrysomelas	x	x									
Leontopithecus chrysopygus	x	x	x								
Leopardus colocolo	x	x					x				x
Leopardus geoffroyi											x
Leopardus guttulus	x	x									x
Leopardus tigrinus	x	x									x
Leopardus wiedii	x	x									x
Lycalopex vetulus	x	x									x
Marmosops paulensis	x	x									
Mazama bororo	x	x									
Mazama nana	x	x		x						x	
Mico rondoni	x	x									
Myrmecophaga tridactyla	x	x		x							
Ozotoceros bezoarticus bezoarticus	x	x						x		x	
Ozotoceros bezoarticus leucogaster	x	x						x		x	
Panthera onca	x	x									x
Phyllomys brasiliensis	x										
Phyllomys unicolor	x										
Priodontes maximus	x	x									
Pteronura brasiliensis				x							
Puma concolor	x	x					x				x
Puma yagouaroundi	x	x					x				x
Rhipidomys cariri	x				x						
Rhipidomys tribei	x	x									
Saguinus niger	x	x									
Sapajus cay	x	x									
Sapajus flavius	x	x	x								
Sapajus robustus	x	x									
Sapajus xanthosternos	x	x									
Tapirus terrestris	x	x								x	
Tayassu pecari	x	x					x	x		x	
Thalpomys cerradensis	x										
Thylamys macrurus	x										
Thylamys velutinus	x										
Tolypeutes tricinctus	x										
Trichechus manatus	x										
Trichechus inunguis				x							
Trinomys eliasi	x	x									
Trinomys mirapitanga	x	x									

Taxon	Impacts										
	HR	HF	PI	AP	WS	ER	FR	AS	OG	TD	RK
Wilfredomys oenax	x										
Xeronycteris vieirai	x										
FISHES											
ACTINOPTERYGII											
Anablepsoides cearensis	x			x							
Ancistrus cryptophthalmus						x					
Ancistrus minutus	x										
Apareiodon davisi	x					x					
Aphyocheirodon hemigrammus				x							
Apteronotus acidops				x	x	x					
Astyanax eremus	x										
Atlantirivulus maricensis	x										
Austrolebias alexandri	x	x									
Austrolebias arachan	x	x			x						
Austrolebias charrua	x				x						
Austrolebias cheradophilus	x										
Austrolebias cyaneus	x	x									
Austrolebias ibicuiensis	x	x									
Austrolebias jaegari	x	x									
Austrolebias juanlangi	x	x			x						
Austrolebias litzi	x	x									
Austrolebias luteoflammulatus	x	x									
Austrolebias melanoorus	x	x									
Austrolebias minuano	x										
Austrolebias nachtigalli	x	x									
Austrolebias nigrofasciatus	x	x									
Austrolebias paucisquama	x										
Austrolebias periodicus	x										
Austrolebias prognathus	x										
Austrolebias univentripinnis	x				x						
Austrolebias varzeae	x										
Austrolebias vazferreirai	x	x									
Austrolebias wolterstorffi	x				x						
Brycon nattereri	x										
Campellolebias brucei	x										
Campellolebias chrysolineatus	x										
Campellolebias dorsimaculatus	x										
Characidium heirmostigmata				x		x					
Characidium oiticicai				x	x	x					
Characidium vestigipinne	x							x			
Chasmocranus brachynemus	x			x							
Cnesterodon hypselurus						x					
Cnesterodon omorgmatos	x			x		x					
Coptobrycon bilineatus	x										
Corumbataia britskii											
Cynolebias leptocephalus	x			x							
Cynopoecilus fulgens	x										
Cynopoecilus intimus	x										
Eigenmannia vicentespelaea						x					
Epinephelus itajara	x										
Glandulocauda caerulea	x	x		x		x					
Gymnogeophagus setequedas	x	x		x		x					
Harttia dissidens						x					
Hasemania crenuchoides	x			x		x					
Hassar shewellkeimi											
Hypsolebias alternatus	x			x	x						
Hypsolebias auratus	x			x	x						
Hypsolebias fasciatus	x										
Hypsolebias flammeus	x										
Hypsolebias flavicaudatus	x										
Hypsolebias fulminantis	x			x	x						
Hypsolebias ghisolfii	x			x	x						
Hypsolebias gibberatus	x										
Hypsolebias harmonicus	x			x	x						
Hypsolebias hellneri	x			x	x						
Hypsolebias longignatus	x										
Hypsolebias lopesi	x										
Hypsolebias magnificus	x			x	x						
Hypsolebias marginatus	x										
Hypsolebias mediopapillatus	x										
Hypsolebias multiradiatus	x										
Hypsolebias notatus	x										
Hypsolebias picturatus	x										
Hypsolebias similis	x										
Hypsolebias tocantinensis	x										
Hypsolebias trilineatus	x			x	x						
Hypsolebias virgulatus	x										
Isbrueckerichthys saxicola	x										
Ituglanis cahyensis	x	x									
Ituglanis passensis						x					
Ituglanis ramiroi						x					
Jenynsia diphyes				x							
Jenynsia sanctaecatarinae				x		x					
Kryptolebias gracilis	x										
Listrura costai	x										
Lophiobrycon weitzmani	x					x					
Loricaria coximensis											
Mucurilebias leitaoi	x										
Maratecoara formosa	x										
Maratecoara splendida	x										
Melanorivulus crixas	x										
Melanorivulus karaja	x										
Melanorivulus kayapo	x										
Melanorivulus kunzei	x										
Melanorivulus litteratus	x										
Melanorivulus pindorama	x										
Melanorivulus pinima	x										
Melanorivulus planaltinus	x										
Melanorivulus rubromarginatus	x										
Melanorivulus salmonicaudus	x										
Melanorivulus scalaris	x	x									
Melanorivulus ubirajarai	x										
Melanorivulus vittatus	x	x									
Microcambeva draco	x	x				x					
Mimagoniates sylvicola	x	x									
Nematolebias catimbau	x				x						
Notholebias vermiculatus	x										
Pamphorichthys pertapeh				x	x						
Phallotorynus fasciolatus	x										
Phallotorynus jucundus				x							
Pimelodella spelaea				x		x					
Plesiolebias canabravensis	x										
Plesiolebias xavantei	x										
Prochilodus britskii	x										
Ophthalmolebias rosaceus	x			x	x						
Otothyris juquiae	x			x	x						
Rhamdiopsis krugi				x		x					
Simpsonichthys cholopteryx	x										
Simpsonichthys nigromaculatus	x			x	x						
Simpsonichthys parallelus	x			x	x						

Taxon	Impacts										
	HR	HF	PI	AP	WS	ER	FR	AS	OG	TD	RK
Simpsonichthys punctulatus	x										
Simpsonichthys zonatus	x				x						
Spintherobolus leptoura	x			x	x						
Stygichthys typhlops				x	x						
Teleocichla centisquama	x										
Trichogenes claviger	x										
Trichomycterus dali				x	x	x					
Trichomycterus rubbioli						x					
Trichomycterus triguttatus				x							
Trichomycterus tropeiro								x			
Xenurolebias myersi	x										
ELASMOBRANCHII											
Paratrygon aiereba	x			x							
REPTILES											
Ameiva parecis	x										
Amerotyphlops amoipira	x										
Amerotyphlops paucisquamus	x	x	x								
Amerotyphlops yonenagae	x										
Amphisbaena arda											
Amphisbaena frontalis											
Amphisbaena supernumeraria	x	x	x								
Amphisbaena uroxena	x			x							
Apostolepis arenaria	x										
Apostolepis gaboi	x										
Apostolepis quirogai	x										
Apostolepis serrana	x										
Apostolepis striata	x										
Atractus caete	x	x	x								
Atractus hoogmoedi	x										
Atractus ronnie	x										
Atractus thalesdelemai	x										
Bachia didactyla	x										
Brasiliscincus caissara	x	x	x								
Bothrops muriciensis	x										
Bothrops pirajai	x	x	x								
Calamodontophis paucidens	x	x	x								
Calamodontophis ronaldoi	x			x							
Colobodactylus dalcyanus	x	x	x								
Contomastix vacariensis	x	x	x				x				
Dactyloa nasofrontalis	x										
Dactyloa pseudotigrina	x										
Ditaxodon taeniatus	x										
Echinanthera cephalomaculata	x	x									
Enyalius erythroceneus	x	x									
Eurolophosaurus amathites	x										
Heterodactylus lundii	x	x	x								
Heterodactylus septentrionalis	x			x							
Homonota uruguayensis	x	x	x								
Hydrodynastes melanogigas	x										
Kentropyx vanzoi	x										
Leposoma baturitensis	x	x									
Leposoma nanodactylus	x	x									
Leposoma puk	x	x	x								
Leposternon kisteumacheri	x	x									
Liolaemus arambarensis	x	x	x								
Liolaemus occipitalis	x	x									
Phalotris multipunctatus	x										
Philodryas livida	x										
Placosoma cipoense	x	x					x		x		
Rodriguesophis chui	x										
Rodriguesophis scriptorcibatus	x										
Stenocercus azureus	x										
Stenocercus dumerilii	x										
Tropidurus erythrocephalus	x										
Tropidurus hygomi	x	x									
Tropidophis grapiuna	x	x	x								
Total	**450**	**239**	**69**	**100**	**40**	**51**	**33**	**16**	**11**	**6**	**15**

HR = Habitat Reduction; HF = Habitat Fragmentation; PI = Population Isolation; AP = Agricultural Pollution; WS = Changes to Water Structures; ER = Erosion; FR = Fire; AS = Introduction Invasive Alien Species; OG = Overgrazing; TD = Transmission Diseases; RK = Retaliatory Killing.

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