

1 *Review*

2 **What threatens Brazilian endangered species and how they are Red-**  
3 **Listed**

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16

17 **Abstract** - Brazil is a continental-sized megadiverse country with high rates of habitat loss and  
18 degradation. Part of the Brazilian biodiversity – including endemic species – is recognized as  
19 threatened. By following the IUCN standards, we review the classification of all the 1172  
20 endangered species in Brazil, analyzing differences among categories and groups. Based on a  
21 subsample of all 464 terrestrial vertebrates we identified 1036 records of threats affecting them.  
22 Criterion B was the most used (56% overall; 70% for CR species; 75% for EN), mainly related to  
23 reductions in their habitat area, extent and/or quality due to deforestation. Data on population  
24 declines (criterion A), number of reproductive individuals (criterion C), and population sizes  
25 (criterion D) are available for only a small fraction of the Brazilian fauna. Criterion E (probability  
26 of extinction in the wild) was used for only one species. Birds and mammals had the highest  
27 diversity of used criteria, while marine fish the lowest (90% related to declining populations).  
28 Two out of three of the 464 vertebrate species analyzed were negatively impacted by  
29 agribusiness. Other major threats are hunting, urban sprawl, rural settlements, and the  
30 construction of hydroelectric dams. Birds and mammals experience more co-occurrence of  
31 threats. Some threats are clearly underestimated in Brazil: climate change was indicated for only  
32 2% species analyzed, but included no birds or amphibians. The main threats identified are linked  
33 to the patterns of economic development in Brazil and the current political and economic context  
34 points to a worrisome conservation scenario in the near future.

35 **Keywords:** Biodiversity conservation; threatening drivers; conservation threats; IUCN criteria;  
36 IUCN Red List; threatened species.

37

## 38 **Resumo**

39 O Brasil é um país continental megadiverso com altas taxas de perda e degradação de habitats.  
40 Parte da biodiversidade brasileira – incluindo espécies endêmicas – está ameaçada. Seguindo  
41 padrões da IUCN, aqui detalhamos a classificação de todas as 1172 espécies ameaçadas de  
42 extinção no Brasil, analisando as diferenças entre categorias e grupos animais. Baseado em uma  
43 amostra de todas as 464 espécies de vertebrados terrestres ameaçados identificamos 1036  
44 registros de ameaças sobre elas. O Critério B foi o mais usado (56% no geral; 70% para espécies  
45 CR; 75% para EN), principalmente em função de reduções na área, extensão e/ou qualidade dos  
46 habitats em função de desmatamento. Dados sobre declínios populacionais (critério A), número  
47 de indivíduos reprodutivos (critério C), e tamanho populacional (critério D) existem para apenas  
48 uma pequena fração da fauna brasileira. O Critério E (probabilidade de extinção na natureza) foi  
49 usado para apenas uma espécie. Aves e mamíferos têm a mais alta diversidade de critérios  
50 usados, enquanto peixes marinhos a menor (90% relacionados com declínios populacionais).  
51 Duas de cada três das 464 espécies de vertebrados analisadas são negativamente afetadas pelo  
52 agronegócio. Outras ameaças incluem a caça, expansão urbana, assentamentos rurais, e a  
53 construção de hidrelétricas. Aves e mamíferos experimentam a maior co-ocorrência de ameaças.  
54 Algumas ameaças estão claramente subestimadas no Brasil: mudanças climáticas foram indicadas  
55 apenas para 2% das espécies analisadas, mesmo assim para nenhuma ave ou anfíbio. As  
56 principais ameaças identificadas estão ligadas aos padrões de desenvolvimento econômico no  
57 Brasil e os contextos político e econômico atuais apontam para um cenário conservacionista  
58 preocupante no futuro próximo.

59 **Palavras-chave:** Ameaças à conservação; Conservação da biodiversidade; critérios da IUCN;  
60 espécies ameaçadas; forças e agentes de ameaça à conservação; Lista Vermelha da IUCN.

61

## 62 **Introduction**

63 Drivers of environmental changes are increasing globally, pushing biodiversity loss at  
64 unprecedented rates in almost all ecosystems on the planet (e.g. Ceballos et al. 2015). The  
65 situation is more severe in tropical regions, with a complex combination of high species richness,  
66 increasing human populations, and high rates of natural habitat loss. But even in the Tropics the  
67 situation is heterogeneous, more worrisome in some countries. This is the case of Brazil, a  
68 country with some world records of biodiversity – including thousands of endemic species – but  
69 also very high rates of habitat loss and degradation and a pessimistic political scenario (e.g.  
70 Abessa et al. 2019; Gonzales, 2019; Phillips 2019).

71 In December 2014, after a hiatus of more than a decade, the Brazilian Minister of  
72 Environment updated the official list of endangered species in Brazil (MMA, 2014). Between  
73 2010 and 2014, more than 1300 specialists evaluated 12,556 species in 73 workshops and four  
74 validation meetings (ICMBio, 2015a, 2015b). All known species of birds, mammals, amphibians  
75 and reptiles in Brazil were evaluated, plus 4507 fish and 3332 invertebrate species, and 1172  
76 species were officially declared endangered in the country. Overall, that evaluation effort was  
77 more than 10 times larger (more than 20 times for marine and freshwater fish) than the previous  
78 one, published in 2003 (ICMBio, 2015b).

79 The list published in 2014 followed all the protocols set by the International Union for  
80 Conservation of Nature (IUCN), which adopt five quantitative criteria and sub criteria: A.  
81 Declining population (past, present and/or projected); B. Geographic range size, and  
82 fragmentation, decline or fluctuations; C. Small population size and fragmentation, decline, or  
83 fluctuations; D. Very small population or very restricted distribution; E. Quantitative analysis of  
84 extinction risk (e.g. Population Viability Analysis) (IUCN 2012; Supplementary Table 1).

85 Identifying threatened species is important, for example, for conservation prioritization  
86 purposes, regulation of trade in wildlife products, or for the legal protection of those species.  
87 However, diagnosing the threats experienced by a taxon or a group of taxa is critical to  
88 understand the risks they experience and, most importantly, to devise strategies to reverse their  
89 negative conservation scenarios. IUCN also adopts a unified classification system of threats  
90 (Salafsky et al., 2008), useful for conservation strategies because it defines and classifies threats  
91 in a standardized way and can be universally applied in different countries and contexts. Such  
92 classification has been used in recent research to determine the major threats to biodiversity  
93 globally (Maxwell et al., 2016) and regionally in Australia (Allek et al., 2018). The adoption of  
94 such internationally-applied criteria allows the scientific community, conservationists and  
95 decision-makers to better analyze and compare why species are threatened and how they were  
96 classified.

97 Here we provide a quali-quantitative analysis on how the Brazilian endangered species are  
98 being Red-Listed and what threatens them. We first identified which were the most-used IUCN  
99 criteria and sub criteria to classify all the 1172 endangered species in Brazil, and analyzed how  
100 they differ among categories and animal groups. Later, using a subsample of all endangered  
101 vertebrates (464 species of birds, mammals, reptiles and amphibians) we investigated in detail the  
102 threats those species face.

103

## 104 **Methods**

105 We considered all 1173 species present in the List of Brazilian Fauna Species Threatened with  
106 Extinction (MMA, 2014). Between 2010 and 2014, 12,256 taxa of the Brazilian fauna were  
107 evaluated, including all vertebrates described for the country, for a total of 732 mammals, 1980  
108 birds, 732 reptiles, 973 amphibians and 4507 fish (3,131 freshwater, including 17 rays, and 1,376

109 marine), plus 3332 invertebrates, including crustaceans, mollusks, insects, porifera, myriapods,  
110 among others (ICMBio, 2018). The Instituto Chico Mendes de Conservação da Biodiversidade  
111 (ICMBio) – the federal authority responsible for the evaluation process – carried out 73  
112 assessments and four validation workshops. ICMBio worked formally together with IUCN for  
113 assessment standardizations and validations and the final list of threatened species was published  
114 in December 2014, containing 110 mammals, 234 birds, 80 reptiles, 41 amphibians, 353 bony  
115 fish (310 freshwater and 43 marine), 55 cartilaginous fish (54 marine and 1 freshwater), 1 hagfish  
116 and 299 invertebrates (MMA, 2014). In total, 448 species were classified as Vulnerable (VU),  
117 406 as Endangered (EN), 318 as Critically Endangered (CR) and 1 as Extinct in the Wild (EW)  
118 (Supplementary Table 1).

119 For a detailed analysis of threats, a sub-sample containing all 464 species of threatened  
120 vertebrates (all terrestrial tetrapods in the assessment) were considered: 233 birds, 110 mammals,  
121 80 reptiles and 41 amphibians, distributed in 37 orders and 114 families (Supplementary Fig. 1).  
122 For birds, the Alagoas curassow *Pauxi mitu* was not considered since it is classified as EW. In  
123 this sub sample, 82 species were CR, 176 EN, and 206 VU (Supplementary Fig. 2). For each of  
124 them, information about threats they experience were taken from official sources of the Ministry  
125 of the Environment, such as the available species' National Action Plans and/or from the  
126 information provided during their assessment and evaluation process. Any references to threats  
127 found were compiled and tabulated in spreadsheets for each of the species, according to their  
128 biological group and threat category (Supplementary Table 2).

129 For 29 of those 464 species it was not possible to identify any related threat due to several  
130 factors: past or current reduction of the population by unknown causes; species without records  
131 of sightings for many years; decline in the number of mature individuals due to unknown causes;  
132 inference that the species is possibly extinct; taxonomic uncertainty; highly endemic species; and

133 species with very restricted occurrence areas and/or areas of occupancy. However, in the 2014  
134 list, no supporting information was found for the lizard *Liolaemus occiptalis* (CR), and therefore  
135 data from the previous 2003 list were used. For the lizard *Tropidurus psammonastes* (EN) no  
136 information was found from either the current list or the 2003 list. This species is classified as  
137 Data Deficient (DD) on IUCN Red List (IUCN, 2018).

138 The identified threats were classified into 11 drivers and 40 sub-drivers as proposed by  
139 Salafsky et al. (2008)(Supplementary Table 2). The driver Geological Events (Sub-drivers  
140 *Volcanoes, Earthquakes/tsunamis, Avalanches/landslides*) was not considered, due to the  
141 irrelevance of such activities to the Brazilian fauna. Five modifications were necessary in the  
142 categories proposed by Salafsky et al. (2008), and all were made with the intention of increasing  
143 the clarity and adequacy of the categories originally proposed (see Methods in the Supplementary  
144 Information).

145

#### 146 **Criteria and sub criteria used**

147 Among the 1172 species analyzed, 1050 species (97%) were classified based on a single  
148 criterion, 113 species were classified based on two, and nine species based on three criteria,  
149 resulting in a total of 1,303 assigned criteria. Overall, criterion B (geographic range size) was the  
150 most widely used (56%), followed by criterion A (declining populations – 24%), criterion D  
151 (very small or restricted populations – 11%), and criterion C (small population size and estimated  
152 continuing decline in the number of mature individuals – 8%) (Fig. 1; Table 1). Criterion E,  
153 which estimates the probability of extinction in the wild, was used for only one species, the  
154 maned-wolf *Chrysocyon brachyurus*, however in combination with another (A3). When  
155 endangered status is considered, criterion B was the most common for categories CR and EN

156 (70% and 75% of the classifications, respectively), but the distribution of categories was more  
157 uniform for VU: 35% for criterion A, 27% for B, 26% for D, and 10% for C

158       Dozens of sub criteria combinations were used but overall the top-3, accounting for 66%,  
159 were B2 (area of occupancy severely fragmented or low number of locations – 29%), B1 (small  
160 extent of occurrence – 27%) and A2 (population reduction observed, estimated, inferred, or  
161 suspected in the past – 10%)(Fig. 1; Table 1). The high proportion of the use of criterion B2 was  
162 inflated by freshwater fish (47% of the 319 criteria for the group) and terrestrial invertebrates  
163 (41% of the 270 criteria for the group). For different categories of threat, the top-3 were B2 for  
164 CR species (44% out of 374 species), D2 for EN species (35% out of 445 species), and D2 for  
165 VU species (24% out of 484 species) (Fig. 1; Table 1).

166       Birds and mammals were the two taxonomic groups with the highest diversity of criteria  
167 used, but C2 and A4 were the most used, respectively (Fig. 2). For the other groups, criteria  
168 usage was more restricted: only four for amphibians and terrestrial invertebrates; and seven for  
169 the other groups. Terrestrial invertebrates and marine fish were the groups with the lowest  
170 diversity in usage, with 90% of the criteria being either B1 or B2 for the first, and 83% A1-A4 for  
171 the second.

172

### 173 **Drivers, sub drivers and taxonomic biases**

174       We identified 1036 records of threats for the 464 vertebrate species analyzed (Supplementary  
175 Table 2). The number of threats per species varied from 1 up to 10, with an average of 2.2  
176 threats/species; 168 species had a single threat recorded, and 58% of the species had two or more  
177 simultaneously. The hooded capuchin monkey *Sapajus cay* (VU), with 10 records, the puma  
178 *Puma concolor* (VU) and the Coimbra-Filho's titi monkey *Callicebus coimbrai* (EN), both with  
179 nine records, were the species with the highest number of threats identified.



180 The three most frequent drivers were *Agriculture and Aquaculture* (affecting 309 species),  
181 *Natural System Modification* (132 spp.), and *Overexploitation* (128 spp.), while the least frequent  
182 were *Pollution* (30 spp.), *Climate Change and Severe Weather* (10 spp.), and *Human Intrusions*  
183 *and Disturbance* (4 spp.) (Figs. 3 and S3). When species' threat category is considered,  
184 *Agriculture and Aquaculture* affected most of the CR species (39 spp.), EN (120 spp.) and VU  
185 (150 spp.) (Fig. 4).

186 The five most frequent sub-drivers were *Cropping* (for 295 species), *Hunting* (87 spp.),  
187 *Livestock farming* (85 spp.), *Housing* (76 spp.), and *Others* (51 spp.) (Figs. 3 and Supplementary  
188 4). *Cropping* and *Livestock farming* were always among the three most frequent sub-drivers for  
189 all animal groups (Supplementary Fig. 5). The sub-driver *Agricultural fire* was recorded for 42  
190 species while *Non-agricultural fire* was recorded for 11. When the category of threat was  
191 considered the sub-drivers *Cropping* and *Hunting* affected most of the CR species (39 and 14  
192 species, respectively) and VU species (142 and 49 species, respectively). *Cropping* (114 species)  
193 and *Livestock Farming* (41 species) were the sub-drivers affecting most of the EN species (Fig.  
194 4).

195 Mammal species were most affected for 6 out of the 10 drivers analyzed, ranging from 30%  
196 up to 89% of the species depending on the driver, and bird species were the most affected for two  
197 drivers (Supplementary Figs. 6-S9). *Agricultural activity* was the top driver for mammals and  
198 birds; reptiles accounted for 20 out of the 50 species affected by the driver *Energy Production*,  
199 while amphibians were 8 out of the 30 species affected by the driver *Pollution*. No driver was  
200 group-specific.

201 For the driver *Agricultural activity*, 206 species were affected by the sub-driver *Cropping*  
202 alone (139 birds, 28 mammals, 27 reptiles, and 12 amphibians); five species were affected by the  
203 sub-driver *Livestock Farming* alone (3 birds, 1 reptile and 1 amphibian); and 68 species were

204 simultaneously affected by *Cropping* and *Livestock Farming* (33 mammals, 11 birds, 17 reptiles,  
205 and 7 amphibians).

206 For the driver *System Modification*, 41 species were affected by the sub-driver *Dams* alone  
207 (15 birds, 15 reptiles, 6 mammals, and 5 amphibians), 30 species were affected by the sub-driver  
208 *Agricultural fire* alone (12 birds; 8 mammals, 8 reptiles, and 2 amphibians); and 9 species by the  
209 sub-driver *Non-agricultural fire* alone (5 birds, 3 mammals, and 1 amphibian). For the driver  
210 *Overexploitation*, 75 species were affected by the sub-driver *Hunting* alone (38 mammals, 32  
211 birds, and 5 reptiles) and 29 species by sub-driver *Logging and Wood Harvesting* (13 reptiles, 12  
212 birds, 3 amphibians, and 1 mammal).

213 Mammals were the most affected group for 8 out of the 10 most-frequent sub-drivers,  
214 varying from 37% up to 82% of the species depending on the sub-driver. The sub-drivers  
215 *Aquaculture*, *Recreational*, *Excess Energy*, *Climate Change* and *Severe Weather n/i*, and  
216 *Droughts* were recorded for mammals only (Supplementary Table 2). Birds were the most  
217 affected group for the sub-drivers *Cropping* (155/295 spp. - 53%), and *Dams* (17/50 spp. - 34%).  
218 Fifteen out of the 37 species (40%) affected by *Mining* were reptiles, and 12 out of 76 species  
219 (16%) affected by *Housing* were amphibians.

220

## 221 **Discussion**

222 More than half of the 1172 endangered species in Brazil are being Red-Listed based on the  
223 continuing decline in the size, extent and/or quality of their habitats (IUCN criterion B).

224 Moreover, the main driver threatening those species is clear: 2/3 of the 464 vertebrate species  
225 analyzed in depth are negatively impacted by agribusiness. Other major threats are related with  
226 hunting, urban sprawl, rural settlements, and the construction of hydroelectric dams. Although  
227 threats were identified, the availability of national-level quantitative data on population decline

228 (criterion A), on the number of sexually reproductive individuals (criterion C), and estimates of  
229 population sizes (criterion D) are highly variable among the Brazilian animal groups – from zero  
230 to the majority of them, to reliable quantitative data for some species of mammals and birds –  
231 making the use of these criteria to be frequently group-specific.

232         The causes of deforestation in tropical regions can be direct – i.e., related to land use, and  
233 directly affecting the environment and vegetation cover – or indirect – i.e., causes which are  
234 related and determine an increase in the demand for actions producing changes in the use of land  
235 (Geist & Lambin 2002). We detected that the five most frequent threatening drivers on our  
236 analysis are a mix of both direct and indirect causes: among the direct causes are agribusiness,  
237 logging, and the implementation of infrastructure such as roads, highways and dams. Indirect  
238 threats can be more difficult to identify and measure, ranging from demographic, economic,  
239 technological, institutional, and cultural issues (Geist & Lambin 2001). In our analysis, these  
240 underlying causes include socio-economic issues, such as population growth and urban sprawl,  
241 tourism and industrial activities, and rural settlements, as well as cultural issues, like wildlife  
242 hunting, and political issues, like changes in the Brazilian Forest Code (Tollefson 2011; Soares  
243 Filho et al. 2014; Roriz et al. 2017).

244         Agricultural activities is the second greatest threat to 8000 species threatened with  
245 extinction globally, affecting 68% of the species (Maxwell et al., 2016). Our analysis confirms  
246 that: agricultural activities affect 47% of the critically endangered species of Brazilian  
247 vertebrates, 68% of the endangered, and 73% of the vulnerable species. The conversion of natural  
248 habitats to the agriculture is now occurring more rapidly in tropical regions and driven by the  
249 demand for commodities such as soybeans, coffee, cocoa, sugar, and palm oil (Curtis et al. 2018).  
250 In the case of Brazil, habitat loss is largely driven by deforestation and several studies have  
251 indicated both large-scale and slash and burn agriculture as the main drivers. The increase in

252 sugarcane expansion, for example, led to significant changes in land use in the Atlantic Forest  
253 (Galindo-Leal & Câmara, 2003), while cattle ranching and soybean cultivation are major drivers  
254 for deforestation in Brazilian Amazonia and the Cerrado (Barona et al., 2010; Fearnside 2005;  
255 Spring 2018). Agriculture and agribusiness also bring with them several indirect causes, such as  
256 the use of fire, recorded for 10% of the species here analyzed. The use of fire in Brazil is closely  
257 related to the intensification of agricultural production and opening of pastures, resulting in an  
258 increase of fire frequency along the Brazilian agricultural frontier (Carrero & Fearnside 2011;  
259 Hantson et al. 2015). Furthermore, agribusiness was tied to 36% of the species for which  
260 pollution was identified as a threat, due to the runoff and leaching of agrochemicals or other  
261 agricultural residues. This emphasizes the large share of direct and indirect effects agriculture and  
262 agribusiness have on threat to species in Brazil.

263         The opening of roads is a form of infrastructure that has a negative effect on wildlife (e.g.  
264 Laurance & Arrea, 2017). Nevertheless, in the next three decades, the total length of additional  
265 paved roads could approach 25 million kilometers worldwide (Alamgir et al. 2017). Studies in  
266 Brazil estimate that up to 475 million animals may die hit by cars annually, made up of 90%  
267 small vertebrates (mainly amphibians), 9% medium-sized vertebrates (such as reptiles and birds)  
268 and 1% large vertebrates (such as jaguars and primates)(CBEE, 2018). In our analysis, 10% of  
269 the species analyzed experienced threats related to the expansion of the road network, but road  
270 kill was identified as a threat to only 2% of them, all mammals, including the maned-wolf  
271 *Chrysocyon brachyurus* and the puma *Puma concolor*.

272         *Underestimating threats* – In addition to the effects of deforestation and fragmentation,  
273 other drivers seem to be clearly underestimated in Brazil. This is the case for climate change.  
274 Climate change can considerably modify the abiotic conditions for the survival of species in the  
275 future, increasing the negative effects of habitat loss and fragmentation (e.g. Colombo & Joly,

276 2010; Mantyka-Pringle et al. 2015; Segan et al. 2016). In fact, a recent meta-analysis to identify  
277 the main drivers of global threats have indicated that climate change is mentioned by 40% of the  
278 published papers, with an increase of 10% per year (Mazor et al. 2018). Climate projections for  
279 the Atlantic Forest in northeastern Brazil point to a temperature rise of around 0.5 °C to 3 °C by  
280 the year 2070, and rainfall decrease between 20-25%, whereas projections for the Cerrado point  
281 to an increase of up to 3.5 °C and reduced rainfall between 20-35% (PBMC 2015). Scenarios for  
282 parts of the Amazonia and the Caatinga are even more worrisome, as those regions may  
283 experience above average effects of climate change. The climatic models for the Caatinga – a  
284 region whose average rainfall is < 800 mm – indicate an increase of 0.5 °C to 1 °C in the air  
285 temperature and a decrease between -10 % and -20 % in the rain during the next three decades  
286 (until 2040), with a gradual increase of temperature to 1.5 °C to 2.5 °C and decrease between -25  
287 % and -35% in the rainfall patterns in the period of 2041-2070 (PBMC 2015).

288         Similar analyses to those presented here indicate that climate change is a major threat to  
289 the endangered species worldwide. Climate change appears as a threat to 21% of some 8,000  
290 globally endangered species (Maxwell et al. 2016) and, in the long run, climate change is already  
291 recognized as the most troubling threat among birds (BirdLife International 2018). Allek et al.  
292 (2018) identified climate change among the most prominent threats for the endangered fauna of  
293 Australia, especially in the east of the country, where the largest number of species of amphibians  
294 are concentrated. Amphibians are sensitive to climate change (Gascon 2007) and in Australia this  
295 is the group with the highest number of Critically Endangered species. Brazil and Australia are  
296 both continental-sized countries subject to climate change, harboring rich and endemic faunas.  
297 However, while Australia has ca. 230 species of amphibians, Brazil has ca. 1,080 (Segalla et al.  
298 2016). Thus, the expected number of amphibian species threatened by climate change would be  
299 certainly bigger in Brazil. Our analysis reveals that climate change is currently listed as a threat to

300 only 2% of the vertebrate species analyzed, and with no amphibians or birds among them.  
301 Moreover, there are important synergies between forest fragmentation, climate vulnerability and  
302 species threat status (e.g. Jetz et al. 2007; Becker et al. 2016), where fragmented forests tend to  
303 be more vulnerable to droughts than intact forests (e.g. Scarano & Ceotto, 2015; Segan et al.  
304 2016). Therefore, the impact of climate change for some specific animal groups in Brazil – like  
305 amphibians and birds – is underestimated, likely more pronounced than currently assessed, and  
306 aggravated by the advanced state of fragmentation present in several Brazilian terrestrial biomes.

307         The role exotic species play in threatening species in Brazil also is likely underestimated.  
308 Worldwide, the presence of predatory exotic species have caused numerous species extinctions,  
309 with the best studied impacts being those of cats, rats and dogs (Jones et al., 2008; Doherty et al.,  
310 2016). Of the 233 bird species here analyzed, invasive or exotic species were recorded as a threat  
311 for only 15. Of these, 60% were related to predation of nests by rats and mice (3 CR, 3 EN and 3  
312 VU). Dogs are already recognized as a conservation problem in the Atlantic Forest, becoming the  
313 most frequent recorded species among all mammal locally (Srbek-Araujo & Chiarello, 2008;  
314 Paschoal et al. 2012; Lessa et al. 2016). However, in our analysis, the negative impact of dogs  
315 was rarely reported as a threat.

316         Eleven percent of the species we analyzed were impacted by threats associated with water  
317 management. Among these, for 9 out of 10 species the implementation of hydroelectric dams was  
318 the main threat. In Brazil, large hydro dams are mainly located and planned for the Amazon,  
319 generating debate on their negative impacts, including the displacement of human populations  
320 due to the flooding of indigenous territories and habitat loss for vertebrates. There is also debate  
321 on whether the energy they produce is actually green (Benchimol & Peres, 2015; Lees et al.,  
322 2016). In our analysis, two of the species affected by hydro dams are the Amazon river-dolphin  
323 *Inia geoffrensis* (EN), and the recently-described Brazilian species *Inia araguaiensis* (Hrbek et

324 al., 2014), found in the Araguaia River basin. This species is on the process of being Red-Listed  
325 (Araújo & Wang 2015). Also, in spite of previous and new evidence (Carter & Rosas 1997;  
326 Palmeirim et al. 2014; Groenendijk et al. 2015) hydroelectric dams were not identified as a threat  
327 to the giant river otter *Pteronura brasiliensis* (VU) in the official documents we analyzed. Large  
328 hydroelectric reservoirs often greatly increase the extent of freshwater environments, but these  
329 often provide poor quality habitats for aquatic biota (Palmeirim et al., 2014). Large dams also  
330 profoundly alter the structure of terrestrial biota with species isolated on the islands formed  
331 (Benchimol & Peres, 2015; Lees et al., 2016). In the current scenario where 2,215 hydro dams  
332 are planned for Amazonia (Finer & Jenkins 2012; Tundisi et al. 2014; Anderson et al. 2018), the  
333 conservation consequences are worrisome. Given the high species richness and endemism of  
334 Amazon region, and considering that Brazil hosts both most of the impacted area and most of the  
335 projected hydro dams, the threat those structures poses to the regional fauna seem underestimated  
336 and their impact must be correctly assessed.

337 *Synergies between threats* – Biodiversity loss may be intensified in response to additive,  
338 synergistic or antagonistic effects (Pereira et al., 2010; Maxwell et al., 2016). The synergy  
339 between threats can worsen the situation of species already threatened (e.g. BirdLife International  
340 2018) and this may occur because the combined effect of two threats may be greater than the  
341 additive effect of these threats separately (Allek et al., 2018). Identifying these synergies is  
342 important both to quantify the risk of extinction and to prioritize threat mitigation (Ducatez &  
343 Sjine, 2017; Allek et al., 2018). Recognizing synergies and trade-offs in a resource-constrained  
344 scenario, with a focus on different targets, can minimize efforts and optimize spending on  
345 conservation (Di Marco et al., 2015).

346 However, few studies address the role of multiple threatening drivers (Ducatez & Sjine,  
347 2017; Mazor et al., 2018). In our analysis, the groups with the most threatened species (birds and

348 mammals) were also the groups with the most co-occurrence of threats. The most frequent sub-  
349 driver (*Cropping*) was recorded for species of all categories of threat in all the animal groups here  
350 analyzed. Cropping was recorded in association with two of the other three sub-drivers of  
351 Agricultural Activities (*Livestock* and *Timber Plantations*) with its association with *Livestock*  
352 *Farming* accounted for 22% of the species affected by Agricultural Activities. Integrated  
353 predictive studies (e.g. Symes et al. 2018) on the relative and synergistic effects of and threats on  
354 the Brazilian biodiversity are still scarce (e.g. Gouveia et al. 2016). Such detailed analyses will be  
355 hampered if some threats are underestimated.

356 *Criterion B, the lack of basic information and the need for refined evaluations* - Gaps in  
357 the basic knowledge on the distribution of some Brazilian species may compromise their  
358 conservation (e.g. Bernard et al., 2011; Sousa-Baena et al. 2013; Oliveira et al. 2017). Some  
359 species indeed have large extent of occurrences (hereafter EOO, the estimate of dispersion of  
360 risk) built based on a few scattered records. However, a large EOO based on isolated and broadly  
361 spaced points may underestimate the real situation of those species, especially for those where the  
362 EOO is overall under strong pressure. In this situation, data that would allow for estimation of the  
363 area of occupancy (hereafter AOO, or the actual best estimate of distribution) would help to  
364 reveal this fragmentation (e.g. Jetz et al., 2008). Accurate data to allow for the estimation of AOO  
365 in these situation is a high research priority. On the other hand, presenting artificially smaller  
366 EOO and AOO as a result of poor data will result in higher threat status and overestimate risk  
367 (IUCN, 2012). Most of the Brazilian species classified under criterion B based on their EOO (B1)  
368 are mammals, reptiles, amphibians, land invertebrates and aquatic invertebrates; and based on  
369 their AOO (B2), birds and freshwater fish. The prevalence of criterion B and the rare use of  
370 criterion E are observed worldwide (e.g. Collen et al. 2016). But, in an utopian scenario where  
371 there was no such high loss or degradation of habitats in the country, many of the Brazilian



372 species would actually be classified as "Data Deficient" due to the total lack of basic data on their  
373 population declines (criterion A), on the number of sexually reproductive individuals (criterion  
374 C), and on estimates of population sizes (criterion D). Currently, 1,670 of 12 556 species  
375 evaluated in Brazil are "Data Deficient" (ICMBio, 2018). The higher use of criterion B exposes,  
376 in fact, a worrisome combination of severe and fast habitat loss and the lack of the most basic  
377 population information for most of the endangered species in Brazil, a situation that must be  
378 reversed.

379 Part of this problem can be reduced with regional assessment initiatives. In fact, IUCN  
380 does support and encourages regional Red Lists (IUCN 2012) and in a country with continental  
381 dimensions such as Brazil the production of more refined state lists may fill some of the  
382 knowledge gaps necessary to better classify some species. In the case of smaller states and for  
383 those with more data and established technical expertise, regional assessments could be a better  
384 alternative. These regional Red Lists can better identify threatened populations or those more  
385 likely to decline on a more detailed spatial scale (e.g. De la Torre et al. 2018), allowing the  
386 development of a strategy to prevent local population declines that eventually lead an entire  
387 species to become threatened with extinction on a wider level. However, currently, only eight of  
388 the 27 Brazilian states (Bahia, Espírito Santo, Minas Gerais, Pará, Paraná, Rio de Janeiro, Rio  
389 Grande do Sul and São Paulo) have their state Red Lists. Similar initiatives must be encouraged  
390 for the other Brazilian states, especially considering that in 2011 legal responsibility for  
391 surveillance and enforcement of administrative penalties involving flora, fauna and  
392 environmental licensing was transferred from the federal agency (IBAMA) to state and municipal  
393 environmental agencies. Therefore, in this case, state and regional Red Lists would have practical  
394 consequences.

395            *A pessimistic conservation scenario ahead* – As of November 2018, Brazil elected a new  
396 president, aligned with a far-right agenda, identified by several analysts as very detrimental to the  
397 future of the country’s environment and biodiversity, especially to the Amazon and indigenous  
398 and traditional peoples, and also resulting in the destabilization of the global climate (e.g.  
399 Carneiro Filho, 2018; Fearnside & Schiffman 2018). As soon as he took office, the president-  
400 elect reduced the role of Brazil’s environmental ministry and the environmental agencies IBAMA  
401 (surveillance and environmental licensing) and ICMBio (protected areas and biodiversity  
402 management) (e.g. Abessa et al. 2019; Phillips 2019). His appointed Minister of the Environment  
403 public declared he was favorable to freeze the creation of new protected areas and Indigenous  
404 lands, plus his intention to “analyze in detail” – including the possibility to degazette – the entire  
405 334 federal protected areas in Brazil (e.g. Kaiser 2019; Borges & Branford, 2019). The minister  
406 also publicly declared to be favorable to open protected areas to mining, reduce licensing  
407 requirements for major infrastructure projects such as dams, industrial waterways, roads and  
408 railways (Branford & Borges, 2019; Gonzales, 2019). The president-elect was deeply supported  
409 by the most outdated and least environmental friendly part of Brazil’s agribusiness, industrial and  
410 commercial sectors. Considering that the main threats identified in our study are directly related  
411 to the agribusiness, mining and infrastructure sectors – the basis of the country’s economy – such  
412 combination of political and economic factors projects a pessimistic conservation scenario ahead  
413 for Brazil’s biodiversity. Under the current role played by the president-elect and his Minister of  
414 the Environment the number of threatened species in Brazil is poised to increase and the degree  
415 of threat of those already red-listed will definitively worse in the near future.

416  
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418 EB, FSB, TEL Jr.

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427

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429

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432

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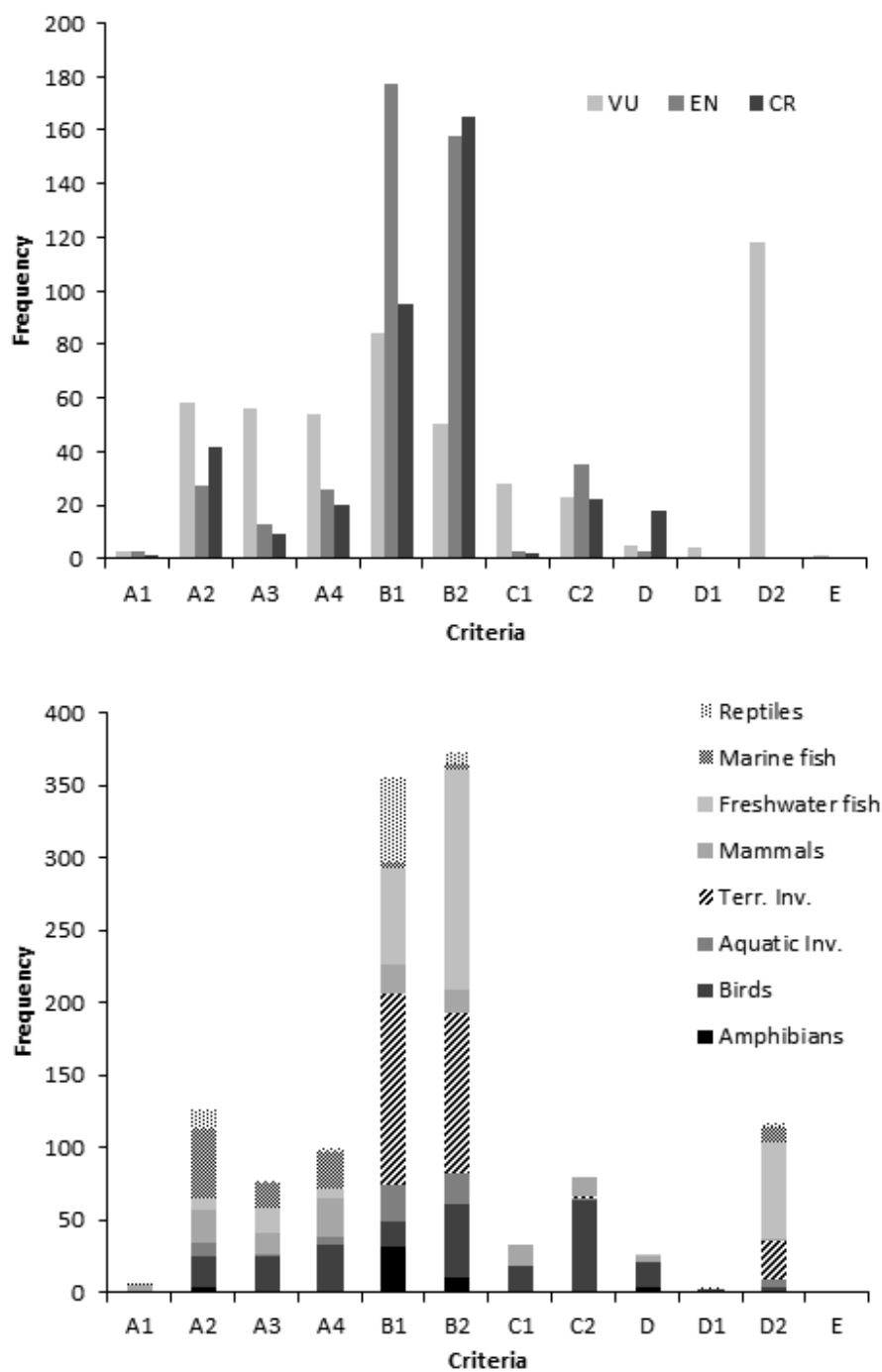
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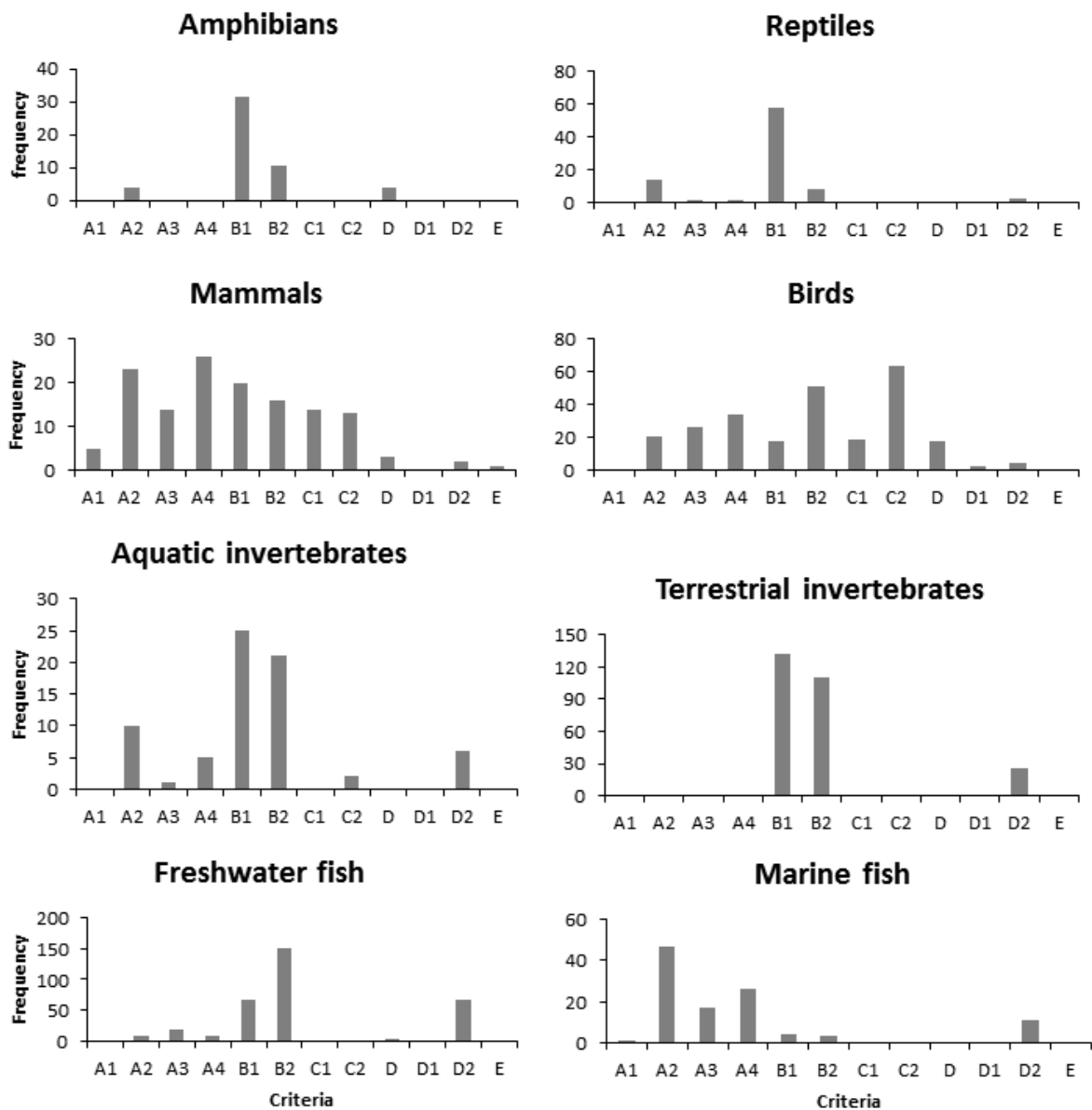
604 TABLE 1 IUCN Red List criteria adopted and threat status for 1172 species officially listed as  
 605 threatened in Brazil in 2014. Some species were listed under two or more criteria, so the total  
 606 number of criteria used is higher than the number of species classified. CR = Critically  
 607 Endangered, EN = Endangered, VU = Vulnerable.  
 608

Criteria	Status			Total
	CR	EN	VU	
A1	1	3	2	6
A2	41	27	61	129
A3	8	14	52	74
A4	19	26	57	102
<b>Total A</b>	<b>69</b>	<b>70</b>	<b>172</b>	<b>311</b>
B1	96	177	81	354
B2	162	158	50	370
<b>Total B</b>	<b>258</b>	<b>335</b>	<b>131</b>	<b>724</b>
C1	2	3	27	32
C2	22	35	23	80
<b>Total C</b>	<b>24</b>	<b>38</b>	<b>50</b>	<b>112</b>
D	18	4	0	22
D1	0	0	4	4
D2	0	0	123	123
<b>Total D</b>	<b>18</b>	<b>4</b>	<b>127</b>	<b>149</b>
<b>Grand Total</b>	<b>369</b>	<b>447</b>	<b>480</b>	<b>1296</b>

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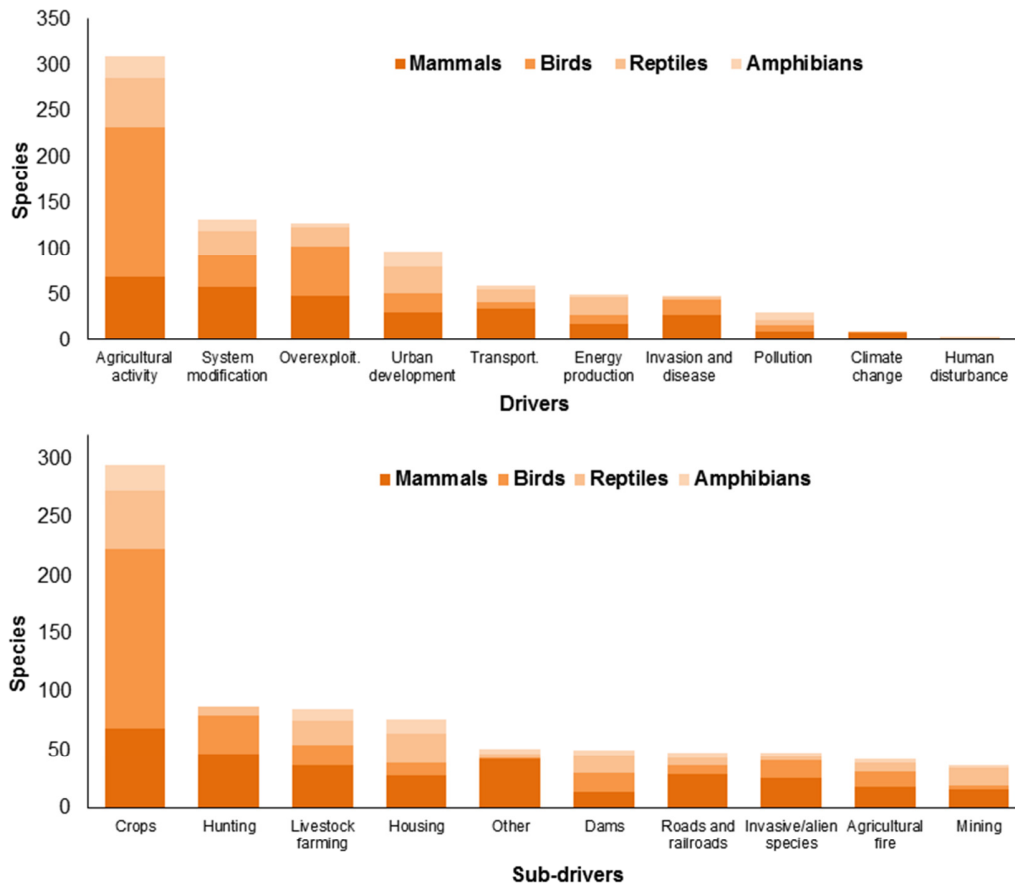


610  
 611 FIG. 1 Distribution of IUCN Red List criteria for 1172 threatened species in Brazils according to  
 612 threatening status (top) and animal group (bottom). VU = Vulnerable, EN = Endangered, CR =  
 613 Critically Endangered.  
 614



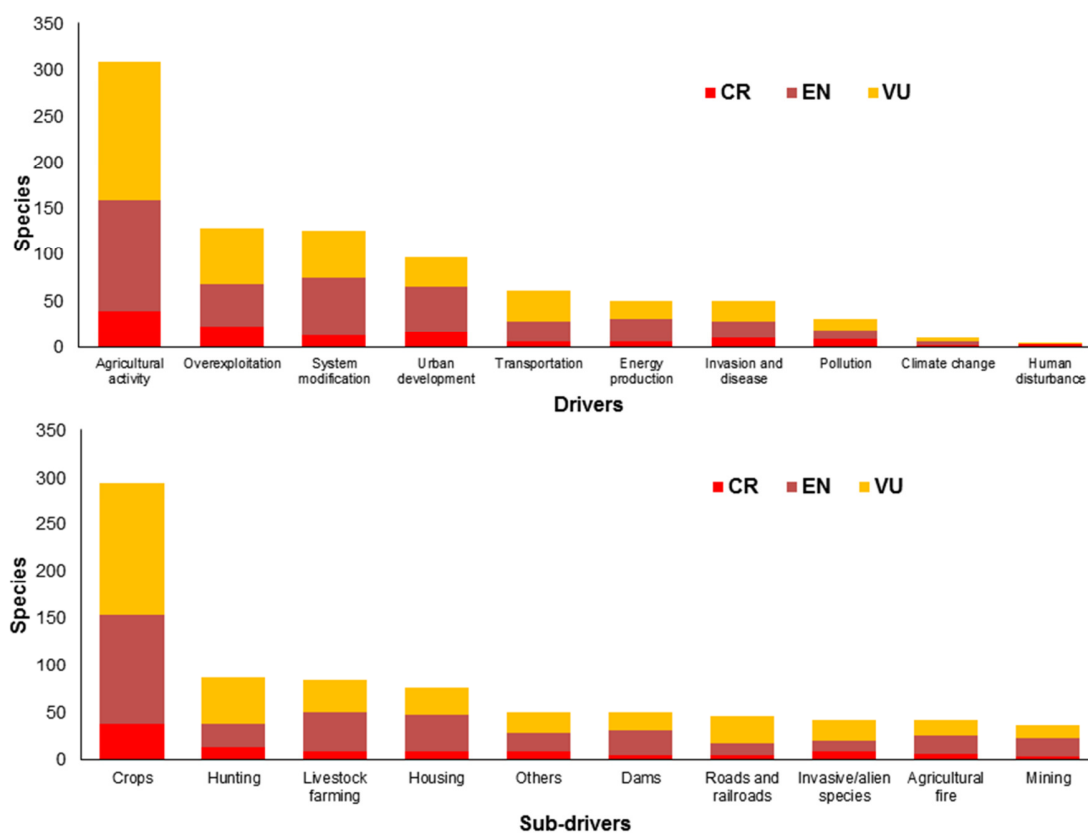
615  
 616 FIG. 2 Distribution of IUCN Red List criteria for 1172 threatened species in Brazil according to  
 617 animal group.

618



619  
620 FIG. 3 Top-10 threatening drivers (top) and sub-drivers (bottom) which affect the conservation of  
621 464 threatened species mammals, birds, reptiles and amphibians in Brazil. Drivers were classified  
622 according to Salafsky et al. (2008).  
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626 FIG. 4 Top-10 threatening drivers (top) and sub-drivers (bottom) which affect the conservation of  
627 464 threatened species of terrestrial vertebrates in Brazil. Drivers were classified according to  
628 Salafsky et al. (2008). CR = Critically Endangered, EN = Endangered, VU = Vulnerable.