









Wildfire against the survival of *Xenarthra*: anteaters, armadillos, and sloths

Incêndios contra a sobrevivência de *Xenarthra*: tamanduás, tatus e preguiças

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Abstract: During 2019 and 2020, Amazon and Pantanal wildfires were news all over the world, followed by shocking images of burnt landscapes and animals. Fires within rainforests and wetlands are seldom related to natural causes. Instead, these are human-driven events, often caused by illegal actions associated with deforestation and land conversion to sustain intensive agriculture and farming, among other impacts. The loss of native vegetation, not only causes habitat loss, fragmentation and degradation, but also increases the risk of natural fires creating a vicious circle. Among the animals mostly threatened by fire are the xenarthrans. Here, we bring attention to this group of mammals, which have several biological adaptations that make them particularly vulnerable to fire events. We present sloths, armadillos and anteaters as valuable components of biodiversity, being relicts of a vast diversity of South American endemics, and comprising many endangered, unique and poorly known species. Last, we conclude that 2019/2020 fires in the Amazon forest and Pantanal wetland, added to a multitude of other threats, are seriously menacing regional diversity components of these emblematic mammals.

Keywords: Agribusiness. Amazon rainforest. Cerrado. Deforestation. Habitat conversion. Pantanal.

Resumo: Durante 2019 e 2020, incêndios em áreas selvagens na Amazônia e no Pantanal foram notícia pelo mundo afora, acompanhados por imagens chocantes de paisagens e animais queimados. Fogos em florestas úmidas tropicais e planícies alagáveis raramente se relacionam a causas naturais. Ao invés, estes são eventos antrópicos, frequentemente causados por ações ilegais, associadas com desmatamento e conversão de uso da terra para sustentar atividades de agricultura e pecuária intensivas, entre outras. A devastação de vegetação nativa não só causa perda, fragmentação e degradação de habitat, mas também aumenta o risco de ocorrência de fogos naturais, gerando um ciclo vicioso. Entre os animais mais ameaçados pelo fogo, estão os xenarthros. Aqui, atentamos para este grupo de mamíferos, que possui inúmeras adaptações biológicas as quais o tornam particularmente vulnerável. Nós apresentamos preguiças, tatus e tamanduás como valiosos componentes da biodiversidade, sendo relíquias de uma vasta diversidade de endemismos sul-americanos e compreendendo várias espécies ameaçadas, únicas e pouco conhecidas. Por fim, concluímos que os incêndios de 2019/2020 na floresta amazônica e no Pantanal, adicionados a uma multitude de outros impactos, estão ameaçando severamente a diversidade regional destes mamíferos emblemáticos.

Palavras-chave: Agronegócio. Floresta úmida amazônica. Cerrado. Desmatamento. Conversão de habitat. Pantanal.

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Recently, particularly during the second semester of 2019 and 2020, fires devastating the Amazon rainforest and Pantanal wetland, the biggest floodplain in the world, captured the attention of the international media and public worldwide (e.g., Hughes, 2019; Kelly *et al.*, 2019; Krauss, 2019; Lusa & Público, 2019; Mendes, 2019; Watts, 2019; Carvalho, 2020; La Croix & AFP, 2020; Lemos, 2020; Lusa, 2020; Ramsay, 2020). These events revived discussions on climate change, loss of ecosystem services, and on sociopolitical and religious issues (Orr, 2005 and subsequent replies).

The environmental repercussions of tropical fires have been extensively investigated (e.g., Ramos-Neto & Pivello, 2000; Cochrane, 2003; Bowman *et al.*, 2009; Morton *et al.*, 2013). These fires are usually intentional, human-driven, and have been frequent and devastating all over the world (e.g., Cochrane, 2003; Bowman *et al.*, 2009; Dwomoh *et al.*, 2019; Clark & Williams, 2020). Huge wildfire events are so drastic that discussions are often regional- or global-scaled, mostly ignoring the most directly affected elements, the local flora and fauna. Disturbing photographs of burnt landscapes and animals have been recently shared in social media networks (e.g., AFP, 2019; Kelly *et al.*, 2019; Lemos, 2020). Among other, a picture of a carbonized giant anteater (*Myrmecophaga tridactyla* Linnaeus, 1758), has powerfully illustrated to public opinion the immediate losses resulting from fire.

Rainforests, like the Amazon, are characterized by high humidity levels and dense vegetation (Corlett & Primack, 2011), which hinder the occurrence of natural wildfires (e.g., Cochrane, 2003). Thus, the risk of natural fire in South American rainforests is low even during the dry season (INPE, 2019). Conversely, in open-vegetation phytogeographies, like savannas and Cerrado in Brazil, fires do naturally occur during the dry season, giving rise to the latent biodiversity during the subsequent rainy season (Abreu *et al.*, 2017; Arruda *et al.*, 2018). Also, managed human-driven fires in such open-vegetation ecosystems might even be beneficial to avoid excessive accumulation of biomass and disproportionate wildfires during dry seasons

(e.g., Coutinho, 1982; Arruda *et al.*, 2018). Similarly, cycles of flood and fire in Pantanal can be beneficial for vegetation regeneration (Oliveira *et al.*, 2014). Nonetheless, contrary to Cerrado, naturally occurring fires are not frequent in the region, and occur in well-defined periods (Macedo *et al.*, 2009), since Pantanal is recognized as a seasonal floodplain, with two known flooding periods: dry (June to September) and full (October to May) (Santos, S. *et al.*, 2007; Oliveira *et al.*, 2014).

In the last decade (2009-2019), a stabilizing trend for the burnt area in the three biomes, Amazon, Pantanal and Cerrado (the latter is here mentioned for comparison purposes only) is observed, particularly during 2014-2017 (Figure 1A). For the Brazilian Amazon and Pantanal, for which public records are available, a mean burnt area of 67,300.8 km²/year (\pm 18,368.9 km²/year) and 10,311.7 km²/year (\pm 4607.1 km²/year) were respectively registered between 2009 and 2019 (Figure 1A) (INPE, 2020a). The area burnt in the Amazon in 2019 surpassed the amount loss during the whole previous year, even after 2019 as ended (Figures 1A and 1B) (INPE, 2020a). In Pantanal, the amount of burnt area has raised in 2019; more than doubled the decade mean (20,835 km²), and a worse scenario is expected for 2020 (Figure 1A), where the number of fires has increased by 78% in August and September 2020 (Figure 2), compared to the same period of the former year (Figure 2; INPE, 2020a). Fire outbreaks were more expressive during August and September, corresponding to 58% and 52% of the area burnt between January 2019 and August 2020 both in the Amazon and Pantanal, respectively (Figure 1B). August/September 2019/2020 fires were also numerous in Bolivia, Peru and Paraguay (INPE, 2020a). Moreover, in March 2019 and February 2020, during the rainy season, more than 80% of the burnt territory in Brazil was in the Amazon (Figure 1B). These evidences exemplify and reinforce both that recent fires in the Amazon and Pantanal are not natural events and the loss of pristine habitats has not halted yet.

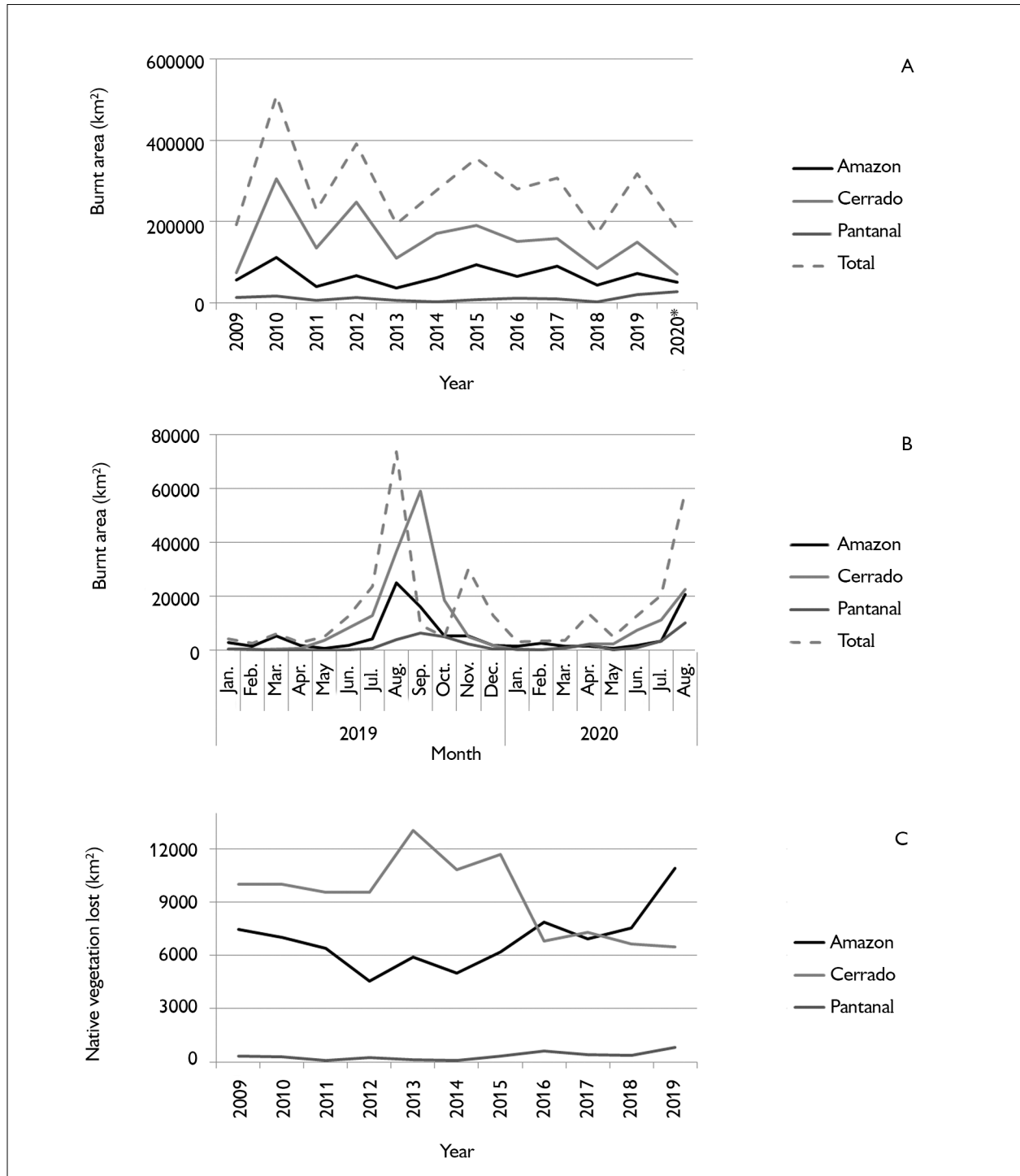


Figure 1. Loss of native vegetation in Brazilian biomes (INPE, 2020a, 2020b; Souza Jr. *et al.*, 2020). Total area burnt in Brazil during (A) the last decade and (B) last year (2019) in the Amazon forest, Pantanal, Cerrado and Brazil (Total); (C) deforestation in the Amazon and Pantanal has been increasing during recent years, particularly in 2019.

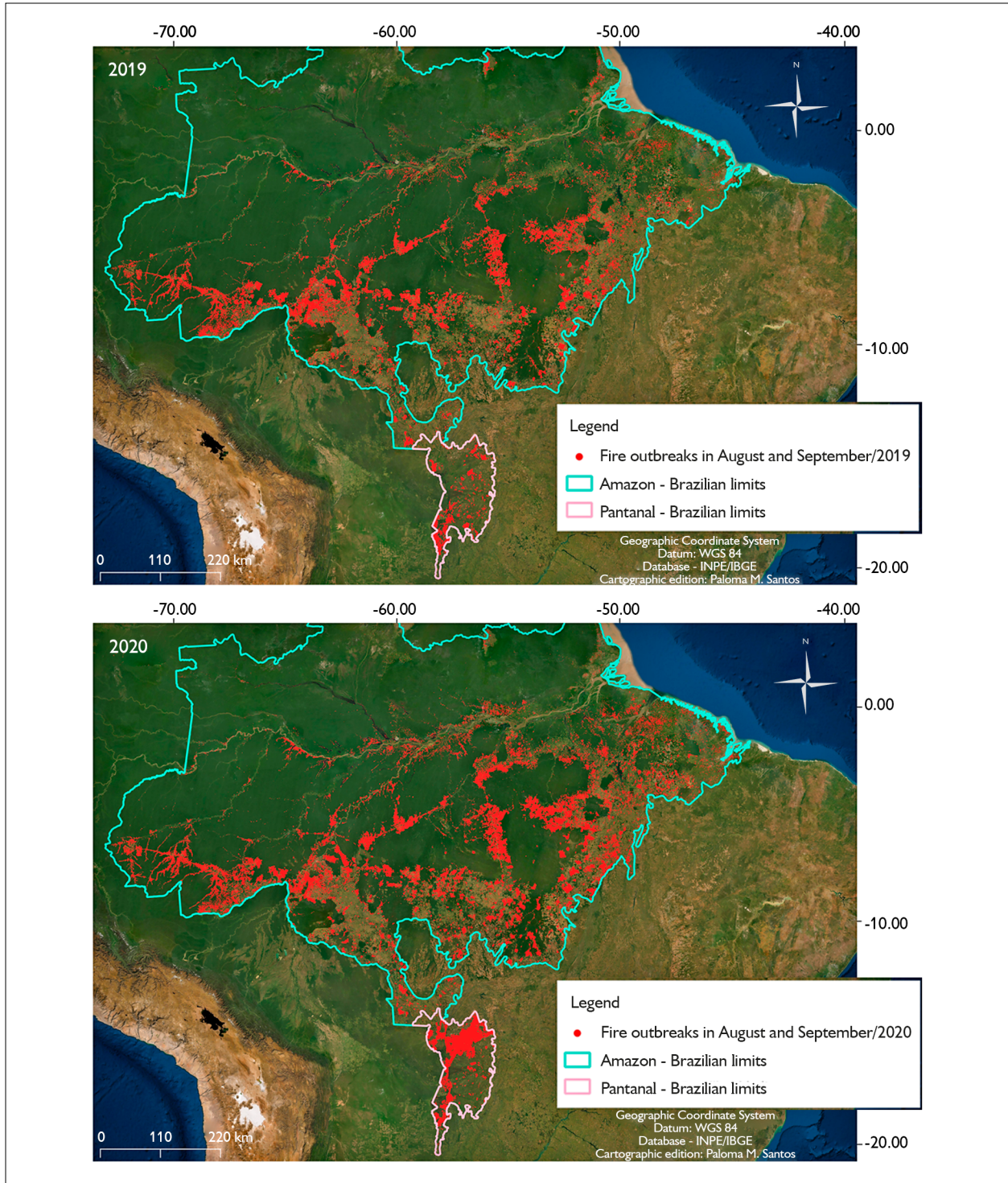
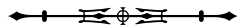


Figure 2. Fire outbreaks in the Amazon and Pantanal biomes during August and September 2019 (upper map) and 2020 (lower map) (INPE, 2020a).



The location of August/September 2019/2020 wildfires, in southern Amazon and northern Pantanal (Figure 2), is not a coincidence. Fires in tropical wild environments have been correlated with deforestation (Ramos-Neto & Pivello, 2000; Morton *et al.*, 2013; Silva Junior *et al.*, 2020). Today, deforested areas present similar risk of natural fire as open dry vegetation regions (INPE, 2020a); showing that the loss of native vegetation increases the risk of fire (Silva, S. S. *et al.*, 2018), as observed also in western Brazilian Amazon. Although *c.* 80% of the Brazilian Amazon and Pantanal native vegetation still stand, deforestation rates remain high (reviewed by Alho *et al.*, 2019 and Guerra *et al.*, 2020 for Pantanal; INPE, 2020b for the Amazon; Souza Jr. *et al.*, 2020), particularly during 2019 (Figure 1C), and their road-oriented pattern results in intense fragmentation and profound transformation of the natural landscape (INPE, 2020b). Deforestation combined with the establishment of agro-silvo-pastoral systems, logging, hydroelectric dam construction, mineral prospection and urbanization have been causing chronic land use conversion in South America (Ribeiro, M. *et al.*, 2009; Ribeiro, E. *et al.*, 2015; Lees *et al.*, 2016; Alamgir *et al.*, 2017; Alho *et al.*, 2019; Guerra *et al.*, 2020; Silva Junior *et al.*, 2020).

Among the wild species affected by August/September 2019/2020 wildfires are mammals of the superorder Xenarthra; 50 million-year old representatives of the South American endemic fauna (Gibb *et al.*, 2016). Anteaters, sloths and armadillos are seriously threatened by fire (Silveira *et al.*, 1999). The Brazilian action plan for the giant anteater and giant armadillo, *Priodontes maximus* (Kerr, 1792), has the specific aim to “decrease the impact of fire on the target species” (MMA/ICMBio, 2019). Xenarthrans have specialized diets, insectivorous (anteaters and armadillos) and folivorous (sloths), resulting in low metabolic rates and body temperatures (McNab, 1992). To maintain their temperature, most xenarthrans are highly dependent on covered areas, as forest-like habitats (e.g., Medri & Mourão, 2005; Cassano *et al.*, 2011; Attias *et al.*, 2018; Bertassoni & Ribeiro, M., 2019), and have several

layers of hair (for Pilosa, Shaw & Carter, 1980; Gilmore *et al.*, 2001), making a highly inflammable fur, rapidly set on and spreading a fire. Additionally, in an adaptation to save energy, some of these animals maintain slow movements (Gilmore *et al.*, 2001; Nagya & Montgomery, 2012; Lewton & Dingwall, 2013; Bertassoni & Ribeiro, M., 2019). Most of them are incapable to run fast in the face of some threat (e.g., Ribeiro, P. R. *et al.*, 2016). This inability hinders the escape of xenarthrans from an advancing fire front. Roadkills are another variable that must be considered during fire outbreaks (Diniz & Brito, 2013), since four species of armadillos and anteaters are among the top 10 of the most road-killed animals in Brazil (Ribeiro, P. *et al.*, 2017); arboreal mammals, such as sloths, also might be impacted by roadkill, although this is a threat mainly disregarded (Srbek-Araujo *et al.*, 2018). After long wildfires, even when burrows may act as protection against direct fires, the warmth soil and the smoke and particulates in the air might be fatal for fossorial animals as armadillos, by causing overheating and accumulation of toxic gases within their burrows (Silveira *et al.*, 1999). Smoke inhalation has been recorded as a direct cause of death for giant armadillos, and indirectly due to consequent bacterial and fungal infections (Arenales *et al.*, 2020).

The superorder Xenarthra comprises over 30 extant species (Burgin *et al.*, 2018, but see also Miranda *et al.*, 2018; Feijó *et al.*, 2019; Santos, P. *et al.*, 2019a). The group is phylogenetically relevant not only due to its even wider extinct diversity (hundreds of extinct species described) (McKenna & Bell, 1997), but mostly because of its basal position in the evolutionary history of placental mammals and especially for the morphological and ecological uniqueness of the extant species of the group (Isaac *et al.*, 2007; Tarver *et al.*, 2016). Half of the present diversity of xenarthrans is considered globally Near Threatened, Threatened or Data Deficient (DD) (Santos, P. *et al.*, 2019a; Superina & Abba, 2020), but most of it is endangered and poorly known at a regional scale (Smith, 2012; Anacleto *et al.*, 2013; Rodríguez *et al.*, 2015; ICMBio/MMA, 2018). Moreover, at regional and

local levels, molecular and morphological evidences have been revealing high differentiation among brown-throated sloth (*Bradypus variegatus* Schinz, 1825) (Silva, S. M. *et al.*, 2018), maned sloth (*Bradypus torquatus* Illiger, 1811) (Lara-Ruiz *et al.*, 2008) and giant anteater (Clozato *et al.*, 2017) populations, respectively; describing new species of the genus *Cyclopes* Gray, 1821 in the Amazon (Coimbra *et al.*, 2017; Miranda *et al.*, 2018) and of the genus *Dasybus* Linnaeus, 1758 across its range (Feijó *et al.*, 2019); and detecting different local adaptations for pathogen resistance within distinct populations of the lesser anteater (*Tamandua tetradactyla* Linnaeus, 1758) (Clozato *et al.*, 2015). These results have clear implications for the conservation status and management practices of xenarthrans. Distinct areas, and therefore different taxa, are facing dissimilar types and degrees of pressure. Local defaunation in tropical deforested areas is well documented, resulting mostly from habitat loss and soil conversion (Canale *et al.*, 2012; Jorge *et al.*, 2013; De Marco *et al.*, 2020). For example, areas with less than 20% of forest cover no longer can sustain populations of maned sloths (*B. torquatus*) in the Atlantic forest (Santos, P. *et al.*, 2019b). Thus, at local-scales, armadillos, sloths and anteaters are seriously threatened; and might be rapidly disappearing, population by population. Under current scenarios of fire and anthropogenic changes in land-use, the xenarthrans are more threatened than ever.

In this context, more dialogue and mutual understanding among the segments of the government and environmental agencies are urgent (reviewed by Laurance, 2019). A step for this integration might be the Environmental Rural Registry (ERR), a mandatory digital registration, which aims to integrate environmental information regarding private rural properties (Brazilian Environmental Law 12,651/2012) (Brançalon *et al.*, 2016). However, agribusiness sectors have generally been more successful in imposing their interests and suppressing popular demands for environmental protection and more sustainable-friendly development strategies (e.g., Lees *et al.*, 2016; Alamgir *et al.*, 2017; Alho *et al.*, 2019; Guerra *et al.*, 2020). It is our role, as wildlife

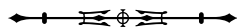
researchers and conservationists, to produce the relevant information and disseminate it to the public and stakeholders. We must continue applying our expertise to point out appropriate strategies for the socioeconomic development of our countries and the protection and sustainable use of their unique and exuberant natural resources and biodiversity.

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