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The return of the giant otter (*Pteronura brasiliensis*) to Tauramena (Casanare, Colombia): relative abundance, distribution, and conservation considerations

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Abstract

The giant otter (*Pteronura brasiliensis*) is endemic to South America, and in Colombia it is distributed in the Amazon and Orinoquia regions. It inhabits rivers, streams, and lagoons, but prefers the latter two in response to resource availability depending on the season. Giant otters are endangered in Colombia, and aspects of their natural history are still unknown in much of their geographic range. Our research aim is to generate information focused on relative abundance, habitat use, and distribution of the giant otter in an area of Colombia where it was thought to be extirpated. The distribution was evaluated with spatial distribution modeling (SDM) and habitat use using the Wallace 2.0.4 package for the department of Casanare in northeastern Colombia. To assess the population status and abundance in the municipality of Tauramena, 30 transects were surveyed in the Tua River and the Piñalito and El Huesero streams in 2021 and 2022. In general, the distribution models highlighted the importance of precipitation, temperature, and forests for the occurrence of this species. In Tauramena, five family groups were detected, which were composed of an average of 4.83 ± SD 3.16 individuals per group and a relative abundance of 1.03 ind./km. These are positive results for giant otters, as they indicate signs of population recovery of a species previously thought to have been extirpated from this region because of hunting and illegal pelt trade. Even though Tauramena is an area with high levels of anthropic disturbances, giant otters are showing signs of adaptability and plasticity, which provide important conservation opportunities. It is expected that this work will become the first step for the generation of additional information on diet, behavior, and population structure that can inform management plans for the giant otter in Colombia.

Keywords:
conservation, ecology, habitat use, Orinoquia, temporal variation

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Introduction

The giant otter (*Pteronura brasiliensis*) is an endemic species of South America, inhabiting the Orinoco, Amazon, and Paraná basins, as well as the coastal hydrographic networks of the Guianas. Its range spans multiple countries, including Bolivia, Brazil, Colombia, Ecuador, French Guiana, Guyana, Paraguay, Peru, Suriname, and Venezuela (Cianfrani et al., 2018; Schiaffini, 2022). In Colombia, it is estimated that the species is distributed in the Orinoco River basin in tributaries such as the Arauca, Casanare, Ele, Lipa, Cravo Sur, Cusiana, Pauto, Meta, Manacacías, Bita, Tomo, Vichada, Duda, Guayabero, Guaviare, and Inírida; and in the Amazon Basin in tributaries such as the Putumayo, Cauayá, Caquetá, Cahuinarí, Apaporis, Mirití-Paraná, and Vaupés, with an elevational range from sea level to 500 m (Lima et al., 2012; Cianfrani et al., 2018; Alviz & Pérez-Albarracín, 2019).

In addition to inhabiting large rivers, giant otters tend to concentrate in specific habitats such as streams and lagoons in response to resource availability (*i.e.*, food and shelter). Variations between climatic seasons influence this habitat use, as water levels fluctuate. During the dry season, family groups occupy well-defined territories, as low water levels concentrate fish and increase the availability of refuge sites for giant otters (Leuchtenberger et al., 2013, 2015; Peñuela et al., 2019). During the wet season, flooding of gallery forests and savannahs allows fish to disperse, forcing otters to expand their territories and travel greater distances to hunt (Peñuela et al., 2019). This seasonal dynamic has been documented in the Orinoquia region of Colombia, where otters are found in streams and wetlands during high-water seasons (June - August) and in main rivers during low-water seasons (January - April) (Díaz & Sánchez, 2002; Franco-Rozo et al., 2015; Alviz & Pérez-Albarracín, 2019).

Giant otters are considered key species in this type of aquatic environment by fulfilling several ecological roles in the ecosystem (Carter & Rosas, 1997; Groenendijk et al., 2005). Giant otters are apex predators that regulate the populations of their prey and maintain a balanced ecosystem (Duplaix et al., 2015). By preying on multiple aquatic species, giant otters contribute to nutrient cycling by influencing the distribution and abundance of prey species (Recharte Uscamaita & Bodmer, 2010). However, this species requires large areas for survival, including gallery and riparian forests for the establishment of burrowing and

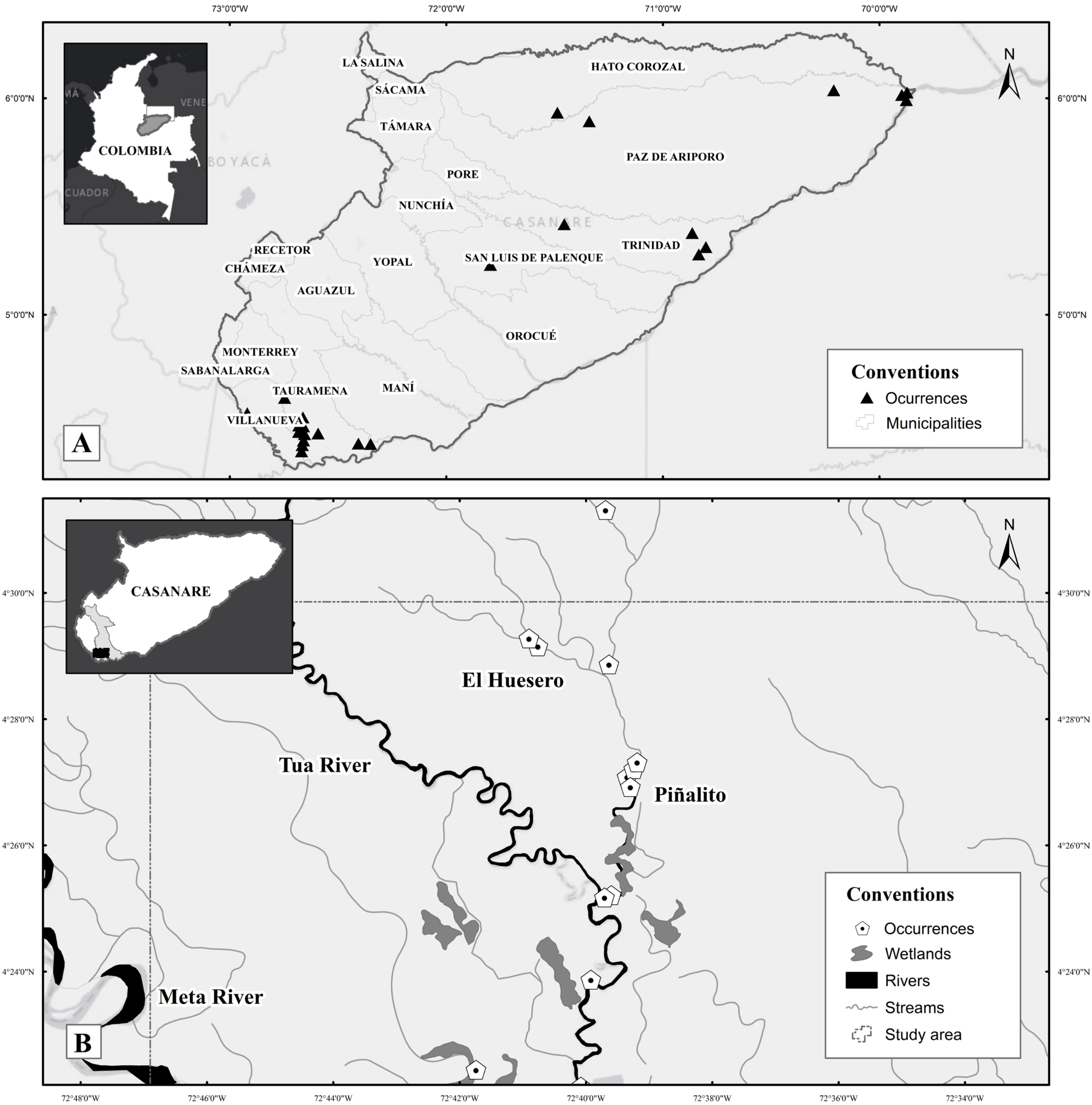

Figure 1. A) Giant otter occurrences between 2010 and 2023 obtained from Fundación Orinoquia Biodiversa's databases, GBIF, Sistema de Información Biológica de Colombia (SiB Colombia), and unpublished grey literature. B) General location of the study area and giant otters observed during the field surveys conducted between February 2021 and April 2022 in Piñalito and El Huesero streams. White hexagons represent registered occurrences of the giant otter.

resting sites. Therefore, the giant otter is considered a species with an umbrella effect in terms of conservation in freshwater ecosystems (Pimenta et al., 2018a). It is recognized that giant otters are facing population declines throughout their range due to land-use changes, forest loss, fragmentation, hunting by retaliation, and climate change (Carter & Rosas, 1997; Rosas-Ribeiro et al., 2012; Lima et al., 2014b; Duplaix et al., 2015). As a result, the giant otter is listed as Endangered (EN) by the IUCN (Groenendijk et al., 2022). The species is also listed in Appendix I of CITES due to a significant population decline throughout its range, which was caused by commercial hunting for its fur in the 20th century (Lima et al., 2014b; Pimenta et al., 2018b; Garbino et al., 2022).

Historically, giant otters were considered extirpated in various regions of South America due to heavy hunting pressure and habitat destruction (Tomas et al., 2015; Pimenta et al., 2018a). The Casanare region was no exception, a fact consistently affirmed by local human communities. However, recent sightings have reignited interest in their conservation. This region, characterized by extensive monoculture agriculture, oil extraction, and expanding human development (Governación del Casanare, 2024), poses unique challenges to giant otter conservation. Habitat fragmentation, pollution from oil extraction, and altered water regimes threaten the species' ability to survive and recolonize its historical range. Understanding how giant otters respond to these specific threats is critical for designing effective conservation strategies.

While significant knowledge exists about the natural history of giant otters, large gaps remain in understanding their foraging behavior, spatial and temporal distribution, population demographics, and adaptability to anthropogenic threats, particularly in regions like northeastern Colombia (Norris & Michalski, 2024). Similarly, the response and adaptability of giant otters to specific threats such as monoculture expansion and oil extraction is poorly understood. This knowledge is critical for assessing and developing mitigation strategies for otter-human conflict and for developing species-specific conservation strategies. We generated information on relative abundance, habitat use, and distribution of the giant otter in northeastern Colombia, where the species was considered extirpated by local communities due to hunting and the fur trade. In this study, we assessed the current relative abundance, habitat use, and spatial distribution of giant otters in northeastern Colombia, focusing on areas where the species was believed to be extirpated. We aim to determine seasonal and habitat-related distribution patterns and gain insights into the population dynamics of giant otters in this region. Our findings will provide crucial information for the development of conservation strategies that address both species-specific needs and broader ecosystem protection, ensuring the long-term survival of this endangered species in the Casanare region.

Material and Methods

Study Area

The study was conducted in the Meta River basin and Tua River sub-basin, located between the municipalities of Tauramena and Villanueva in the Department of Casanare (Fig. 1A). The area has an annual temperature range of 22°C to 36°C and an average annual rainfall of 2,000 mm. The region has an extreme unimodal rainfall regime, with a marked rainy season (winter) from May to October and an extreme dry season (summer) from November to April (Viloria La Hoz, 2009). Tauramena is located in the Andean-Orinoquean foothills of Casanare, with an elevational variation of 100 to 3,300 m. The lower area to the south of the municipality has large extensions of savannahs and complex networks of gallery and riparian forests (Correa-Gómez & Stevenson, 2010). These forests have been strongly transformed by anthropic activities, such as non-traditional extensive livestock farming and the growing of monocultures (Lasso et al., 2011). In general, the region has traditionally been a ranching area, and its cultural development is strongly linked to dairy farming and traditional livestock management. However, in recent years, there has been a rapid expansion of oil palm and rice crops, which has led to the transformation and loss of natural habitat.

Monitoring was conducted mainly in the Tua River, Piñalito, and El Huesero streams in Tauramena (Fig. 1B). These water bodies are tributaries of the Meta River, which provides a consistent water flow to the streams across seasons, potentially sustaining food resources for both otters and human communities. The Tua River has suffered various changes as a consequence of the agricultural and extractive activities that have been increasing rapidly since the 1990s (Orjuela & Castaño, 2019). Consequently, approximately 80% of the forest cover that surrounded the river has been deforested and fragmented. The Piñalito and El Huesero streams are characterized by having floodable and non-floodable gallery forests that have been preserved despite agricultural expansion. These forests are key elements in sustaining biodiversity, because of their structural and functional heterogeneity (Alviz et al., 2023).

Spatial Distribution Modeling and habitat use

Spatial Distribution Models (SDM) were built based on presence data of the species obtained from Orinoquia Biodiversa Foundation (FOB) databases, GBIF (https://www.gbif.org/country/CO/), SiB Colombia (https://biodiversidad.co/), and unpublished grey literature available for Casanare (Fig. 1A). To minimize geographic bias associated with the obtained databases, the data were filtered based on criteria potentially affecting model performance and variable correlations (Phillips et al., 2006; Guzman et al., 2023; Machado-Aguilera et al., 2024). These criteria include (1) credibility, based on type of evidence (*i.e.*, human observation, collected specimen) and source (*i.e.*, scientific papers), (2) geographical precision (*i.e.*, lack of coordinates), (3) duplicate coordinates, and (4) spatial clustering, identified by removing records within 2 km using the "Spatial Thinning" function in Wallace (v. 2.0.5). This filtering reduced the number of occurrence records from 34 to 21. The final database was used in MaxEnt software to obtain the final model.

We used 21 environmental covariates including forest cover layer (Copernicus Global Land Service: Land Cover 100 m), water occurrence (Pekel et al., 2016), and the 19 bioclimatic variables from CHELSA Bioclims Version 2.1 (Karger et al., 2017) at high resolution (30 arcsec, ~1 km). All covariates were processed in raster format and clipped to the study area. Variables were selected according to the habitat requirements of giant otters. Giant otters depend on forests and water bodies to conduct

Table 1. Percent contribution and permutation importance of environmental variables in the distribution model and habitat use of the giant otter in Casanare, Colombia

Variable	Name	Percent contribution	Permutation importance
bio_9	Mean Temperature of Driest Quarter	29.4	68.8
bio_19	Precipitation of Coldest Quarter	21.8	14.8
bio_15	Precipitation Seasonality	16.4	0
bio_4	Temperature Seasonality	13.1	1.1
bio_5	Maximum Temperature of Warmest Month	5.1	0.4
bio_7	Temperature Annual Range	3.5	12.7
bio_10	Mean Temperature of Warmest Quarter	3.3	0.1
landcover	Land cover	0.9	0.7

their daily activities. Therefore, these variables are expected to significantly influence their distribution.

We modelled the potential distribution of giant otters using the algorithms of MaxEnt 3.4.4 (Phillips et al., 2017). Since the default parameters of MaxEnt lead to overfitted models (Morales et al., 2017), we built 50 models from different sets of feature classes based on Linear (L), Quadratic (Q), Hinge (H), and Product (P) functions, regularization values (from 0.5 to 4, with steps of 0.5), and used background data (from 10,000 to 50,000 points, with 10,000 steps). Background point generation is one of the most widely used techniques to complement presence-only data with pseudo-absences (Valavi et al., 2022). The number of background points selected (n = 10,000) was high enough to generate samples in all the environments that are being evaluated in the distribution model (Renner et al., 2015; Hefley & Hooten, 2016; Araújo et al., 2019).

Models were evaluated using different cross-validation (block partitioning, jacknife, and k-fold cross-validation) and thresholding techniques (Pérez-Valladares et al., 2022). For final model selection, the average values of the omission rate (or MTP/10 pct) and Akaike Information Criterion (AICc) were used (Muscarella et al., 2014). We used Akaike criterion to compare models, which allowed us to determine which model best fits the data from our selected set. We used the R Wallace 2.0.5 (Kass et al., 2023) to build and evaluate distribution models. The Wallace interface allows processing, adjusting, evaluating, and visualizing the resulting models from all possible combinations between feature classes, regularization values, and background points. Once the configuration for obtaining the best predictive model was identified, the MaxEnt interface was used for visualization and final evaluation of the data set (Radosavljevic & Anderson, 2014).

In MaxEnt, 50 replicates with 5,000 iterations were used to build the models via cross-validation with 100,000 background points. Model evaluation employed the area under the curve (AUC) derived from the ROC curve. AUC is a widely used metric for assessing a model's ability to discriminate between suitable and unsuitable habitat. It ranges from 0.5 (indicating poor performance) to 1.0 (indicating excellent performance) (Phillips et al., 2006). The cloglog output was chosen to generate a raster model with values between 0 and 1. Following previous studies in South America (García et al., 2012; Wallace et al., 2012; Guzman et al., 2023), the final raster was reclassified into five categories: unsuitability (UNAR, 0 – 0.14), low suitability (LSAR, 0.14 – 0.30), intermediate suitability (ISAR, 0.30 – 0.50), high suitability (HSAR, 0.50 – 0.75), and very high suitability (VHSAR, 0.75 – 1.0). The final maps and figures were built using ArcGIS 10.8.2.

Population surveys and data collection

Between 2021 and 2022, 30 transects (22 aquatic and 8 terrestrial) were surveyed during the dry, wet, and transition seasons (dry-wet, wet-dry). The methodology proposed by Groenendijk et al. (2005) was used and adjusted for each site. The length of the transects varied between 3 and 24 km, depending on the time of year, water body length, and accessibility. Transects were conducted by two mammalogists and a local guide in a non-motorized canoe at a speed of 3 - 5 km/h. Transects were conducted between 7:00h and 17:30h during 10 effective sampling days for each weather station.

Terrestrial transects were conducted during two or three stops made during the aquatic transects, in areas where burrows and latrines had previously been recorded along both streams. Transects ranged in length from 0.5 to 1 km. Direct observations and giant otter signs such as footprints, latrines, and dens were registered along with coordinates, date, time, habitat description, and photographs of each record. During these direct observation events, the total number of individuals observed, group composition, activity, and behavioral reactions to the observer were recorded. Relative abundance was calculated as the number of observed individuals divided by the distance covered during each season and the total distance monitored. The groups were photographed and filmed during the encounter using a Sony Alpha 52 camera with a 300 mm lens. The obtained footage was edited, corrected, and cropped to draw sketches of the distinctive throat marks of each individual for identification purposes. The sketches were made using the 'Sketchbook' application, which allows drawing on photographs and generating images in .jpeg format for further use. Individuals were identified by their gular spots, head shape, and ears.

The extreme unimodal climatic regime of the Orinoquia allowed us to divide the groups into different seasons. Giant otters recorded between May and October correspond to records during the rainy season, and those recorded between November and April correspond to records during the dry season. Transitional periods were defined as the beginning (last 10 days of April) and end (last 10 days of October) of the rainy season. In addition, in each season, the family groups were divided according to the individualization and identification of the dominant pair. In this way, it was possible to monitor the groups between seasons to determine and record temporal changes in group composition.

Results

Distribution and habitat suitability in Tauramena and Casanare

The models obtained were selected according to their high explanatory power and low dimensionality (number of covariates). The best model had the feature classes LQHP with regularization

Table 2. Relative abundance of each group of giant otters that were identified during the survey through the climatic seasons: dry (D), dry-wet transition (D-W), wet (W), and wet-dry transition (W-D).

Group	Inds (n)	D	D-W	W	W-D
Topochas	6	6	-	-	-
Mataoscura	7	7	-	-	-
Piñalito(1)	5	2	4	2	-
Piñalito(2)	6	-	6	-	4
Piñalito(3)	3	-	3	-	3
Total	27	15	13	2	7
Abundance (ind./km)	1.03	0.57	0.49	0.08	0.27

parameters of 5 (AUCTEST = 0.94, AUCDIFF = 0.036, ORMTP = 0.02, ΔAIC = 0) and feature classes LQ with regularization parameters of 3.5 (AUCTEST = 0.94, AUCDIFF = 0.032, ORMTP = 0.02, ΔAIC = 0.18). Model evaluation metrics indicated good discriminatory ability, low overfitting, and low omission rates. Therefore, these models likely provide a reliable representation of the distribution and habitat suitability for giant otters in Casanare. The selected distribution model was visually inspected based on ground-knowledge of the study area. There was good agreement between predicted general patterns and the observed distribution of giant otters; areas that present high levels of transformation and areas where otters have not been recorded in the last decade coincide with areas of low habitat suitability. According to the permutation contribution, Mean Temperature of Driest Quarter (29.4%), Precipitation of Coldest Quarter (21.8%), and Precipitation Seasonality (16.4%) were the most important predictor variables in the final model (Table 1).

According to the model, very high suitability areas (VHSAR) correspond to the Casanare, Ariporo, and Cravo Norte River basins in the north of the department (Fig. 2). These areas have forest ecosystems in a good conservation state, as anthropic activities are not very pronounced. VHSAR are also found in the basins of the Upía, Tua, Cusiana, Unete, and Charte rivers in the south of the department. Anthropogenic pressures are mainly related to oil extraction and the expansion of monocultures (*e.g.*, rice). In contrast, unsuitability areas (UNAR) correspond to the middle basin of the Meta River that divides the departments of Casanare and Vichada. These areas correspond to the Maremare, Duya, Yunaque, and Guanapalo streams that present a high anthropogenic pressure (*i.e.*, extensive rice crops) in their riparian forests.

Population relative abundance

The study area has a total length of 26.28 linear kilometers, which includes the Tua River, Piñalito and El Huesero streams, and La Ciega Lagoon. Of the water bodies sampled, the only one that did not have any signs of giant otter was the Tua River. Each area was sampled repeatedly during each season, giving a total sampling effort of 330.17 kilometers. In total, 27 individuals were observed, integrating five family groups, which represents a group size average of 4.83 ± SD 3.16 individuals per group (2 to 9 individuals per group) and a relative abundance of 1.03 ind./km.

Of the 27 individuals observed, 22 could be identified from the sketches of the distinctive throat marks. The groups were divided into Topochas and Mataoscura groups corresponding to the dry season, and Piñalito 1 - 3 corresponding to the transition between the dry and wet seasons and resampled during the wet and wet-dry seasons (Table 2). In addition, a total of 42.29 km of terrestrial transects were sampled, recording four burrows, two latrines, two feeding sites, and eight tracks. According to the local human communities, burrows are reused during the dry season.

Discussion

Potential distribution and habitat suitability analysis confirm the significance of precipitation patterns and forest in giant otter occurrence, as reported in previous studies in Brazil, Bolivia, and Peru (Lima et al., 2012; Ayala et al., 2015; Caballero et al., 2015; Tomas et al., 2015; Flores Ponce et al., 2017; Mendoza et al., 2017; Noonan et al., 2017; Schiaffini, 2022). Although much of the territory is highly suitable for giant otters, they tend to avoid foothills and the central area of Casanare due to the high deforestation rates as a consequence of monoculture expansion. In contrast, the northern part of Casanare (Paz de Ariporo and Hato Corozal) has areas with high habitat suitability, mainly gallery, riparian, and dense forests associated with the Casanare and Ariporo rivers. The southern part of the department has areas with high suitability values, although it faces greater anthropogenic pressures due to agricultural expansion and oil extraction, negatively impacting water bodies (Orjuela & Castaño, 2019). Despite this, the constant presence of the giant otter in these mixed landscapes could be advantageous in terms of conservation. Giant otters' ability to persist in mixed landscapes indicates some resilience to human disturbances. This resilience suggests that, with proper management and conservation efforts, there may be opportunities to mitigate the negative impacts of human activities on their habitats. On the other hand, their presence can contribute to maintaining or restoring habitat connectivity. By utilizing both natural and modified habitats, giant otters may help in preserving corridors for other wildlife species, enhancing overall biodiversity conservation.

Giant otters displayed a preference for streams, lagoons, and 'madre viejas' (a wetland ecosystem characterized by its separation from, though not necessarily isolation from, the rivers that originally formed it), avoiding rivers that are subject to constant anthropogenic intervention, such as the Tua River. The Tua River has suffered various diversions as a result of agricultural and extractive activities (*i.e.*, oil palm and oil extraction) that are expanding rapidly. These activities have caused heavy flooding throughout the river basin. Additionally, as part of the agricultural and livestock expansion, approximately 80% of the forest cover that surrounded the Tua River has been deforested and fragmented (Orjuela & Castaño, 2019). This has led to a loss of habitat and resources for giant otters. On the contrary, in streams such as the Piñalito and El Huesero, gallery forests have been conserved in a large part of their channel. This has provided key resources for giant otters, such as food, shelter, and breeding sites.

Table 3. Compilation of studies that estimated the relative abundance of the giant otter (*Pteronura brasiliensis*) in South America, since 2000. Additional information is provided on the type of habitat, number of family groups, and registered and individualized individuals.

Author	Country	Habitat	km	Groups/Inds	Ind./km	ID ind.
Fraser et al. (1993)	Bolivia	River	293		0.20	
Painter et al. (1994)	Bolivia	River	168		0.26	
Botello (2000)	Colombia	River	30		0.8	
Van Damme et al. (2002)	Bolivia	River		21/76		
Ayala & Wallace (2009)	Bolivia	River, Stream	168.4	10/30	0.18	10
Suárez (2010)	Colombia	Rivers	217	-	0.17	-
Zambrana et al. (2012)	Bolivia	Rivers		13/57 1/3	0.31	38
Armas & Padilla (2010)	Colombia	Stream	39	-	0.17	-
Lima et al. (2014b)	Brazil	Streams	18.181	12/771	0.09	30
Ayala et al. (2015)	Bolivia	River, Stream	1318.6	-/271	0.02-0.18	109
Tomas et al. (2015)	Brazil	River, Stream	383		0.30, 0.74, 1.00	
Mendoza et al. (2017)	Peru	Rivers	179.94 113.04 309.25 116.32	22/128	2.2 1.43 0.5 0.43	- - - -
Flores Ponce et al. (2017)	Peru	Rivers	89.6 68.7	-/42	0.29	-
Pimenta et al. (2018b)	Brazil	Lakes, Streams	97.3	-	-	-
Garrote et al. (2021)	Colombia	Rivers	38.87	6/30	0.17	30
This study	Colombia	River, Stream	251.6	5/27	1.03	22

Giant otter relative abundances in Tauramena are similar to those reported in Brazil (1.00 ind./km) (Tomas et al., 2015) and Peru (1.43 ind./km) (Mendoza et al., 2017), and represent the highest reported for Colombia (Garrote et al., 2021) (Table 3). These otters had been considered locally extinct for over 15 years as a consequence of the fur trade, but they have shown signs of recovery in the last six years. With maintained environmental conditions and reduced anthropic pressures, we expect their populations to grow in the next decade as it has occurred in other zones along their distribution range (Recharte Uscamaita & Bodmer, 2010; Lima et al., 2014b; Pimenta, et al., 2018b).

Different changes were observed throughout the monitoring project, mainly in aspects related to family groups composition. During the dry season and the dry-wet transition, the number of individuals in each group varied between 3 and 5 at the time of the sightings. According to the local human communities, giant otters may be forming a larger group (between 10 and 15 individuals) during the dry season. For example, groups of between 12 and 15 individuals have been observed repeatedly together in the Piñalito Stream. These cohesive groups may form more prominently during periods of lower food availability to enhance foraging efficiency and thus increase the chances of cub survival (Duplaix, 1980; Duplaix et al. 2015; Leuchtenberger et al. 2015). Despite low food resource availability, refuge accessibility increases within the gallery and riparian forests where individuals establish burrows, latrines, and resting sites.

The initial observation of the giant otters was reported as part of the Topochas' group during the dry season, when six individuals were recorded in the upper basin of the Piñalito stream. Two of the identified individuals in the Topochas' group were subsequently observed during a different dry season in the same area as the seven individuals belonging to the Mataoscura's group. The transition to the wet season was characterized by an increase in the frequency of documented occurrences in which Piñalito(2) and Piñalito(3) groups were observed in independent encounters within the lower basin of the Piñalito Stream, with a total of six and three individual specimens, respectively. Notably, Piñalito(2) was recorded with two young cubs. Additionally, Piñalito(1) was also observed during the same monitoring period with four members of the family within the middle basin of the stream. In contrast, the lowest number of observed events occurred during the wet season and were identified as two members of the Piñalito(1) in the upper basin of Piñalito Stream and one cub accompanied by an adult in the basin of Huesero Stream. The transition back to the dry season was defined by the identification of Piñalito(2) with four members and Piñalito(3) with the three consistent members in the lower basin of the stream. Giant otter sightings are more frequent during the dry season when fish resources are concentrated in permanent water bodies, as has been previously reported in Brazil, Ecuador, and Peru (Lima et al., 2012; Groenendijk et al., 2014; de Oliveira et al., 2015; Pacca et al., 2016). This behavior facilitates the documentation of group

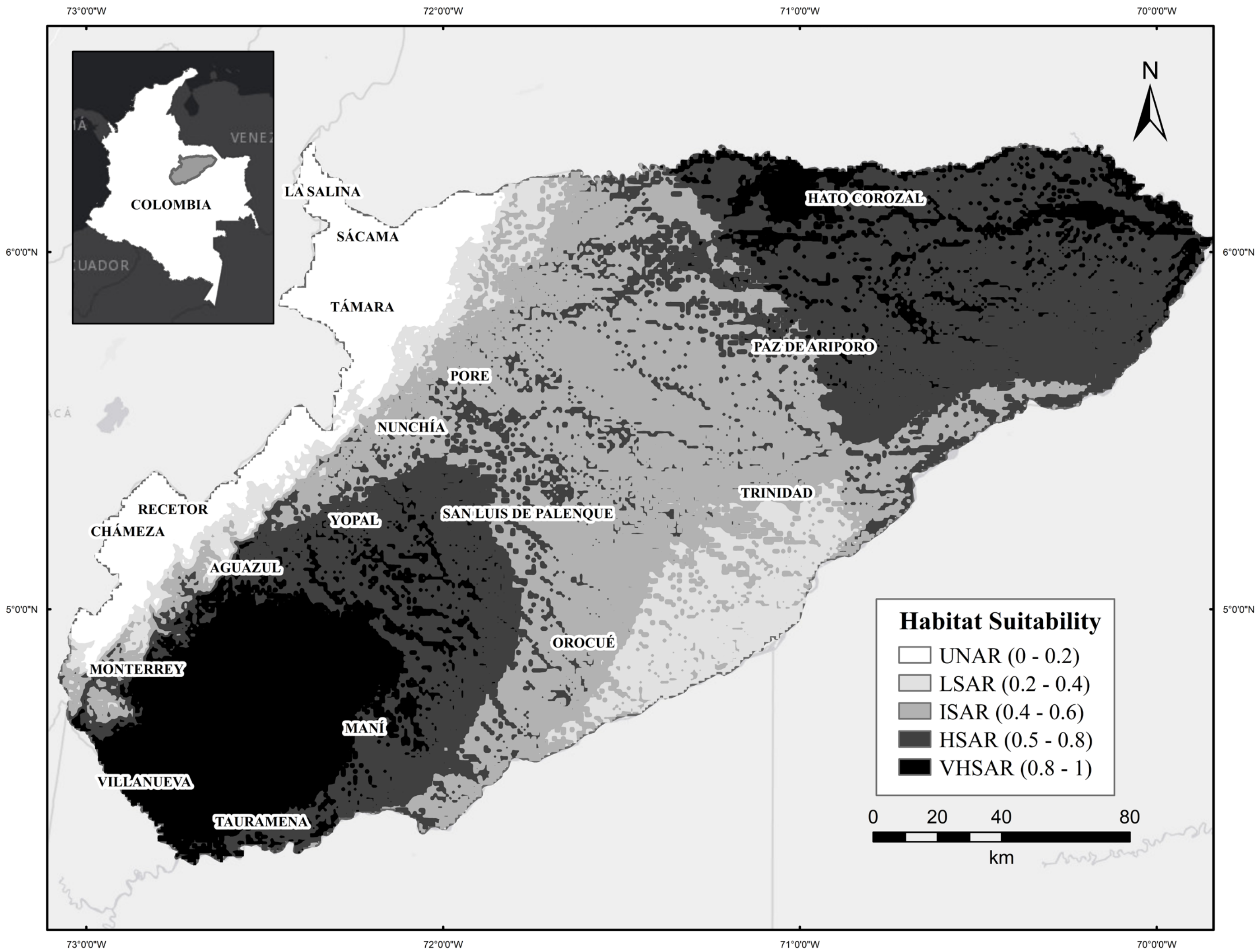

Figure 2. Habitat suitability map for the giant otter in Casanare, Colombia. Unsuitability Area (UNAR), Low Suitability Area (LSAR), Intermediate Suitability Area (ISAR), High Suitability Area (HSAR), and Very High Suitability Area (VHSAR).

composition, sex determination, and generating behavioral catalogs. In addition, it may also affect the species detectability and occurrence data. The survival of individuals is threatened by retaliatory hunting, often in response to negative interactions with fisheries (Leuchtenberger et al., 2020). Since groups exhibit strong territorial fidelity and individuals tend to concentrate in specific areas (Leuchtenberger et al., 2015), targeted killings can be more effective. Unfortunately, such events have been occurring in recent years in the area, with some local community members blaming giant otters for depleting fishing resources. This conflict is consistent throughout the distribution range of the giant otter in South America (Rosas-Ribeiro et al., 2012; Leuchtenberger et al., 2020; Cook et al., 2022; Recharte et al., 2024).

During the wet season and wet-dry transition period, the composition of the giant otter population changes considerably. Water levels are noticeably high, which increases resource availability and disperses the population more than during the dry season (Leuchtenberger et al., 2013). In the study area, gallery and riparian forests are subject to heavy flooding, reaching depths of up to seven meters in some sectors. This forces individuals to move extensive distances in search of refuge, as high areas are scarce and burrow establishment becomes a limiting factor (de Oliveira et al., 2015; Schiaffini, 2022). Therefore, the probabilities of sighting individuals, finding tracks, burrows, and latrines are considerably low, and greater sampling efforts would need to be employed.

Even though giant otters are returning to Tauramena, they are facing threats like deforestation, crude oil contamination of water bodies, and retaliatory hunting. Deforestation events have been observed in some stream areas, and crude oil accumulation has been noted at the lower part of the Piñalito at the mouth of the Tua River. High amounts of solid waste accumulate in the zone between the Piñalito and El Huesero. Retaliatory hunting has increased as giant otter populations have grown in recent years due to potential competition for fishing resources (Lima et al., 2014a; de Oliveira et al., 2015).

In these socio-economically complex areas, the implementation of conservation strategies is crucial. One strategy is environmental education, which aims to change the way local communities view giant otters in order to reduce human-wildlife conflict. Education initiatives should focus on raising awareness of the ecological role of the species, while also addressing any misconceptions. Gathering primary information on giant otter diet, behavior, and population structure is essential to develop evidence-based management plans. This research could inform actions such as habitat restoration, the establishment of protected areas, or guidelines for sustainable land use practices that take into account the ecological needs of otters.

In addition, promoting economic alternatives such as well-regulated ecotourism can provide local communities with financial incentives to participate in conservation efforts. Ecotourism programs should be developed in collaboration with local stakeholders to ensure that they are sustainable and culturally appropriate. In addition, participatory community monitoring programs could empower local residents to become directly involved in the long-term tracking of giant otter populations, thereby fostering a sense of ownership and stewardship over the conservation process.

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