

Effect of land use on the community of medium and large mammals in the canal Candelaria stream, Santa Fe, Argentina

Abstract

Medium and large mammals play a key ecological role in terrestrial ecosystems as top predators, seed dispersers, scavengers, and habitat modifiers. In the highly anthropized landscapes of southeastern Santa Fe province, Argentina, these species face increasing pressure due to habitat fragmentation caused by agricultural, urban, and livestock expansion. This study aimed to evaluate the impact of land use on the richness, relative abundance, and diversity of medium and large mammals along the Canal Candelaria stream. Fieldwork was conducted seasonally between July 2024 and June 2025 in three sections of the stream with varying levels of human disturbance: a preserved riparian zone (lower basin), an urban section (middle basin), and an agriculturally dominated area (upper basin). Data were collected using transects, footprint tracking, direct observation, camera trapping, and interviews with local residents. Statistical analyses included diversity indices (Shannon, Simpson, Pielou), Kruskal-Wallis tests, ANOVA, hierarchical clustering, and principal component analysis. Results showed a significant decline in species richness and diversity in more disturbed sections. The lower basin harbored the highest richness (9 species) and more balanced community structure, while the urban section supported only two generalist species. These findings highlight the role of riparian remnants as biodiversity refuges and stress the urgent need for integrated conservation strategies in heavily modified agricultural-urban landscapes.

Keywords: medium and large mammals, land use, biodiversity, habitat fragmentation, ecological indicators, Canal Candelaria, Santa Fe, Argentina

Volume 9 Issue 2 - 2025

Pablo Guillermo Rimoldi

Environmental Studies Center in Veterinary Science (CEAV),
Faculty of Veterinary Sciences - National University of Rosario
(FCV-UNR), Argentina

Correspondence: Pablo Guillermo Rimoldi, Ph.D in Veterinary Sciences, Master in Biodiversity and Restoration of Natural Spaces. Center for Environmental Studies in Veterinary Science (CEAV). Chair of Biology and Ecology. Faculty of Veterinary Sciences, National University of Rosario (FCV-UNR). Boulevard Ovidio Lagos and National Route 33, Casilda, Santa Fe, Argentina

Received: May 10, 2025 | **Published:** May 28, 2025

Introduction

Medium and large mammals play an essential ecological role in terrestrial ecosystems. As top predators, seed dispersers, scavengers, and habitat modifiers, they directly influence population dynamics, trophic networks, and landscape structure. Moreover, due to their spatial requirements, longevity, and sensitivity to environmental changes, these mammals serve as excellent indicators of a system's ecological integrity. The loss of these species implies not only the disappearance of a faunal component but also the degradation of critical ecological functions.

The ecosystems of southeastern Santa Fe province, particularly those linked to the Canal Candelaria stream, are among the most anthropized environments on the planet, resulting from decades of intense human transformation. The region has experienced extensive agricultural, livestock, and urban expansion, leading to severe habitat fragmentation and near-total landscape homogenization.¹⁻³ This situation is worsened by the lack or weak implementation of specific environmental policies, limiting opportunities for the conservation of local and regional biodiversity.⁴⁻⁵

In this context, remnants of riparian vegetation and natural spaces associated with rural and peri-urban areas become crucial refuges for wildlife—especially medium and large mammals that require continuous or connected habitats to sustain viable populations.^{6,7} However, anthropogenic pressure on these habitats is heterogeneous: some areas retain structural integrity, while others are heavily degraded or fully urbanized, with waste and pollution that affect habitat quality and biological communities.⁸

Recent studies in southern Santa Fe have documented the richness and composition of medium and large mammals in rural and urban landscapes, showing biodiversity loss in altered areas and highlighting the importance of natural corridors and vegetation remnants.^{8,9} These works emphasize that, despite widespread transformation, functional natural relicts still persist and play a key role in ecological connectivity and the survival of species sensitive to human disturbance.¹⁰

This study focuses on the Canal Candelaria stream, where we assessed the community of medium and large mammals in three sections with varying degrees of disturbance: a preserved riparian zone associated with grazing fields (lower basin), a highly urbanized area with waste accumulation (middle basin), and an agricultural-dominated zone (upper basin). The aim was to analyze how land use and human intervention affect mammal richness, relative abundance, and diversity, with the goal of providing useful information for local conservation and environmental management strategies.

Material and methods

Study area: The study was conducted in the Canal Candelaria stream basin, located in the southern part of Santa Fe Province, Argentina, within the Caseros Department (Figure 1). This watercourse originates near the town of Sanford and flows eastward, passing through rural and urban areas—including the city of Casilda—until it drains into the Saladillo stream, a tributary of the Paraná River.¹¹

The region is characterized by a temperate Pampean climate, with average annual precipitation ranging from 900 to 1,100 mm, mainly concentrated in spring and summer. The dominant soils are typical Argiudolls, which are fertile and highly suitable for agriculture, contributing to intensive land use for farming activities.¹²

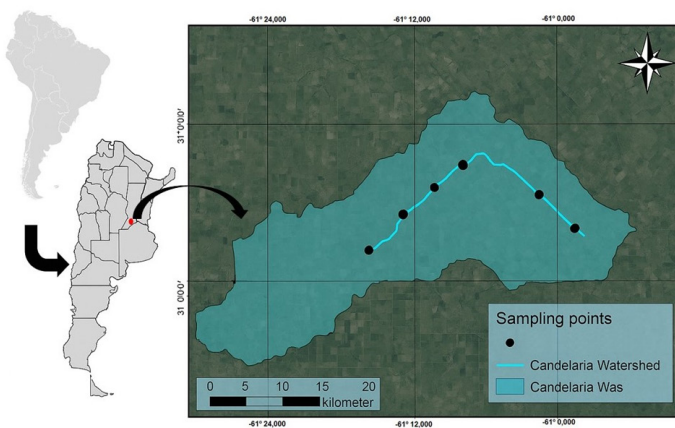


Figure 1 Basin of the Canal Candelaria Stream, southern Santa Fe province, Argentina.

The basin includes grassland environments, crop edges, and riparian vegetation in varying states of conservation, especially in less urbanized sectors. The drainage system has been partially canalized to facilitate agricultural runoff, which has altered the stream's natural course and the structure of riparian habitats. Three main sections can be distinguished along the stream: the upper rural stretch (Sanford), the middle urban stretch (Casilda), and the lower peri-urban/rural stretch (A° Saladillo). This gradient allows for the assessment of land-use impacts on local biodiversity.

Study design and sampling: Fieldwork was conducted seasonally to account for environmental and biological variability throughout the year. Eight sampling campaigns were planned between July 2024 and June 2025, with at least two surveys per season (autumn, winter, spring, and summer). This strategy aimed to adequately represent seasonal fluctuations in the activity and presence of medium and large mammals, given the high variability in their physical, ecological, and behavioral traits.^{13–15} Therefore, applying a single technique would not be sufficient to capture the entire community.

Study area and sampling transects: The study was carried out at six sampling stations distributed across three distinct sections of the Canal Candelaria stream: the upper, middle, and lower basins. It is important to note that the sampling did not cover the entire surface of these basins but was focused on the stream channel and adjacent areas directly connected to it. The aim was to assess the presence and relative abundance of medium and large mammals in representative sites of each section, considering the specific environmental characteristics of each zone. At each station, a 3-kilometer-long transect was established, with a variable width not exceeding 50 meters—corresponding to the maximum detectability limit for animal tracks.¹⁶ Surveys were conducted during daylight hours at an average speed of 1 km/h to maximize the detection of tracks, indirect signs, and direct observations.

Mammal detection methods: Due to the ecological and behavioral heterogeneity of medium and large mammals, an integrated set of techniques was used to record their presence:

I. Track and activity sign surveys: Direct and indirect data such as footprints, feces, burrows, dens, and bone remains were collected along the transects. For each record, the type, number, and size of the tracks were noted, along with GPS coordinates (Garmin Etrex). Findings were documented using digital photography (Nikon D3000), plaster casts of tracks, and

acetate sketches. Taxonomic identification was confirmed using illustrated guides and reference collections.^{17–22}

II. Semi-structured Interviews with Local Residents and Hunters: Interviews were conducted using species checklists and visual aids to verify mammal presence in the area. This complementary information was used to validate field records.

III. Direct Observation and Camera Trapping: To detect elusive or nocturnal species, direct visual observations and camera traps were employed, complementing indirect methods.

Statistical analysis

Species presence and relative abundance data by site and stream section were organized into tables for processing and quantitative analysis. Ecological diversity indices were calculated — Shannon-Wiener (H'), Simpson ($1-D$), and Pielou's evenness (J') — to characterize the structure and composition of the mammal community in each section of the Canal Candelaria stream.

Before selecting statistical tests, assumptions of normality (Shapiro-Wilk test) and homogeneity of variances (Levene's test) were evaluated using functions from the stats package in R (version 4.3.1). Since richness values did not meet the normality assumption, the non-parametric Kruskal-Wallis test (`kruskal.test()`) was applied to compare species richness among sections. For diversity indices, an analysis of variance (ANOVA, `anova()` function) was used, as variance homogeneity was observed. However, due to non-normality in some data (particularly in the middle and upper sections), results were interpreted cautiously, acknowledging statistical limitations. As a complementary measure, Kruskal-Wallis was also considered for the Shannon index in future replications.

When significant differences were detected in ANOVA, post-hoc multiple comparisons were performed using Tukey's test (`TukeyHSD()` function). Additionally, multivariate techniques were applied to assess similarity and clustering patterns among sampling units. Hierarchical clustering based on Bray-Curtis distance and principal component analysis (PCA) were conducted using the `vegan` and `stats` packages in R. To complement faunal composition analysis, Venn diagrams were generated (using the `VennDiagram` package) to identify and visualize exclusive and shared species among stream sections. All analyses were performed in R version 4.3.1, with a statistical significance level of $\alpha = 0.05$.

Mathematical and methodological detail

Species presence and relative abundance data by site and stream section were organized into tables for processing and quantitative analysis. To characterize the structure and composition of the mammal community in each section of the Canal Candelaria stream, the following ecological diversity indices were calculated:

Shannon-Wiener Index (H')

$$H' = -\sum_{i=1}^S p_i \ln(p_i)$$

where p_i is the proportion of individuals of species i , and S is the total number of species. This index accounts for both species richness and evenness (Shannon, 1948).²³

Simpson's Index ($1-D$)

$$D = \sum_{i=1}^S p_i^2 ; 1 - D = \text{Simpson diversity}$$

This index emphasizes the dominance of common species in the community (Simpson, 1949).²⁴

Pielou's Evenness (J)

$$J' = \frac{H'}{\ln(S)}$$

which measures the evenness of species distribution (Pielou, 1966).²⁵

Before selecting statistical tests, the assumptions of **normality** and **homogeneity of variances** were evaluated:

Shapiro-Wilk test (Shapiro & Wilk, 1965)²⁶ for normality:

Tests the null hypothesis that the data come from a normal distribution.

Levene's test (Levene, 1960)²⁷ for homogeneity of variances:

More robust than Bartlett's test when dealing with non-normal data.

These were implemented using functions from the **stats** package in **R** (version 4.3.1). Since richness values did not meet the normality assumption, the **non-parametric Kruskal-Wallis test** was applied:

Kruskal-Wallis Test

$$H = \frac{12}{N(N+1)} \sum_{i=1}^k n_i (R_i - \bar{R})^2$$

where R_i is the average rank of group i , and N is the total number of observations. A non-parametric test for differences in medians across groups (Kruskal & Wallis, 1952).²⁸

For diversity indices that met assumptions of homogeneity of variance, **one-way analysis of variance (ANOVA)** was used:

ANOVA (Fisher, 1925)²⁹:

Tests differences between group means assuming normality and equal variances. The F statistic is:

$$F = \frac{MS_{between}}{MS_{within}}$$

where MS is the mean square.

Due to slight deviations from normality (especially in the middle and upper sections), results were interpreted cautiously, and the Kruskal-Wallis test was also considered for future replications.

When significant differences were detected in ANOVA, **Tukey's Honestly Significant Difference (HSD)** test was applied:

Tukey HSD (Tukey, 1949)³⁰:

A post-hoc test that controls the family-wise error rate and performs pairwise comparisons using the studentized range distribution.

To explore patterns in species composition among sampling units, multivariate analyses were used:

Hierarchical cluster analysis

Based on **Bray-Curtis dissimilarity**

$$BC_{ij} = 1 - \frac{2C_{ij}}{S_i + S_j}$$

where C_{ij} is the sum of the lesser counts for shared species between samples i and j ; S is the total number of individuals in each sample (Bray & Curtis, 1957)³¹.

Principal component analysis (PCA)

A linear transformation that reduces dimensionality by projecting the data onto principal components that maximize variance. The method involves:

- I. Standardizing the data,
- II. Calculating the covariance matrix,
- III. Deriving eigenvectors and eigenvalues, and
- IV. Projecting data onto the new axes (Hotelling, 1933)³².

Results

Species richness and composition

The following species of medium and large mammals were recorded: red opossum (*Lutreolina crassicaudata*), white-eared opossum (*Didelphis albiventris*), large hairy armadillo (*Chaetophractus villosus*), pampas gray fox (*Lycalopex gymnocercus*), Geoffroy's cat (*Leopardus geoffroyi*), common skunk (*Conepatus chinga*), lesser grison (*Galictis cuja*), capybara (*Hydrochoerus hydrochaeris*), and coypu (*Myocastor coypus*). In addition to systematically recorded species, other mammals were detected opportunistically but were not included in the statistical analysis due to non-standardized recording methods. These include several rodent species such as *Akodon azarae*, *Oligoryzomys flavescens*, *Calomys musculus*, *Calomys laucha*, *Holochilus chacarius*, *Holochilus brasiliensis*, and *Cavia aperea*, as well as introduced and synanthropic species such as *Rattus norvegicus*, *Rattus rattus*, and *Mus musculus*. The European hare (*Lepus europaeus*), a widespread exotic species in agricultural landscapes, was also observed. Additionally, activity from several bat species was noted, though precise identification would require specialized methods not used in this study. Total species richness of medium and large mammals differed significantly between stream sections (Kruskal-Wallis, $H = 11.27$, $p = 0.0036$). The lower basin had the highest richness with nine recorded species, followed by the upper basin with four species, and the urban middle basin with only two. This pattern suggests an inverse relationship between landscape disturbance and mammal species richness Table 1.

Table 1 Species richness per stream section

Species	Lower basin	Middle basin	Upper basin
<i>Lutreolina crassicaudata</i>	X		
<i>Didelphis albiventris</i>	X	X	X
<i>Chaetophractus villosus</i>	X		X
<i>Lycalopex gymnocercus</i>	X		X
<i>Leopardus geoffroyi</i>	X		
<i>Conepatus chinga</i>	X		
<i>Galictis cuja</i>	X		
<i>Hydrochoerus hydrochaeris</i>	X		
<i>Myocastor coypus</i>	X	X	X

Relative abundance

In the lower basin, the most abundant species were *Lycalopex gymnocercus* (0.38), *Leopardus geoffroyi* (0.19), and *Chaetophractus villosus* (0.18). In the middle basin, *Didelphis albiventris* showed a high relative abundance (0.32). In the upper basin, *Chaetophractus villosus* (0.12) was one of the most representative. *Myocastor coypus* was present in all three sections, although with lower abundance in the middle and upper basins compared to the lower basin associated with the Saladillo stream (Figure 2).

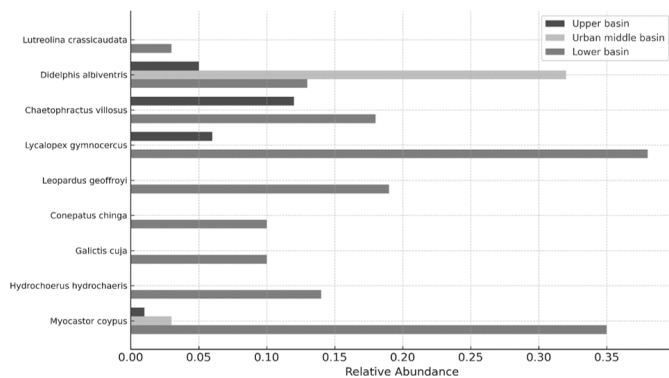


Figure 2 Relative abundance of mammals by section (grayscale visualization).

Diversity indices

The diversity indices reflected patterns consistent with species richness. The Shannon index (H') differed significantly among sections (ANOVA, $F = 12.7$, $p = 0.0051$), with the highest value in the lower basin (2.49), intermediate in the upper basin (0.79), and lowest in the urban middle basin (0.61). This indicates that the lower basin supports a more diverse and structured community. The Simpson index ($1-D$) was highest in the upper basin (0.97), followed by the middle basin (0.89), and lowest in the lower basin (0.64). These values suggest lower dominance in the upper basin, where relative abundance is more evenly distributed among a few disturbance-tolerant species. Pielou's evenness (J') was highest in the lower basin (0.87), indicating a more balanced distribution among a greater number of species. In contrast, the urban section exhibited lower richness and intermediate evenness (0.76), suggesting uniformity among a few dominant generalist species Table 2.

Table 2 Diversity indices per stream section

Section	Species Richness (S)	Shannon (H')	Simpson ($1-D$)	Evenness (J')
Lower basin	9	2.49	0.64	0.87
Middle basin	2	0.61	0.89	0.76
Upper basin	4	0.79	0.97	0.57

Species distribution and exclusivity

Venn diagrams revealed that the lower basin hosts several exclusive species—such as *Leopardus geoffroyi*, *Conepatus chinga*, and *Hydrochoerus hydrochaeris*—associated with preserved, low-disturbance environments. The urban middle section included only two generalist species: *Didelphis albiventris* and *Myocastor coypus* (Figure 3). The upper basin, near the town of Sanford, showed an intermediate composition, sharing species with both the lower and middle sections, including *Chaetophractus villosus* and *Didelphis albiventris*.

These patterns suggest a process of ecological simplification in the most anthropized sections, characterized by the loss of sensitive species and the dominance of disturbance-tolerant taxa. Multivariate techniques were applied to explore the similarity in medium and large mammal composition among the three sections of the Canal Candelaria stream. The hierarchical clustering analysis, based on Bray-Curtis distance, revealed a clear separation between the middle (urban) basin and the remaining sections, which showed greater similarity (Figure 4). This pattern indicates that the faunal community

in the urban section is the most distinct, with lower species richness and a predominance of generalist species.

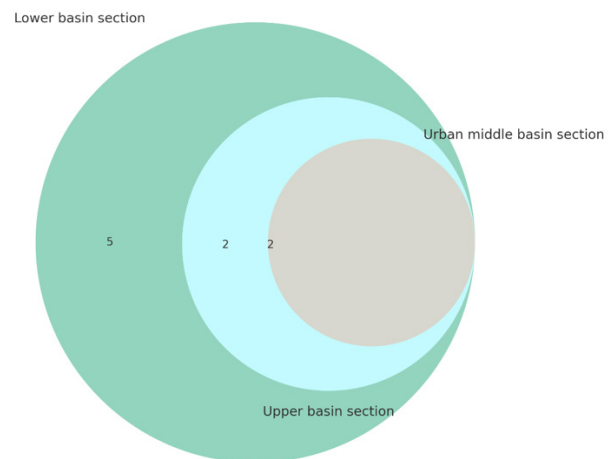


Figure 3 Venn diagram of shared and exclusive species among sections.

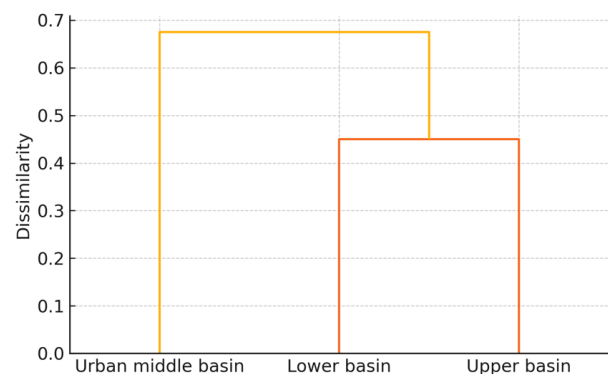


Figure 4 Hierarchical clustering (Bray-Curtis).

The principal component analysis (PCA) explained 100% of the total variance with the first two components (PC1 = 80.85%, PC2 = 19.15%). The resulting plot showed a clear differentiation among the three sections (Figure 5). The lower basin was separated due to its high species richness and the presence of exclusive species, while the middle basin exhibited a reduced and distinct composition. The upper basin occupied an intermediate position, reflecting a more simplified community compared to the lower section, but with some shared elements.

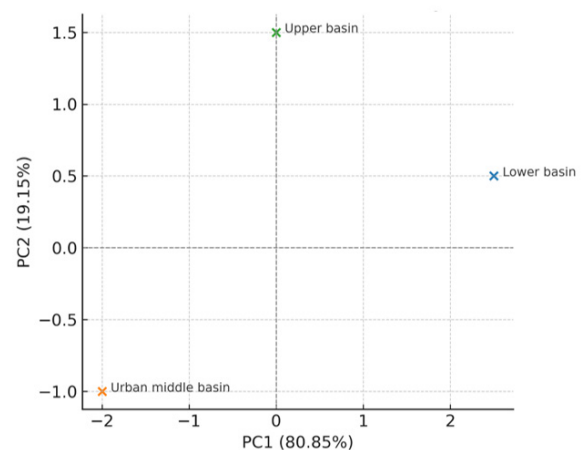


Figure 5 PCA of relative abundance of mammals by stream section.

Discussion

The results obtained in this study reinforce and expand on previous evidence regarding the critical influence of land use on the structure and composition of medium and large mammal communities in southern Santa Fe landscapes. The significant variation in species richness (Kruskal-Wallis, $H = 11.27$, $p = 0.0036$) and Shannon diversity index (ANOVA, $F = 12.7$, $p = 0.0051$) among the studied sections demonstrates a strong correlation between the degree of anthropogenic disturbance and mammal diversity.

Consistent with the findings of Rimoldi & Chimento (2018), habitat fragmentation and loss in agricultural landscapes reduce the richness and diversity of sensitive species.⁸ In this context, the lower basin—characterized by well-preserved riparian vegetation and lower human pressure—recorded the highest species richness (9 species) and a high Shannon index value (2.49), reflecting a more diverse and balanced community. The exclusive presence of species such as *Leopardus geoffroyi*, *Galictis cuja*, *Conepatus chinga*, and *Hydrochoerus hydrochaeris* emphasizes the conservation value of this site.

In contrast, the urban middle section exhibited the lowest richness (2 species) and the lowest diversity (Shannon = 0.61), dominated by generalist species like *Didelphis albiventris* and *Myocastor coypus*. This pattern aligns with Alesio et al. (2023), who noted that these species, due to their ecological plasticity, can persist in highly disturbed urban environments.⁹ However, their persistence often comes at the cost of structural simplification within the community—a phenomenon also observed in other cities in central Argentina.^{33,34}

The upper basin near Sanford showed intermediate richness (4 species) and mixed values in diversity indices: moderate Shannon diversity ($H' = 0.79$) but the highest Simpson index ($1-D = 0.97$), indicating low dominance and a relatively even distribution among a few disturbance-tolerant species. This suggests that although the agricultural matrix limits richness, the presence of vegetated corridors or natural patches supports the persistence of species such as *ChaetophRACTUS villosus* and *Lycalopex gymnocercus*, in line with.⁹

The Venn diagrams and relative abundance data support this interpretation, showing that the lower basin not only hosts more species but also maintains a more balanced abundance distribution ($J' = 0.87$). In contrast, the middle and upper basins exhibit simplified communities dominated by few generalist species.

Multivariate analyses further support the patterns revealed by diversity indices and species richness. Both hierarchical clustering and PCA indicate that the middle basin harbors a clearly distinct, impoverished mammal community dominated by opportunistic species—consistent with its high level of anthropogenic disturbance. In contrast, the lower basin stands out as a biodiversity hotspot, with the presence of sensitive and exclusive species, underscoring its value as a conservation refuge.

The intermediate position of the upper basin in both analyses suggests that, despite the dominant agricultural matrix, riparian corridors still enable the persistence of certain species. These results are consistent with previous studies, which emphasize the importance of vegetation remnants and landscape connectivity for mammal conservation in fragmented environments.^{8,9}

These patterns reveal a process of biological homogenization in more disturbed areas, with significant ecological consequences: the loss of specialist species, reduced ecosystem resilience, and functional impoverishment of communities. The presence of top predators and

indicator species in the lower basin highlights the importance of preserving these remnants as biodiversity reservoirs and functional nodes within regional trophic networks.⁸

In this sense, the integration of these results with regional and global studies emphasizes the urgency of implementing conservation policies that integrate productive matrices with restored, functional riparian corridors.^{7,35} Only through ecologically informed land-use planning will it be possible to sustain complex, functional, and representative mammal communities in southern Santa Fe.

Conclusion

The results demonstrate that land use is a key factor influencing the diversity, composition, and structure of medium- and large-sized mammal communities in the Canal Candelaria stream basin. The lower section, near the Saladillo stream, with lower human disturbance and better-preserved riparian cover, functions as a critical refuge for sensitive and keystone species, supporting the highest levels of species richness and biological diversity.

In contrast, the middle section, associated with the urban area of Casilda, and the upper section, near the town of Sanford, are highly impacted by urbanization and intensive agriculture, respectively. These areas host simplified communities dominated by generalist species tolerant to disturbance, reflecting processes of biological homogenization that compromise the ecological functionality of the landscape.

These findings highlight the urgent need to implement integrated environmental policies that prioritize the conservation of natural remnants—especially riparian buffers—and promote ecological connectivity between habitat fragments. Additionally, it is essential to encourage sustainable agricultural and urban practices that minimize biodiversity loss.

This study provides key evidence to inform land-use planning and environmental management in one of the most anthropized regions of Argentina, underscoring the strategic role of medium- and large-sized mammals as indicators and agents of ecosystem health.

Consent and ethical approval

As per university standard guideline, participant consent and ethical approval have been collected and preserved by the authors.

Competing interests

Authors have declared that no competing interests exist.

Authors' contributions

This work was carried out by the author. The author read and approved the final manuscript.

References

1. Fahrig L. Effects of habitat fragmentation on biodiversity. *Annual Review of Ecology, Evolution, and Systematics*. 2003;34:487–515.
2. Haddad NM, Brudvig LA, Clobert J, et al. Habitat fragmentation and its lasting impact on Earth's ecosystems. *Science Advances*. 2015;1(2):e1500052.
3. Bertiller MB, Laterra P, Araujo F, et al. *Perspectivas para una gestión ambiental de tierras más sostenible en Argentina*. INTA. 2019.
4. Biasatti NR, Rimoldi P, Cabrera L. *Desafíos de la conservación biológica en el espinal y la pampa húmeda santafesina, los mamíferos del sur de Santa Fe*. Ministerio de Medio Ambiente, Provincia de Santa Fe. ISBN 978-987-45488-3-2. 2019. p. 106.

5. Crespo D, Piudo L, Cagnoni M, et al. Efectos de la transformación antrópica sobre los mamíferos del centro-este de Argentina: patrones y recomendaciones para su conservación. *Mastozoología Neotropical*. 2021;28(1):137–148.
6. Beier P, Noss RF. Do habitat corridors provide connectivity? *Conservation Biology*. 1998;12(6):1241–1252.
7. Laurance WF, Camargo JLC, Luizão RCC, et al. The fate of Amazonian forest fragments: A 32-year investigation. *Biological Conservation*. 2011;144(1):56–67.
8. Rimoldi PG, Chimento NR. Diversidad de mamíferos nativos medianos y grandes en la cuenca del río Carcarañá, provincia de Santa Fe (Argentina). *Revista del Museo Argentino de Ciencias Naturales*. 2018;20(2):333–341.
9. Alesio CJ, Paiz DA, Rimoldi PG. Diversidad y patrones de distribución estacional de mamíferos silvestres medianos y grandes en la cuenca media del arroyo Saladillo, Santa Fe, Argentina. *Acta Zoológica Lilloana*. Advance online publication. 2023;68(2).
10. Pérez-Solano LA, González M, López-Tello E, et al. Mamíferos medianos y grandes asociados al bosque tropical seco del centro de México. *Revista de Biología Tropical*. 2018;66(3):1232–1243.
11. Secretaría de Recursos Hídricos de Santa Fe. *Plan director del arroyo Saladillo*. Ministerio de Aguas, Servicios Públicos y Medio Ambiente, Gobierno de la Provincia de Santa Fe. 2013.
12. INTA. *Carta de suelos de la República Argentina: Hoja Casilda 3360-I*. Instituto Nacional de Tecnología Agropecuaria. 2010.
13. Voss RS, Emmons LH. Mammalian diversity in Neotropical lowland rainforests: A preliminary assessment. *Bulletin of the American Museum of Natural History*. 1996;230:1–115.
14. Voss RS, Lunde DP, Simmons NB. Mammals of Paracou, French Guiana: A Neotropical lowland rainforest fauna. Part 2. Nonvolant species. *Bulletin of the American Museum of Natural History*. 2001;263:1–236.
15. Zapata-Ríos G, Araguillín E, Jorgenson JP. Caracterización de la comunidad de mamíferos no voladores en las estribaciones orientales de la Cordillera del Kutukú, Amazonía Ecuatoriana. *Mastozoología Neotropical*. 2006;13(2):227–238.
16. Gallina-Tessaro S, López-González C. *Manual de técnicas para el estudio de la fauna* (Vol. 1). Universidad Autónoma de Querétaro / Instituto de Ecología, A.C. 2011.
17. Becker M, Dalponte JC. *Rastros de mamíferos silvestres brasileños: Um guia de campo* (2ª ed.). Editora da Universidade de Brasília. 1991.
18. Acosta G, Simonetti JA. Guía de huellas de once especies de mamíferos del bosque templado chileno. *Boletín del Museo Nacional de Historia Natural (Chile)*. 1999;48:19–27.
19. Villalba R, Yanosky A. *Guía de huellas y señales: Fauna paraguaya*. Asunción, Paraguay. 2000.
20. Guzmán-Lenis AR, Camargo-Sanabria A. Importancia de los rastros para la caracterización del uso de hábitat de mamíferos medianos y grandes en el bosque Los Mangos (Puerto López, Meta, Colombia). *Acta Biológica Colombiana*. 2004;9(1):11–22.
21. Canevari M, Vaccaro O. *Guía de mamíferos de América del Sur*. L.O.L.A. Editorial. 2007.
22. Pautasso M. Plant disease and global change—The importance of long-term data sets. *New Phytologist*. 2008;177(1):8–11.
23. Shannon CE. *A mathematical theory of communication*. *The Bell System Technical Journal*. 1948;27(3):379–423.
24. Simpson EH. *Measurement of diversity*. *Nature*. 1949;163:688.
25. Pielou EC. The Measurement of Diversity in Different Types of Biological Collections. *Journal of Theoretical Biology*. 1966;13(1):131–144.
26. Shapiro SS, Wilk MB. An analysis of variance test for normality (complete samples). *Biometrika*. 1965;52(3/4):591–611.
27. Levene H. *Robust tests for equality of variances*. In: I Olkin editor. *Contributions to Probability and Statistics*. Stanford University Press. 1960. p. 278–292.
28. Kruskal WH, Wallis WA. Use of ranks in one-criterion variance analysis. *Journal of the American Statistical Association*. 1952;47(260):583–621.
29. Fisher RA. *Statistical Methods for Research Workers*. Oliver & Boyd. 1925.
30. Tukey JW. Comparing individual means in the analysis of variance. *Biometrics*. 1949;5(2):99–114.
31. Bray JR, Curtis JT. An ordination of the upland forest communities of southern Wisconsin. *Ecological Monographs*. 1957;27(4):325–349.
32. Hotelling H. Analysis of a complex of statistical variables into principal components. *Journal of Educational Psychology*. 1933;24:417–441.
33. Pautasso M. Observed impacts of climate change on terrestrial birds in Europe: An overview. *Italian Journal of Zoology*. 2012;79(3):296–314.
34. Burgos L, Acosta RM, Fonrouge RD, et al. Prevalencia de un parásito zoonótico, *Diocotophyma renale* (Goeze, 1782), en caninos machos de una zona riverense al Río de la Plata, Provincia de Buenos Aires, República Argentina. *Revista de Patología Tropical*. 2015;43(4):420–426.
35. Hilty J, Worboys GL, Keeley A, et al. *Guidelines for conserving connectivity through ecological networks and corridors*. IUCN. 2020.