











Long-term ecological program reveals high species richness of medium- and large-sized mammals in forest fragments of the Cerrado

Roniel Freitas-Oliveira^{1,2,3,4*} , Marco Antônio Guimarães-Silva³ , Tainã Lucas Andreani³ ,
Wellington Hannibal⁶ , Helbert S. Barbosa³ , João Vitor Vinhais Sousa³, Rogério P. Bastos⁵ ,
Jânio C. Moreira⁶  & Alessandro Ribeiro Morais³ 

¹Instituto Nacional de Ciência e Tecnologia em Ecologia, Evolução e Conservação da Biodiversidade, Goiânia, GO, Brasil.

²Universidade Federal de Jataí, Laboratório de Macroecologia, Jataí, GO, Brasil.

³Instituto Federal Goiano, Laboratório de Ecologia, Evolução e Sistemática de Vertebrados, Rio Verde, GO, Brasil.

⁴Universidade Estadual de Goiás, Laboratório de Ecologia e Biogeografia de Mamíferos, Quirinópolis, GO, Brasil.

⁵Universidade Federal de Goiás, Instituto de Ciências Biológicas, Departamento de Ecologia, Goiânia, GO, Brasil.

⁶Instituto Federal Goiano, Laboratório de Estudos em Divulgação Científica, Ensino de Biociências e Zoologia de Vertebrados Aplicada à Saúde, Rio Verde, GO, Brasil.

*Corresponding author: freitasronielbio@gmail.com

FREITAS-OLIVEIRA, R., GUIMARÃES-SILVA, M.A., ANDREANI, T.L., HANNIBAL, W., BARBOSA, H.S., SOUSA, J.V.V., BASTOS, R.P., MOREIRA, J.C., MORAIS, A.R. **Long-term ecological program reveals high species richness of medium- and large-sized mammals in forest fragments of the Cerrado.** *Biota Neotropica* 25(2): e20251750. <https://doi.org/10.1590/1676-0611-BN-2025-1750>

Abstract: We inventoried medium- and large-sized mammals in private properties in a long-term ecological program entitled *Effect of Landscape Configuration and Composition on Biodiversity: Multilevel Analysis* (PELD EBMN), in Southwest of Goiás state, Brazilian Midwest, Cerrado. We inventoried 60 sites in forest fragments inside private properties using camera trap, between March 2022 and April 2023, with 30 days of continuous sampled, after which the camera trap was removed and reinstalled after a period of approximately six months. We registered a total of 31 medium- and large-sized mammals species, with our sampled effort, the largest one employed in the region, the richness found here is the largest already recorded for this region, representing 60% of medium- and large-sized mammals listed from Cerrado. Beyond this, we found seven threatened and two “Data deficient” species, which highlights that despite deforestation in the last century, this region is still capable of harboring threatened species. However, we recorded three exotic, invasive, or domestic species, which is a worrying scenario, which could compromise the ecological balance of the region. Finally, we found that *Tapirus terrestris*, although threatened, was the most frequent species recorded in our study, showing the potential of this area for medium- and large-sized mammals conservation. Therefore, in the first sampled year of PELD EBMN we found a medium- and large-sized mammals richest in the study area, showing the potential of this project in the long term.

Keywords: Camera trap; Brazilian Midwest; PELD; private properties; threatened species.

Estudo ecológico de longa duração revela alta riqueza de espécies de mamíferos de médio e grande porte em fragmentos florestais do Cerrado

Resumo: Inventariamos mamíferos de médio e grande porte em áreas privadas no programa ecológico de longa duração intitulado *Efeitos da composição e configuração da paisagem na biodiversidade: uma análise multinível (PELD EBMN)*, no Sudoeste do estado de Goiás, Centro-Oeste brasileiro. Inventariamos 60 sítios em fragmentos florestais dentro de propriedades privadas usando armadilhas fotográficas, entre março de 2022 a abril de 2023, com 30 dias de amostragens contínuas, depois dos quais a armadilha fotográfica foi removida e reinstalada depois de um período de aproximadamente seis meses. Registramos um total de 31 espécies de mamíferos de médio e grande porte, com nosso esforço amostral, o maior empregado na região, a riqueza encontrada aqui é a maior já registrada para a região, representando 60% dos mamíferos de médio e grande porte listados para o Cerrado.

Além disso, encontramos sete espécies ameaçadas e duas espécies “Deficiente de dados”, as quais sublinham que apesar de desmatado no último século, essa região é ainda capaz de abrigar espécies ameaçadas. No entanto, registramos três espécies exóticas, invasoras ou domésticas, o que é um cenário preocupante, pois as mesmas podem comprometer o balanço ecológico da região. Finalmente, encontramos que *Tapirus terrestris*, apesar de ameaçada, foi a mais frequente espécie registrada em nosso estudo, demonstrando o potencial dessa área para a conservação de mamíferos de médio e grande porte. Portanto, no primeiro ano de amostragem do PELD EBMN encontramos uma alta riqueza de mamíferos de médio e grande porte na área de estudo, demonstrando o potencial desse projeto a longo prazo.

Palavras-chave: Armadilha fotográfica; Centro-oeste brasileiro; PELD; propriedades privadas; espécies ameaçadas.

Introduction

The Brazilian Cerrado is widely regarded as one of the most threatened savanna in the world. Recognized as a global biodiversity hotspot due to its high levels of endemism, this unique ecosystem faces escalating risks from significant anthropogenic pressures (Myers et al. 2000, Silva and Bates 2002). Ongoing human activities continue to endanger its biodiversity, a trend projected to worsen in the coming decades. Colman et al. (2024) estimate that, under current legislation, the Cerrado could lose up to 26.5 million hectares of native vegetation by 2050.

Intensive land use is believed to have caused the extinction of approximately 14% of terrestrial vertebrate species (Semenchuk et al. 2022). In addition, mammalian diversity is negatively impacted by anthropogenic disturbances (Resende, Viana-Junior & Bovendorp 2024), which is particularly concerning for the mammals native to the Cerrado. The Cerrado is home to 268 mammal species, 34 of which are endemic and 29 nationally threatened (Abreu et al. 2023). This pattern is also evident in the state of Goiás, within the Cerrado, which hosts 191 mammal species, including 28 nationally threatened species, primarily medium- and large-sized mammals (Hannibal et al. 2021). Consequently, this unique fauna continues to face significant threats from human activity.

The coverage of the Brazilian biomes (e.g., Cerrado) protected areas network is not reliability to protect biodiversity (Vieira, Pressey & Loyola 2019); therefore, the remnants of native vegetation present on private properties play a crucial role in preserving the ranges of threatened vertebrate species (De Marco et al. 2023). Furthermore, there is a growing call to the conservation of large private properties to mitigate future loss of native Cerrado vegetation (Colman et al. 2024). The southwestern region of Goiás, in particular, is dominated by private properties and without expressive conservation units, besides being heavily anthropized with extensive agricultural land used for grain production (IBGE 2021). This region also hosts the long-term ecological project *Effect of Landscape Configuration and Composition on Biodiversity: Multilevel Analysis* (PELD EBMN) [see methods – <https://www.projetoebmn.com/>]. Given this context, the aim of this study was to inventory medium- and large-sized mammals in the PELD EBMN landscape in the southwest of Goiás, in the Midwest of Brazil.

Material and Methods

1. Study area

The study area is part of the long-term ecological research project *Effect of Landscape Configuration and Composition on Biodiversity: Multilevel Analysis* (PELD EBMN – <https://www.projetoebmn.com/>), located in the Brazilian Midwest (Figure 1a, b). The PELD EBMN encompasses a 100 km² landscape within the Cerrado biome, spanning the municipalities of Aparecida do Rio Doce, Cachoeira Alta, Jataí, Montividiu, Rio Verde, Santa Helena, Santo Antônio da Barra and Quirinópolis, in the southwest of Goiás state. This area is situated on private lands, with no sampling units located in conservation units (UC) (Figure 1c).

Field sampling was conducted in natural vegetation areas within these private properties, which in general are legally protected by Brazilian Native Vegetation Protection Law (Law No. 12,651/2012), but aren't UC, are just private native areas that cannot be deforested. Under the Brazilian Native Vegetation Protection Law (Law No. 12,651/2012), private landowners are required to maintain specific vegetation areas, including Legal Reserves (LRs) and Areas of Permanent Preservation (APPs). However, this private protected area is different from UC, once it doesn't have management plans, or any type of biodiversity management or monitoring. The native vegetation found in the PELD EBMN is characteristic of the Cerrado biome and includes forests, savannas, wetlands, and grasslands.

Historically, the Southwest Goiás state area (e.g., where the PELD EBMN are located) has been subject to extensive deforestation, particularly between 1965 and 1985, when large areas of native vegetation were cleared for pasture and crop cultivation (de Arruda et al. 2019). Subsequently, between 1985 and 2016, many of these pasture lands were converted into agricultural areas (Siqueira and Faria 2019).

1.1. Medium- and large-sized mammals sampling

We surveyed 60 sites to record the occurrence of medium- and large-sized mammals within the PELD EBMN landscape between March 2022 and April 2023. Camera traps (Bushnell Trophy Cam Pine L20 Low Glow models) were installed on trees approximately 40 centimeters above the ground. One camera trap was set up per site, and each trap remained active for 30 consecutive days, recording videos with a duration of 10 seconds each. After this period, the camera trap was

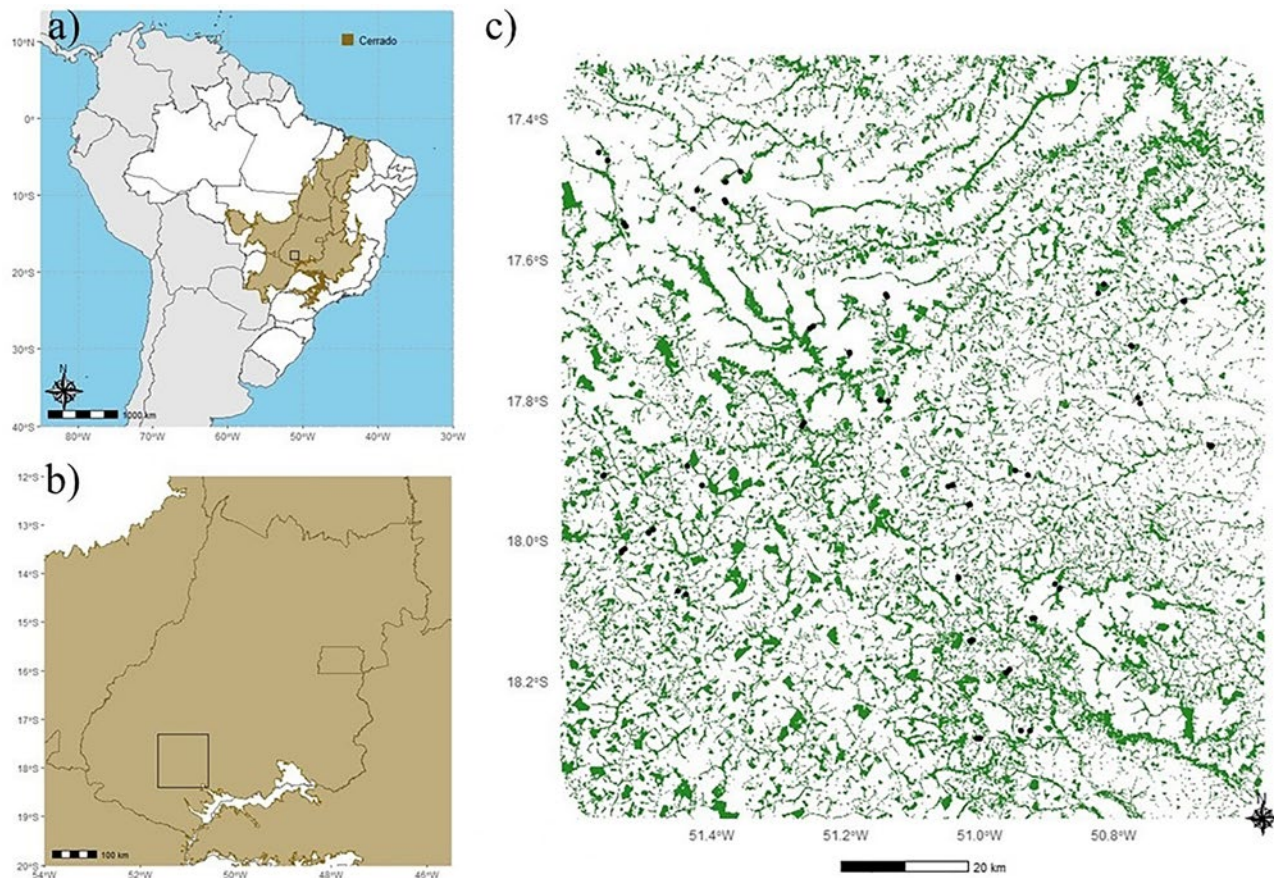


Figure 1. The study area, ecological long duration project (PELD) Effect of landscape configuration and composition over biodiversity: multilevel analysis (EBMN), in the Brazilian Midwest. a) Brazilian Midwest, b) Goiás state and c) PELD EBMN landscape.

removed and reinstalled after approximately six months, continuing to record for another 30 consecutive days. This sampling effort resulted in a total of 3,600 trap-days. The videos collected during the survey are available in the Coleção de Vertebrados Alípio de Miranda-Ribeiro (CVAMR) at the Instituto Federal Goiano, Campus Rio Verde, Goiás.

Taxonomic classification followed Abreu et al. (2023), except for *Coendou longicaudatus boliviensis* (Brandt 1835), which follows Menezes et al. (2021) and *Sylvilagus minensis* (Thomas 1901), following (Ruedas et al. 2017). The conservation status of each species was determined based on the Brazilian National List of Threatened Species (MMA 2022) and the Red List of the International Union for Conservation of Nature (IUCN 2024).

We used the complete dataset of medium- and large-sized mammals recorded in the PELD EBMN landscape to construct a species accumulation curve. For this analysis, we applied the Jackknife 1 estimator using the “poolaccum” function from the *vegan* package (Oksanen et al. 2022). For visualization, we used the “ggplot” function from the *ggplot2* package (Wickham 2016).

Results

We recorded 31 species of native medium- and large-sized mammals in the PELD EBMN landscape, distributed across nine orders, 18 families, and 28 genera (Table 1, Figure 2). Among these species,

we highlight the occurrence of seven threatened species—four globally and seven nationally threatened—such as *Chrysocyon brachyurus* (Illiger 1815), *Myrmecophaga tridactyla* (Linnaeus 1758), *Priodontes maximus* (Kerr 1792), *Tapirus terrestris* (Linnaeus, 1758), and *Tayassu pecari* (Link 1795). Additionally, we found two species categorized as “Data Deficient,” *Mazama rufa* (Illiger 1815) and *Dasyprocta azarae* (Lichtenstein 1823) (Table 1).

The most frequently encountered species in the sampled sites ($n = 60$) were *Tapirus terrestris* [n. sites = 45], *Dicotyles tajacu* (Linnaeus, 1758) [n. sites = 41], *Dasyprocta novemcinctus* (Linnaeus, 1758) [n. sites = 35], *Nasua nasua* (Linnaeus, 1766) [n. sites = 30], and *M. tridactyla* [n. sites = 22] (Table 1 and Figure 3). In addition to native species, we also recorded three exotic, invasive, or domestic species: *Bos taurus*, *Canis lupus familiaris*, and *Sus scrofa* (Linnaeus, 1758), which occurred in 9, 21, and 5 sites, respectively (Table 1 and Figure 3). The rarefaction curve stabilized with the sampling effort, reaching the Jackknife 1 richness estimate for the study area (richness = 32.18, standard deviation = 1.34, Figure 4).

Discussion

Detailed biodiversity sampling can ensure the persistence and maintenance of ideal areas for conservation (Diniz-Filho et al. 2008). With our sampling effort, which included 60 sites, this is the largest

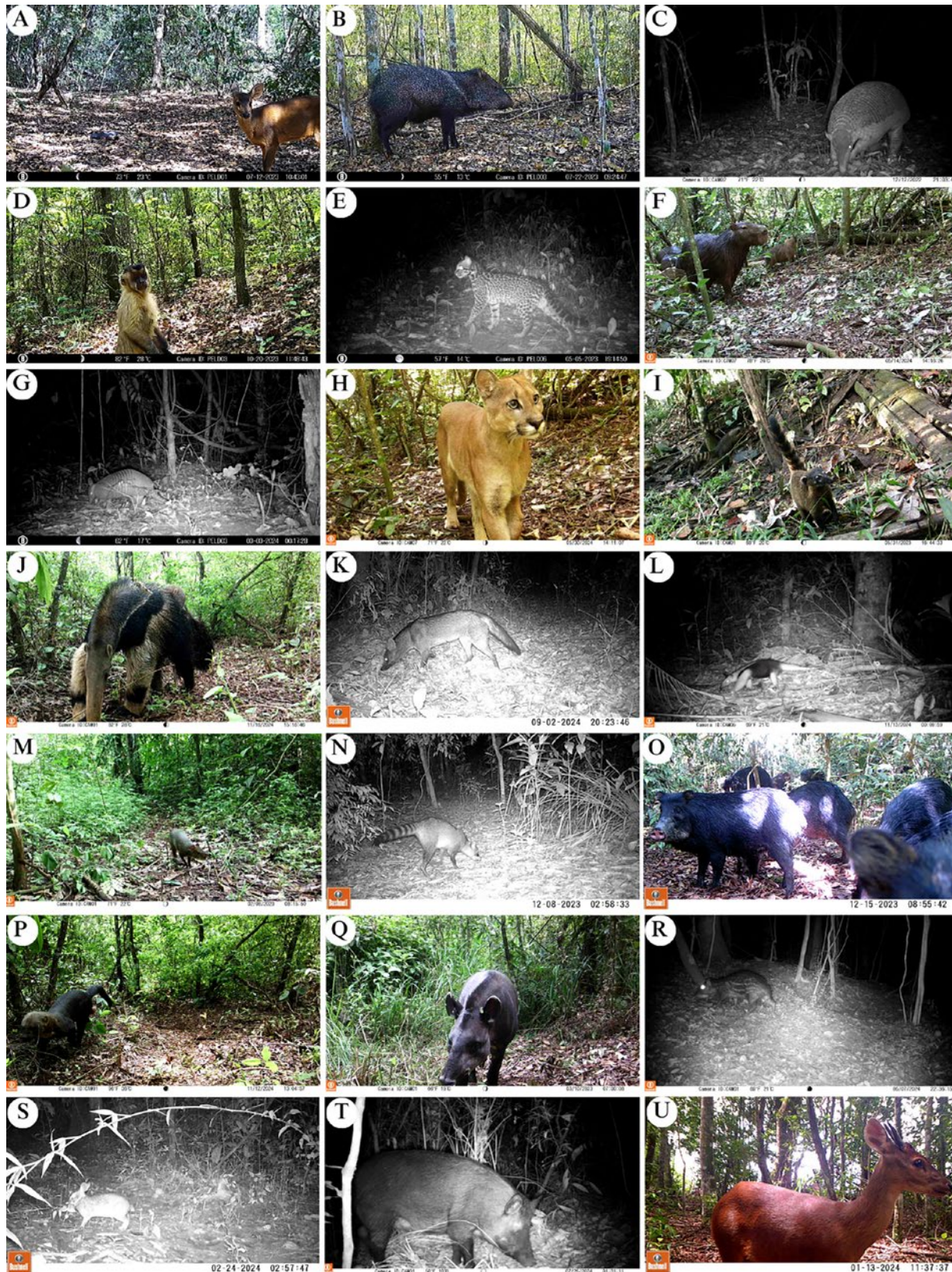


Figure 2. Medium- and large-sized mammals recorded in the long-term ecological research project in the Brazilian Midwest. A) *Subulo gouazoubira*; B) *Dicotyles tajacu*; C) *Priodontes maximus*; D) *Sapajus libidinosus*; E) *Leopardus pardalis*; F) *Hydrochoerus hydrochaeris*; G) *Dasyopus novemcinctus*; H) *Puma concolor*; I) *Nasua nasua*; J) *Myrmecophaga tridactyla*; K) *Cerdocoyon thous*; L) *Tamandua tetradactyla*; M) *Dasyprocta azarae*; N) *Procyon cancrivorus*; O) *Tayassu pecari*; P) *Eira barbara*; Q) *Tapirus terrestris*; R) *Cuniculus paca*; S) *Sylvilagus minensis*; T) *Sus scrofa*; U) *Mazama rufa*.

Table 1. Medium- and large-sized mammals recorded in the long-term ecological research project (PELD) *Effect of Landscape Configuration and Composition on Biodiversity: Multilevel Analysis* (EBMN). *N. sites*: number of sites where the species was recorded; *MMA*: conservation status according to the Brazilian National List of Threatened Species (Ministry of the Environment); *IUCN*: conservation status according to the International Union for Conservation of Nature's Red List of Threatened Species. *VU*: Vulnerable; *DD*: Data Deficient. Species marked with an asterisk (*) are exotic, invasive, or domestic species.

Taxon	Common name	N. Sites	Conservation status	
			MMA	IUCN
DIDELPHIMORPHIA				
Didelphidae				
<i>Didelphis albiventris</i> Lund, 1840	White-eared Opossum	21		
PILOSA				
Myrmecophagidae				
<i>Myrmecophaga tridactyla</i> Linnaeus, 1758	Giant Anteater	22	VU	VU
<i>Tamandua tetradactyla</i> (Linnaeus, 1758)	Southern Tamandua	12		
CINGULATA				
Chlamyphoridae				
<i>Cabassous squamicaudis</i> (Lund, 1845)	Cerrado naked-tailed armadillo	1		
<i>Cabassous tatouay</i> (Desmarest, 1804)	Greater Naked-tailed Armadillo	2		
<i>Euphractus sexcinctus</i> (Linnaeus, 1758)	Yellow Armadillo	2		
<i>Priodontes maximus</i> (Kerr, 1792)	Giant Armadillo	4	VU	VU
Dasyopodidae				
<i>Dasyopus novemcinctus</i> (Linnaeus, 1758)	Nine-banded Armadillo	35		
<i>Dasyopus</i> sp.		3		
PRIMATES				
Aletidae				
<i>Alouatta caraya</i> (Humboldt, 1812)	Black-and-gold Howler Monkey	1		
Cebidae				
<i>Sapajus libidinosus</i> (Spix, 1823)	Bearded Capuchin	21		
CARNIVORA				
Canidae				
<i>Canis familiaris</i> Linnaeus, 1758*	Domestic dog	21		
<i>Cerdocyon thous</i> (Linnaeus, 1766)	Crab-eating Fox	8		
<i>Chrysocyon brachyurus</i> (Illiger, 1815)	Maned Wolf	1	VU	
Felidae				
<i>Herpailurus yagouaroundi</i> (É. Geoffroy Saint-Hilaire, 1803)	Jaguarundi	4	VU	
<i>Leopardus</i> sp.		1		
<i>Leopardus braccatus</i> (Cope, 1889)	Pampas Cat	1	VU	
<i>Leopardus pardalis</i> (Linnaeus, 1758)	Ocelot	12		
<i>Leopardus emiliae</i> (Thomas, 1914)	Emilia Oncilla Cat	1		
<i>Puma concolor</i> (Linnaeus, 1771)	Puma	8		
Mustelidae				
<i>Eira Barbara</i> (Linnaeus, 1758)	Tayra	16		
<i>Lontra longicaudis</i> (Olfers, 1818)	Neotropical Otter	1		
Procyonidae				
<i>Nasua nasua</i> (Linnaeus, 1766)	South American Coati	30		
<i>Procyon cancrivorus</i> (Cuvier, 1798)	Crab-eating Raccoon	1		

Continue...

...Continuation

Taxon	Common name	N. Sites	Conservation status	
			MMA	IUCN
PERISSODACTYLA				
Tapiriidae				
<i>Tapirus terrestris</i> (Linnaeus, 1758)	Lowland Tapir	45	VU	VU
CETARTIODACTYLA				
Bovidae				
<i>Bos taurus</i> Linnaeus, 1758*	Cow	9		
Cervidae				
<i>Mazama rufa</i> (Illiger, 1815)	Red brocket	3		DD
<i>Subulo gouazoubira</i> (Fischer, 1814)	Gray Brocket	8		
<i>Mazama</i> sp.		3		
Suidae				
<i>Sus scrofa</i> Linnaeus, 1758*	Wild Boar	5		
Tayassuidae				
<i>Dicotyles tajacu</i> (Linnaeus, 1758)	Collary Peccary	41		
<i>Tayassu pecari</i> (Link, 1795)	White-lipped Peccary	10	VU	VU
RODENTIA				
Caviidae				
<i>Hydrochoerus hydrochaeris</i> (Linnaeus, 1766)	Capybara	6		
Cuniculidae				
<i>Cuniculus paca</i> (Linnaeus, 1766)	Agouti	15		
Dasyproctidae				
<i>Dasyprocta azarae</i> (Lichtenstein, 1823)		6		DD
Erethizontidae				
<i>Coendou longicaudatus</i> Daudin, 1802	Brazilian Porcupine	3		
LAGOMORPHA				
Leporidae				
<i>Sylvilagus minensis</i> (Thomas, 1901)	Tapeti	2		

effort in the region compared to previous studies (e.g., 10 sites in Morais et al. 2022; 6 sites in Oliveira, Morais & Terribile 2019; and 20 sites in Hannibal et al. 2023). It is also worth highlighting that the aforementioned studies (Morais et al. 2022, Oliveira, Morais & Terribile 2019, Hannibal et al. 2023) used activity searches in addition to camera traps, whereas we relied solely on camera traps. Despite this difference, our sampling effort resulted in a significant richness of medium- and large-sized mammals in the PELD EBMN landscape, representing ~60% of the known species richness of medium- and large-sized mammals for the Cerrado biome (Paglia et al. 2012) and 70% of the known species richness for Goiás state (Hannibal et al. 2021).

When compared to local studies (e.g., 16 species in Morais et al. 2022; 23 species in Oliveira, Morais & Terribile 2019; and 25 species

in Hannibal et al. 2023), the species richness of medium- and large-sized mammals recorded here represents an increase of 94%, 35%, and 24%, respectively. This demonstrates the potential of our sampling effort, which, as far as we know, is the largest in the state of Goiás for medium- and large-sized mammals. Moreover, these results are based on the first sampling year of the PELD EBMN project, with at least two more years of sampling remaining, further enhancing our potential to gather more comprehensive data for the region.

Additionally, we highlight the presence of threatened species (e.g., *Myrmecophaga tridactyla*, *Tapirus terrestris*, *Pecari tajacu*) in the PELD EBMN landscape. This indicates that, despite the intense deforestation in the past century, the area, which now experiences lower deforestation rates (de Arruda et al. 2019, Siqueira and

Long-term program reveals high mammals richness

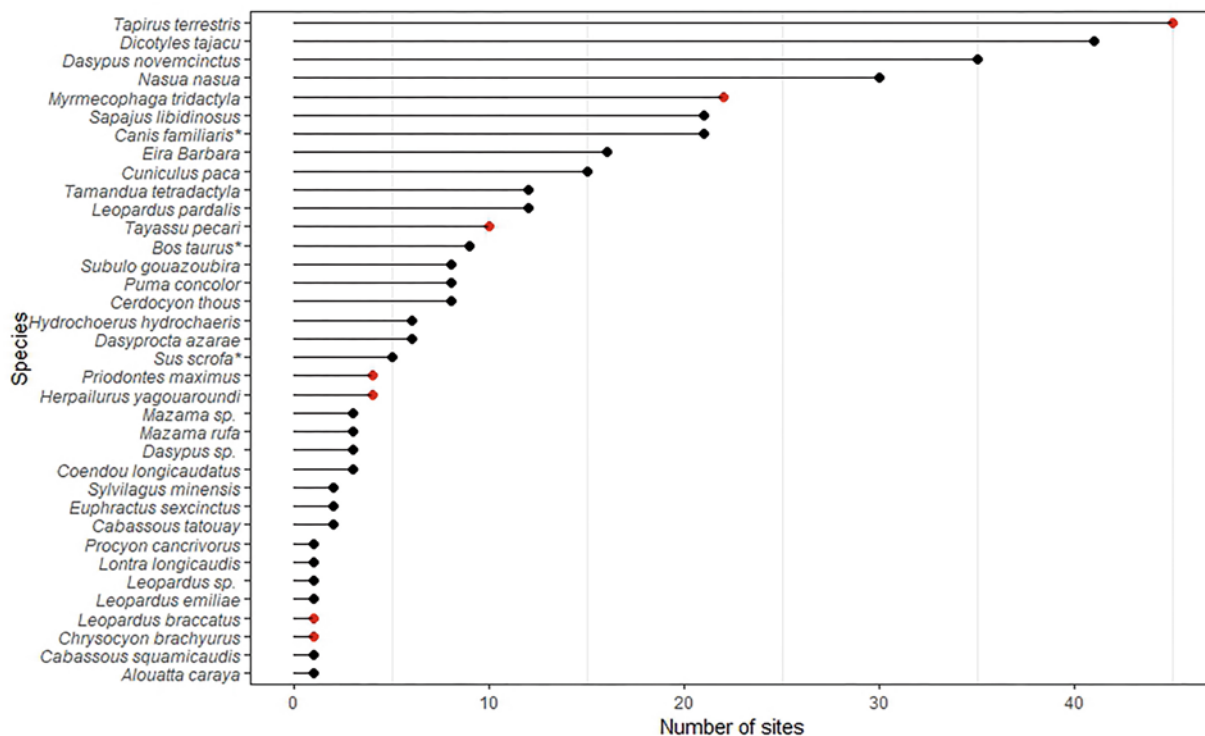


Figure 3. Number of sites with occurrence of each species of medium- and large-sized mammals recorded in the long-term ecological research project (PELD) *Effect of Landscape Configuration and Composition on Biodiversity: Multilevel Analysis (EBMN)*. Red point colors correspond to “Vulnerable” species, while black points correspond to non-threatened species according to MMA (2022). Species marked with an asterisk (*) are exotic, invasive, or domestic species.

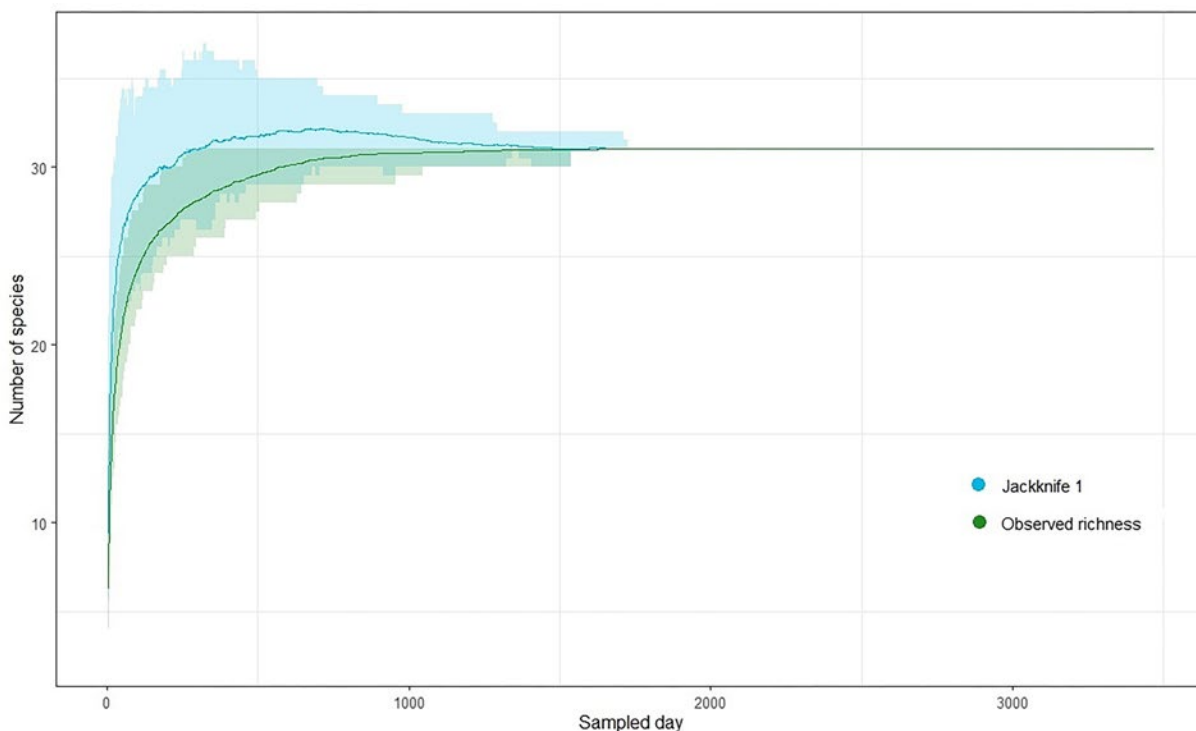


Figure 4. Species accumulation curve for observed (green line) and estimated (Jackknife 1, blue line) species richness. The green and blue colors represent the observed and estimated species richness, respectively, along with the 95% confidence intervals.

Faria 2019, Trigueiro, Nabout & Tessarolo 2020), still harbors threatened species. Given that our study was conducted exclusively within private properties, specifically LRs and APPs, which are protected by Brazil's Native Vegetation Protection Law (Law No. 12.651, 2012), this underscores the importance of the PELD EBMN project for ecological studies on these species. The presence of threatened species in private properties aligns with the findings of De Marco et al. (2023), which suggest that private protected areas can shelter up to 25% of the range of threatened vertebrates in the Cerrado.

It is important to emphasize that not only did we find threatened species in the PELD EBMN landscape, but two of them (*M. tridactyla* and *T. terrestris*) were among the most frequently recorded species across the sampled sites. This suggests that the PELD EBMN landscape may serve as either a temporary habitat or a permanent part of the home range for these species. *Myrmecophaga tridactyla* is negatively affected by fragmentation (Pinto et al. 2018), while *Tapirus terrestris* is impacted by environmental disturbances (Fernandes-Santos et al. 2020). Given that the PELD EBMN is located in a highly fragmented landscape, this could affect the health and population dynamics of these species. Furthermore, due to its ecological significance, *T. terrestris* acts as a “safe-guard” species, meaning its conservation benefits other species as well.

Other frequently recorded species in the sampled sites included *Dasypus novemcinctus*, *D. tajacu*, and *Nasua nasua*, all of which have been previously documented in the region (Oliveira, Morais & Terribile 2019, Morais et al. 2022, Hannibal et al. 2023). However, a long-term study such as PELD EBMN has the potential to accumulate valuable data over time, enhancing our understanding of population variations and contributing to the broader ecological knowledge of these species.

We are also concerned about the presence of non-native species in the PELD EBMN landscape, as the introduction of such species is a major threat to biodiversity. The presence of domestic dogs (*Canis familiaris*, Linnaeus 1758) is particularly concerning, as they can negatively affect native fauna through predation, competition, and the spread of diseases (Guedes et al. 2021, Lessa et al. 2016). Additionally, wild boar *Sus scrofa* Linnaeus, 1758 is a global biodiversity threat, impacting 672 taxa worldwide (Risch, Ringma & Price 2021). The presence of this invasive species in an already fragmented landscape may exacerbate the problem, potentially attracting hunters. Moreover, the distribution of *S. scrofa* overlaps with native peccaries (*Tayassu pecari* and *D. tajacu*), which could lead to competition and other negative ecological interactions. This is particularly concerning, as *T. pecari* was only recently recorded in the region (Freitas-Oliveira et al. 2024).

In conclusion, the medium- and large-sized mammal inventory conducted in the first year of the PELD EBMN project yielded greater species richness than previous studies for the region. The information gathered here can contribute to the conservation of these species, particularly in the context of private properties, which are rarely addressed in conservation efforts. Furthermore, this study provides valuable insights into the presence of threatened species in anthropogenically impacted areas with intense agricultural activity, and highlights the importance of large-scale studies in fragmented regions for effective biodiversity conservation.

Acknowledgments

This research was carried out within the context of long-term ecological research project, “Landscape composition and configuration effects on biodiversity: a multi-taxon analysis” (PELD EBMN), supported by the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) (process n. 445982/2024-1) and Fundação de Amparo à Pesquisa do Estado de Goiás (FAPEG) (process n. 202110267000956). We also would like to thank the owners of the rural properties where the samplings of species were carried out. ARM, WH and RPB thanks the CNPq for their research productivity. JCM is grateful to IF Goiano for providing HC300A model camera traps and vehicles for fieldwork.

Associate Editor

Diego Astúa

Author Contributions

Roniel Freitas-Oliveira: designed the manuscript; identified medium- and large-sized mammal records; wrote the manuscript; reviewed and edited the manuscript.

Marco Antônio Guimarães-Silva: designed the manuscript; conducted fieldwork; identified medium- and large-sized mammal records; reviewed and edited the manuscript.

Tainã Lucas Andreani: conducted fieldwork.

Wellington Hannibal: reviewed identifications of *M. rufa* and *S. gouazoubira*, small felids, and armadillos; reviewed and edited the manuscript.

Helbert S. Barbosa: conducted fieldwork.

João Vitor Vinhais Sousa: conducted fieldwork.

Rogério P. Bastos: reviewed the manuscript.

Jânio C. Moreira: reviewed the manuscript.

Alessandro Ribeiro Morais: designed the manuscript; wrote the manuscript; reviewed and edited the manuscript.

Conflicts of Interest

The authors declared that they have no conflict of interest.

Ethics

This study did not involve human beings and/or clinical trials that should be approved by an Institutional Committee.

Data Availability

The data supporting the findings of this study are available at: <https://doi.org/10.48331/scielodata.GCY6W5>.

References

- Abreu, E.F., Casali, D.M., Garbino, G.S.T., Loretto, D., Loss, A.C., Marmontel, M., Nascimento, M.C., Oliveira, M.L., Pavan, S.E., & Tirelli, F.P. 2023. Lista de mamíferos do Brasil. Comitê de Taxonomia da Sociedade Brasileira de Mastozoologia (CT-SBMz). <https://www.sbmz.org/mamiferos-do-brasil>.
- de Arruda, M.R., Slingerland, M., Santos, J.Z.L., & Giller, K.E. (2019). Agricultural Land Use Change and Associated Driving Forces over the Past 180 Years in Two Municipalities of the Brazilian Cerrado. *GeoJournal* 84(3), 555–570. doi: 10.1007/s10708-018-9875-2.

- Brasil (2012) Lei nº 12,651, de 25 de maio de 2012. Dispõe sobre a proteção da vegetação nativa. https://www.planalto.gov.br/ccivil_03/_ato2011-2014/2012/lei/112651.htm. (accessed 11 September 2023).
- Colman, C.B., Guerra, A., Almagro, A., Roque, F.O., Rosa, I.M.D.R., Fernandes, G.W.F., & Oliveira, P.T.S. (2024). Modeling the Brazilian Cerrado Land Use Change Highlights the Need to Account for Private Property Sizes for Biodiversity Conservation. *Scientific Reports* 14(1), 4559. doi: 10.1038/s41598-024-55207-1.
- De Marco Jr, P., Souza, R.A., Andrade, F.A., Villén-Pérez, S., Nóbrega, C.C., Campello, L.M., & Caldas, M. (2023). The Value of Private Properties for the Conservation of Biodiversity in the Brazilian Cerrado. *Science* 380 (6642), 298–301. DOI: 10.1126/science.abq7768
- Diniz-Filho, J.A.F., Bini, L.M., Pinto, M.P., Terribile, L.C., Oliveira, G., Vieira, C.M., Blamires, D., Barreto, B.S., Carvalho, P., Rangel, T.F.L.V.B., Tôres, N.M., & Bastos, R.P. (2008). Conservation Planning: A Macroecological Approach Using the Endemic Terrestrial Vertebrates of the Brazilian Cerrado. *Oryx* 42(04), 567. doi: 10.1017/S0030605308001129.
- Fernandes-Santos, R.C., Medici, E.P., Testa-José, C., & Micheletti, T. (2020). Health Assessment of Wild Lowland Tapirs (*Tapirus terrestris*) in the Highly Threatened Cerrado Biome, Brazil. *Journal of Wildlife Diseases* 56(1), 34–46. doi: 10.7589/2018-10-244.
- Freitas-Oliveira, R., Guimarães-Silva, M.A., Andreani, T.L., Hannibal, W., Bastos, R.P., Moreira, J.C., & Morais, A.R. (2024). New Records of White-Lipped Peccaries in Altered Landscapes of the Brazilian Midwest. *Mammal Research* 69(1), 177–82. doi: 10.1007/s13364-023-00729-8.
- Guedes, J.J.M., Assis, C.L., Feio R.N., & Quintela, F.M. (2021). The Impacts of Domestic Dogs (*Canis familiaris*) on Wildlife in Two Brazilian Hotspots and Implications for Conservation. *Animal Biodiversity and Conservation* 44(1), 45–58. doi: 10.32800/abc.2021.44.0045.
- Hannibal, W., Zortéa, M., Calaça, A.M., Carmignotto, A.P., Bezerra, A.M.R., Carvalho, H.G., Bonvicino, C.R., Martins, A.C.M., Aguiar, L.M.S., Souza, M.B.S., Mattos, I., Oliveira, R.F., Brito, D., Silva, D., Guimarães, M.A., Carmo, E.M.B., & Moreira J.C. (2021). Checklist of Mammals from Goiás, Central Brazil. *Biota Neotropica* 21(3), doi: 10.1590/1676-0611-BN-2020-1173.
- Hannibal, W., Willyan, H.P.C., Bernardes-Dias, A.C., Alves, C., Bernardes, P.R., & Silva, T.L.L. (2023). Non-Volant Mammals of the Serra Da Fortaleza Wildlife Refuge, Southern Goiás, Central Brazil. *Check List* 19(6), 883–900. doi: 10.15560/19.6.883.
- IBGE (2021). Instituto Brasileiro de Geografia e Estatística. Produção Agrícola municipal. Available in: <https://www.ibge.gov.br/estatisticas/economicas/agricultura-e-pecuaria/9117-producaoagricola-municipal-culturas-temporarias-e-permanentes.html>. Accessed in March 21 of 2023
- IUCN. 2024. “The IUCN Red List of Threatened Species.” Accessed on 9 of august of 2024.
- Lessa, I., Guimarães, T.C.S., Bergallo, H.G., Cunha, A., & Vieira, E.M. (2016). Domestic Dogs in Protected Areas: A Threat to Brazilian Mammals? *Natureza e Conservação* 14(2):46–56. <https://doi.org/10.1016/j.ncon.2016.05.001>
- Menezes, F.H., Feijó, A., Fernandes-Ferreira, H., Costa, I.R., & Cordeiro-Estrela, P. (2021). Integrative systematics of Neotropical porcupines of *Coendou prehensilis* complex (Rodentia: Erethizontidae). *J Zoo Syst Evol Res.* 00, 1-30. <https://doi.org/10.1111/jzs.12529>
- Morais, A.R., Freitas-Oliveira, R., Moreira, J.C., Souza, A.O., Bittar, B.B., Carvalho, F.M.V., Oliveira, G.V., Santos, L.R.S., Guimarães, M.A., Amorim, N.P.L., Assis, R.A., Borges, R.E., Oliveira, S.R., Andreani, T.L., & Siqueira, M.N. (2022). Multi-Taxon Inventory and Landscape Characterization in an Agrosystem of the Brazilian Midwest Targeted for Payment for Environmental Services. *Biota Neotropica* 22(1). <https://doi.org/10.1590/1676-0611-BN-2021-1283>
- MMA (2022) BRASIL, Ministério do Meio Ambiente. Portaria MMA nº 148, de 7 de junho de 2002 DOU 108, de 08 de junho de 2022, Seção 1, página 74
- Myers, N., Mittermeier, R.A., Mittermeier, C.G., Fonseca, G.A.B., & Kent, J. (2000). Biodiversity Hotspots for Conservation Priorities. *Nature* 403(6772), 853–58. doi:10.1038/35002501.
- Oksanen, J., Simpson, G., Blanchet, F., Kindt, R., Legendre, P., Minchin, P., O’Hara, R., Solymos, P., Stevens, M., Szoecs, E., Wagner, H., Barbour, M., Bedward, M., Bolker, B., Borcard, D., Carvalho, G., Chirico, M., De Caceres, M., Durand, S., Evangelista, H., FitzJohn, R., Friendly, M., Furneaux, B., Hannigan, G., Hill, M., Lahti, L., McGlenn, D., Ouellette, M., Cunha, E.R., Smith, T., Stier, A., Ter Braak, C.J.F., & Weedon, J. (2022). *_vegan: Community Ecology Package_*. R package version 2.6-8 <https://CRAN.R-project.org/package=vegan>.
- Oliveira, R.F., Morais, A.R., & Terribile, L.C. (2019). Medium- and Large-Sized Mammals in Forest Remnants of the Southern Cerrado: Diversity and Ecology. *Neotropical Biology and Conservation* 14(1), 29–42. doi: 10.3897/neotropical.14.e34835.
- Paglia, A.P., Fonseca, G.A.B., Rylands, A.B., Herrmann, G., Aguiar, L.M.S., Chiarello, A.G., Leite, Y.L.R., Costa, L.P., Siciliano, S., Kierulff, M.C.M., Mendes, S.L., Tavares, V.C., Mittermeier, R.A., & Patton, L. (2012). *Lista Anotada Dos Mamíferos Do Brasil 2ª Edição*. Vol. 6.
- Pinto, F.A.S., Bager, A., Clevenger, A.P., & Grilo, C. (2018). Giant Anteater (*Myrmecophaga tridactyla*) Conservation in Brazil: Analysing the Relative Effects of Fragmentation and Mortality Due to Roads. *Biological Conservation* 228,148–57. doi: 10.1016/j.biocon.2018.10.023.
- Resende, P.S., Viana-Junior, A.B., & Bovendorp, R.S. (2024). A Meta-Analysis of the Effects of Anthropogenic Disturbances on Tropical Mammal Functional Diversity. *Mammal Review*, 55(1), e12356. <https://doi.org/10.1111/mam.12356>
- Risch, D.R., Ringma, J., & Price, M.R. (2021). The Global Impact of Wild Pigs (*Sus Scrofa*) on Terrestrial Biodiversity. *Scientific Reports* 11(1), 13256. <https://doi.org/10.1038/s41598-021-92691-1>
- Ruedas, L.A., Silva, S.M., French, J.H., Platt II, R.N., Salazar-Bravo, J., Mora, J.M., & Thompson, C.W. (2017). A prolegomenon to the systematics of the South American cottontail rabbits (Mammalia, Lagomorpha, Leporidae: *Sylvilagus*): designation of a neotype for *S. brasiliensis* (Linnaeus, 1758), and restoration of *S. andinus* (Thomas, 1897) and *S. tapetillus* Thomas, 1913. *Misc. Publi. Mus. Zool.* 205:1–67.
- Semenchuk, P., Plutzer, C., Kastner, T., Matej S, Bidoglio, G., Erb, K.H., Essl, F., Haberl, H., Wessely, J., Krausmann, F., & Dullinger, S. (2022). Relative effects of land conversion and land-use intensity on terrestrial vertebrate diversity. *Nat Commun* 13, 615. <https://doi.org/10.1038/s41467-022-28245-4>
- Silva, J.M.C., and Bates, J.M. (2002). Biogeographic Patterns and Conservation in the South American Cerrado: A Tropical Savanna Hotspot. *BioScience* 52(3), 225–33.
- Siqueira, M.N., and Faria, K.M.S. (2019). Análise Da Dinâmica Da Paisagem No Município de Rio Verde, Goiás, Brasil: Uma Ferramenta Para a Escolha de Áreas Prioritárias Para a Conservação. *Sociedade & Natureza* 31, e38832. <http://dx.doi.org/10.14393/SN-v31-2019-38832>
- Trigueiro, W.R., Nabout, J.C., & Tassarolo, G. (2020). Uncovering the Spatial Variability of Recent Deforestation Drivers in the Brazilian Cerrado. *Journal of Environmental Management* 275(1), 111243. doi:10.1016/j.jenvman.2020.111243.
- Vieira, R.R.S., Pressey, R.L., & Loyola, R. (2019). The Residual Nature of Protected Areas in Brazil. *Biological Conservation* 233, 152–61. doi: 10.1016/j.biocon.2019.02.010.
- Wickham H. 2016. *Ggplot2: Elegant Graphics for Data Analysis*. Springer-Verlag New York, 2016.

Received: 27/01/2025

Accepted: 01/06/2025

Published online: 30/06/2025