

Potential distribution and current records of Neotropical otter (*Lontra annectens*) in central Mexico

BEATRIZ MORALES-GONZÁLEZ¹, CUAUHTÉMOC CHÁVEZ^{2*}, ENRIQUE MARTÍNEZ-MEYER³, AND JUAN PABLO GALLO-REYNOSO⁴

¹Doctorado en Ciencias Biológicas y de la Salud, Universidad Autónoma Metropolitana, México. Email: bea.mrlsg@gmail.com (BM-G).

²Departamento de Ciencias Ambientales, División de Ciencias Biológicas y de la Salud. Universidad Autónoma Metropolitana, Unidad Lerma. Av. De las Garzas 10, El Panteón. C. P. 52005, Lerma de Villada. Estado de México, México. (CC).

³Instituto de Biología, Universidad Nacional Autónoma de México. Tercer Circuito, S/N Ciudad Universitaria Coyoacán, CDMX, C.P. 04510. E-mail: emm@ib.unam.mx, (EM-M).

⁴Centro de Investigación en Alimentación y Desarrollo A. C., Unidad Guaymas. Carretera al Varadero Nacional km 6.6, Las Playitas, C. P. 85480, Guaymas. Sonora, México. E-mail: jpgallo@ciad.mx, (JPG-R).

*Corresponding author: j.chavez@correo.ler.uam.mx

The distribution of the Neotropical otter (*Lontra annectens*), recently recognized as a separate species after its taxonomic separation from *Lontra longicaudis annectens*, in central Mexico is poorly known. This study aimed to update its distribution in the State of Mexico using a potential distribution model and field validation to identify priority areas for conservation. The model was generated with the *kuenm* package in R, incorporating topographical, climatic, and ecological variables. The presence of the species was verified at nine model-predicted sites based on interviews and field trips carried out between April 2024 and March 2025, including expeditions in rivers in the municipality of Temascaltepec. The model predicted an approximate potential distribution of 5300 km of suitable water bodies, representing only a fraction of the state territory. Field validation confirmed the presence of the species in the Telpintla, Grande, and Chilero rivers and documented the Vado River, Temascaltepec, for the first time. Additionally, interviews confirmed its presence in Malinalco and adjacent areas. These findings update the distribution of *L. annectens* in the State of Mexico and identify areas with high ecological suitability that should be prioritized for its conservation.

Keywords: State of Mexico, indirect evidence, distribution models, new records, Temascaltepec.

La distribución de la nutria neotropical (*Lontra annectens*), recientemente reconocida como especie independiente tras su separación taxonómica de *Lontra longicaudis annectens*, es poco conocida en el centro de México. Este estudio tuvo como objetivo actualizar su distribución en el Estado de México mediante un modelo de distribución potencial y su validación en campo, con el fin de identificar áreas prioritarias para la conservación. El modelo se generó con el paquete *kuenm* en R, utilizando variables topográficas, climáticas y ecológicas. La presencia de la especie se verificó en nueve sitios predichos por el modelo a partir de entrevistas y recorridos de campo realizados entre abril de 2024 y marzo de 2025, incluyendo exploraciones en ríos del municipio de Temascaltepec. El modelo predijo una distribución potencial aproximada de 5,300 km de cuerpos de agua adecuados, lo que representa solo una fracción del territorio estatal. La validación en campo confirmó la presencia de la especie en los ríos Telpintla, Grande y Chilero, y registró por primera vez el río Vado, Temascaltepec. Adicionalmente, las entrevistas corroboraron su presencia en Malinalco y áreas cercanas. Estos resultados permiten actualizar la distribución de *L. annectens* en el Estado de México e identifican zonas con alta idoneidad ecológica que deben considerarse prioritarias para su conservación.

Palabras clave: Estado de México, evidencias indirectas, modelos de distribución, nuevos registros, Temascaltepec.

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Otters are regarded as of great ecological importance because they are top predators in aquatic ecosystems and are sensitive to drastic environmental changes (Gómez-Nísino 2006; Sánchez et al. 2007; Monroy-Vilchis and Mundo 2009; Ramos-Rosas et al. 2012). The Neotropical otter, also known as “water dog”, has recently been recognized as a separate species. Recent analyses of nuclear genome data have revealed a marked genetic separation between trans-Andean Neotropical otters, *Lontra annectens* (Mayor 1897), and the other cis-Andean otters (de Ferran et al. 2024).

In Mexico, this species thrives in various aquatic ecosystems, including rivers, streams, lagoons, lakes, mangroves, and reservoirs. It shows a wide and varied geographical distribution, ranging from sea level in the

Pacific and Gulf of Mexico coasts and mangrove areas, to altitudes above 1000 m a.s.l. in the Mexican plateau, parts of the Trans-Mexican Volcanic Belt and Sierra Madre del Sur, as well as in mountainous areas and upper river basins in the states of Oaxaca, Chiapas, Puebla, Veracruz (Gallo-Reynoso 1989; 1997), Sonora and Chihuahua (Gallo-Reynoso et al. 2019).

Despite its broad distribution and its status as a bioindicator species (Gómez-Nísino 2006; Sánchez et al. 2007; Monroy-Vilchis and Mundo 2009; Arellano Nicolás et al. 2012), the Neotropical otter faces various threats that have adversely impacted its populations and distribution in some regions of Mexico. The main threats include pollution of rivers and lakes, deforestation, habitat degradation,

poaching, and infrastructure development such as river canals and hydroelectric facilities (Gallo-Reynoso *en Chehébar* 1990; Gallo-Reynoso 1997; Rheingantz *et al.* 2017; 2021). In general, the threats facing *Lontra longicaudis* have been identified. However, given its reassignment to *Lontra annectens*, these have not yet been fully determined, making it necessary to characterize these threats, its potential distribution, and its state of conservation. The International Union for Conservation of Nature (IUCN) has listed this species as “Near Threatened” and reports a decreasing population trend (Rheingantz *et al.* 2021). In Mexico, it is listed as endangered in the short to mid term under the Mexican Standard NOM-059-SEMARNAT-2010 (DOF 2019).

The geographical distribution of the Neotropical otter proposed by the IUCN does not include the central region of Mexico. However, the presence of this species in the State of Mexico was documented in 1576, when the hunting of a “water dog” was recorded in the Santa Cruz Coacalco Lagoon (Gallo-Reynoso 1989). Later, in 1981, the species was recorded in Malinaltenango (Gallo-Reynoso 1989). In the southern area of the State of Mexico, its presence was documented in rivers and streams in Villa Guerrero, Santo Tomás, Temascaltepec, Zacazonapan, and Bejucos through indirect evidence, including tracks, feeders, and interviews with inhabitants and fishers in the region (Gallo-Reynoso 1989). Then, the presence of the species in the municipality of Temascaltepec was confirmed in 1998 (Brito-Cruz *et al.* 1998).

The latest records of the species in the State of Mexico correspond to the Temascaltepec region (Simón-Martínez 2003; Monroy-Vilchis and Mundo 2009; Guerrero-Flores *et al.* 2013). However, this area, like many others in the state, is undergoing an accelerated landscape transformation associated with the expansion of agriculture and livestock raising (SEMARNAT 2016), which has transformed the riparian ecosystems and reduced the availability of shelters and resources, jeopardizing the quality and availability of suitable habitats for the species (Gallo-Reynoso 1997).

In Michoacán, there are confirmed records of otter in the Balsas River basin, particularly in areas with clean rivers and well-conserved riparian vegetation, as well as in mountainous regions of the eastern part of the state and the Pacific coast (Monterrubio-Rico and Charre-Medellín 2014). Similarly, its presence has been documented in the Sierra Norte de Puebla (Ramírez-Bravo 2010) and the Huasteca Hidalguense (Aguilar-López *et al.* 2015; Hernández-Silva *et al.* 2024), where aquatic systems remain well preserved. In contrast, there are no recent records from Tlaxcala and Morelos, although its presence has been inferred from basin connectivity with adjacent regions, such as Puebla and the State of Mexico (Sierra-Huelsz and Vargas-Contreras 2002).

At the local scale, the use of species distribution models has been instrumental in identifying areas with optimal conditions for reintroducing locally extinct species or for establishing new protected areas (Guisan and Simmermann

2000). These models enable the integration of ecological information into the design of conservation strategies based on scientific evidence (Franklin and Miller 2010). Additionally, these models can be useful for anticipating areas at risk of invasion or conflict between humans and wildlife (Peterson *et al.* 2011).

As information on the distribution and state of the habitat of this species in central Mexico is scarce and outdated, the main objective of this study was to produce a potential distribution model for the Neotropical otter in the State of Mexico, supplemented with verification field work to determine its presence and distribution, aiming to identify the most suitable areas for conservation. This research not only contributes to the preservation of an emblematic species but also supports the conservation of aquatic biodiversity by providing a scientific basis for decision-making in environmental policy and education.

Materials and methods

Study area. The State of Mexico, located in the central region of the country, covers 22 351 km² (Figure 1). It is part of the Trans-Mexican Volcanic Belt, characterized by mountainous areas, valleys, and riparian and lake basins with elevations ranging from 300 m to more than 4600 m a.s.l. at the highest peak of the state, Nevado de Toluca (INEGI 2020). The regional climate is temperate-subhumid and cold in the mountains and warm-subhumid in the southern region. The mean annual temperature ranges from 12 °C to 22 °C. Annual precipitation ranges from 600 to 1500 mm, with most falling from May to October (CONABIO 2008). The predominant vegetation types are fir forest, mountain cloud forest, pine forest, pine-oak forest, oak forest, oak-pine forest, low deciduous forest patches, and induced grassland (CONABIO 2011).

The state is located in the “Lerma-Chapala-Santiago” hydrological basin in the central-western zone, which encompasses approximately 2900 km of rivers and streams (CAEM 2023). The Lerma River, its main tributary, is heavily polluted as it flows through the Toluca Valley industrial zone (Carreño de León *et al.* 2018). The “Alto Pánuco” area — the driest in the state — is located in the north, with annual precipitation below 600 mm, creating semiarid conditions (CAEM 2023). In contrast, the southern region comprises the Balsas River basin, where high precipitation and local topography result in approximately 230 interconnected rivers and streams totaling more than 5300 km (CAEM 2023), which can be key to the presence of otters. The Temascaltepec sub-basin originates at the peak of Nevado de Toluca, at 4595 m a.s.l. The stream flows to 800 m a.s.l. before reaching the Tingambato Hydroelectric Power Plant, in the state of Michoacán. It then joins the Tilostoc River, a tributary of the Cutzamala River, which, farther down, joins the Balsas River. The Temascaltepec River is the main watercourse in the region and plays a key role in aquatic connectivity and habitat availability for otters (Manzo Delgado and López García 1997).

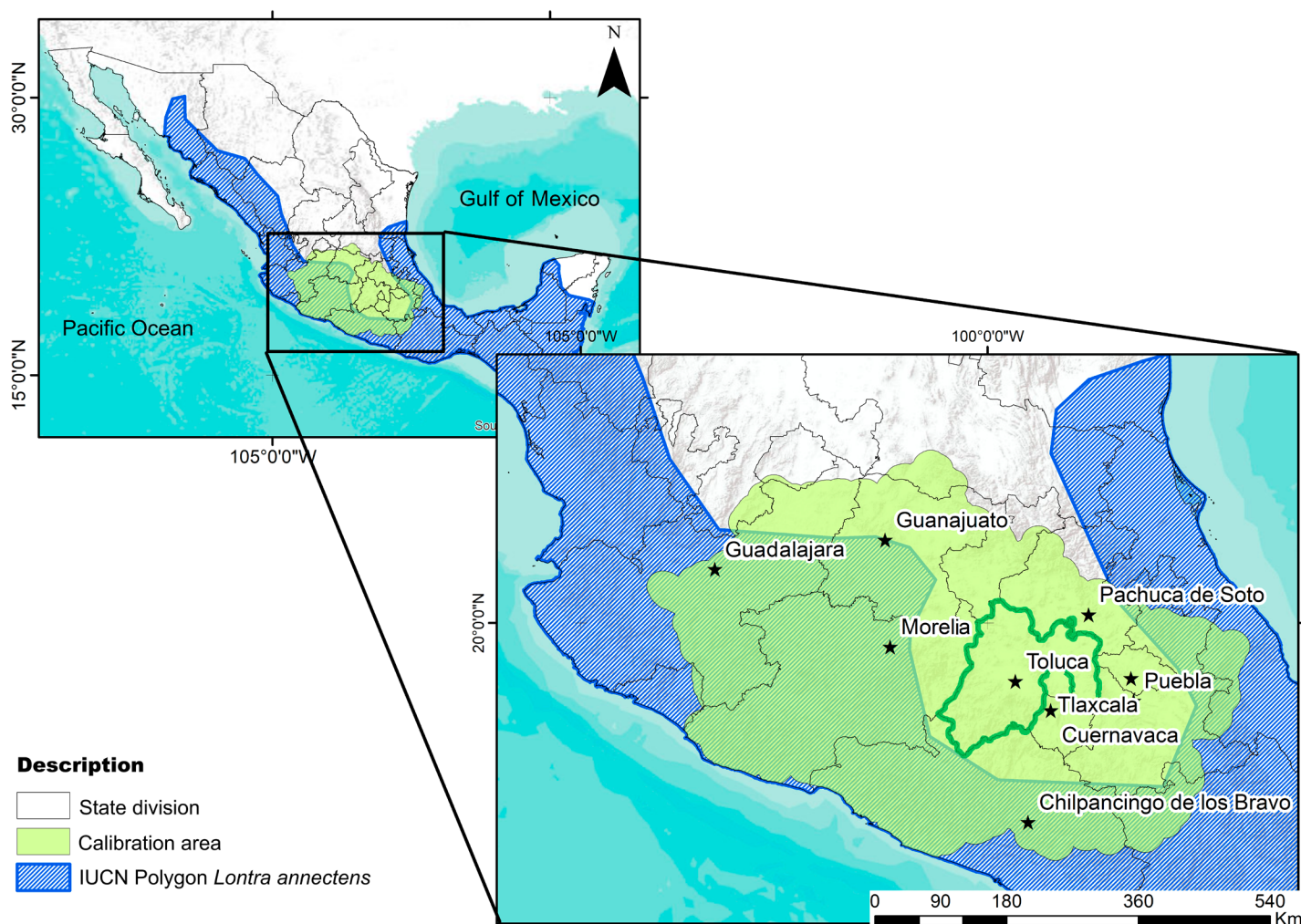


Figure 1. Study area showing the historical accessibility hypothesis (M area) delimited in green and its intersection with the distribution polygon proposed by IUCN for *Lontra annectens*. The State of Mexico is highlighted.

There are 84 protected natural areas of various categories, including the Nevado de Toluca Flora and Fauna Protection area; the Valle de Bravo-Tilostoc-Temascaltepec Basin Natural Resources Protection Area; and the Sierra de Nanchititla State Flora and Fauna Protection Area (CEPANAF 2023). These regions can play a fundamental role in Neotropical otter conservation by providing more stable environmental conditions and low anthropogenic disturbance, being an object of spatial evaluation and interpretation of results in distribution models (CONABIO 2023), in addition to supplying water to nearby communities and the Cutzamala System of Mexico City.

Potential distribution map. A calibration area was delimited based on the map of terrestrial ecoregions of Mexico (SD1, INEGI-CONABIO-INE 2008), focused on the central region of the country. This area represents the historical accessibility hypothesis for the Neotropical otter, known as the M area within the conceptual framework of the BAM diagram (Figure 1; Soberón et al. 2017).

We conducted a comprehensive literature survey and review of records of *L. annectens* for Mexico, particularly in the State of Mexico and neighboring states, considering the calibration area (Figure 1; SD2). We considered records

for the period 1987–2024, which corresponds to the time interval used for constructing the environmental variables, to ensure that the model adequately reflects the ecological conditions of the species and avoid bias when estimating its potential distribution (Araújo and Peterson 2012).

Records lacking explicit geographic coordinates were georeferenced using the localities described in the original sources that included information on the municipality, the locality, or proximity to a water body. To this end, we used topographic maps at a 1:250 000 scale. To minimize spatial bias and avoid overfitting in areas with higher sampling effort, duplicate records were excluded using a 1 km spatial filter between points, implemented with the spThin package in R (Aiello-Lammens et al. 2015). This distance was considered adequate, given the spatial resolution of the environmental layers used. This process yielded 105 presence records, which were randomly divided into two subsets: 70% for calibration (74 records) and 30% for evaluation (31 records).

Topographic, climatic, and ecological variables were examined based on ecological factors relevant to Neotropical otters (Table 1). These layers were either included or excluded from the variance inflation factor (VIF)

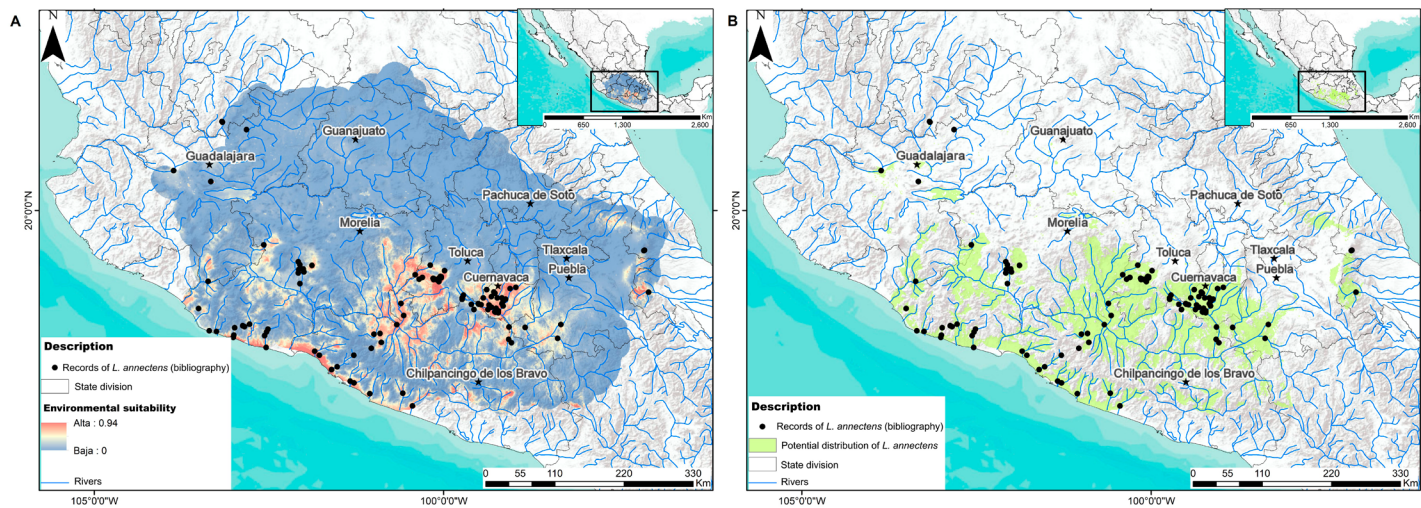


Figure 2. Potential distribution of *Lontra annectens* in central Mexico, showing the literature records obtained and the predicted suitable areas. Each record in the map represents a sampling locality. a) Continuous model; b) binary model.

to reduce collinearity between environmental variables. This process enabled the identification of highly correlated variables that may be redundant in explaining the distribution of the species (Aiello-Lammens *et al.* 2015). VIF values were calculated considering a VIF exclusion threshold >10. Variables that exceeded this value were excluded, and only those with low or moderate collinearity (VIF < 10) were selected for the final modeling of the potential distribution (SD3). All environmental variables were standardized to a spatial resolution of 1 km and delineated according to the defined calibration area.

Candidate models were created using the kuenm package in R (Cobos *et al.* 2019). This package implements the MaxEnt algorithm (Phillips *et al.* 2006; Phillips and Dudik 2008), enabling evaluation of various sets of environmental layers across multiple configurations. In Maxent, we explored 10 values of the regularization multiplier (0.2, 0.4, 0.6, 0.8, 1, 1.2, 1.4, 1.6, 1.8, 2) and 31 combinations of features (l, q, p, t, h, lq, lp, lt, lh, qp, qt, qh, pt, ph, th, lqp, lqt, lqh, lpt, lph, lth, qpt, qph, qth, pth, lqpt, lqph, lqth, lpth, qpth, lqpth).

The regularization multiplier controls model complexity by penalizing overfitting; larger values tend to produce more generalized models that are less fitted to the training data, whereas smaller values produce more specific and fitted models (Merow *et al.* 2013; Morales *et al.* 2017). On the other hand, features determine the relationship between potentiality and environmental variables, thereby influencing the flexibility of the model in representing complex distributions and ecological niches (Phillips and Dudik 2008; Elith *et al.* 2011). In this sense, the joint evaluation of both hyperparameters facilitates balancing fit and predictive capacity, thereby increasing the robustness and transferability of the resulting models (Warren and Seifert 2011).

The performance and selection of the best model were evaluated based on the statistical significance of the partial ROC curve (Cobos *et al.* 2019), omission rates (OR),

Table 1. Environmental variables used to model the potential distribution of *Lontra annectens*.

Variables	Source
Topographic variables	
Digital Elevation Model (DEM)	Mexican Elevation Continuum MEC – INEGI (2013)
Slope	EarthEnv (2010)
Climatic variables	
<hurs> Near-surface relative humidity hurs_max / hurs_mean / hurs_min / hurs_range	
<rsds> Downward surface shortwave radiation rsds_max / rsds_mean / rsds_min / rsds_range	
<pet> Potential evapotranspiration pet_max / pet_mean / pet_min / pet_range	
<cmi> Climatic moisture index cmi_max / cmi_mean / cmi_min / cmi_range	
<swb> Site water balance	
<npp> Net potential primary productivity	
Bio 1. Mean annual temperature	
Bio 2. Mean diurnal range	
Bio 3. Isothermality	
Bio 4. Temperature seasonality	
Bio 5. Maximum temperature of the warmest month	
Bio 6. Minimum temperature of the coldest month	
Bio 7. Annual temperature range	
Bio 10. Mean temperature of the warmest quarter	
Bio 11. Mean temperature of the coldest quarter	
Bio 12. Annual precipitation	
Bio 13. Precipitation of the wettest month	
Bio 14. Precipitation of the driest month	
Bio 15. Precipitation seasonality	
Bio 16. Precipitation of the wettest quarter	
Bio 17. Precipitation of the driest quarter	
Ecological variables	
Landsat Normalized Difference Vegetation Index (NDVI)	INEGI (2013)
Landsat Index of Surface Quality Water from Space	INEGI (2013)
Anthropogenic variables	
Ecosystem Integrity Index (EII)	CONABIO (2018)

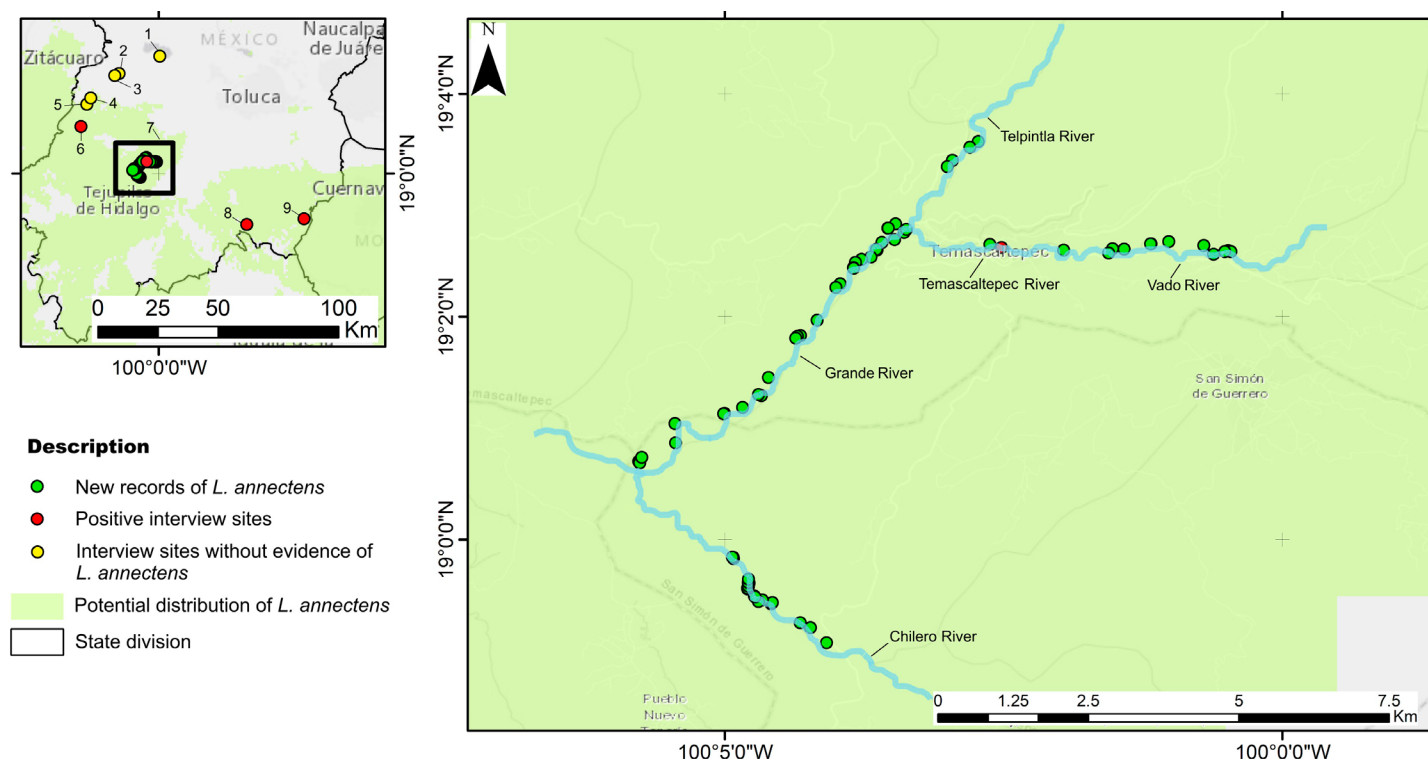


Figure 3. New records of *L. annectens* in the Temascaltepec region and interviews in potential sites in the State of Mexico. Yellow dots mark interviewed localities with no evidence of the presence of otters; red dots indicate sites with confirmed Neotropical otter presence; and green dots are the records obtained during our sampling in the Temascaltepec region. Localities: 1) Villa Victoria; 2) San José Villa de Allende, Villa de Allende; 3) La Peña, Villa de Allende; 4) Parque el Salto Chihuahua, Ixtapan del Oro; 5) Casas Largas tourist corridor, Ixtapan del Oro; 6) Santo Tomás; 7) Temascaltepec; 8) Tonatico y 9) El Platanar, Malinalco. Records: a) spraints in the Vado River, b) feeder in the Chilero River, and c) spraints in the Grande River.

and the Corrected Akaike Information Criterion for small sample sizes (AICc). A 10% omission was considered, and 10 replicates per bootstrap were applied. From the final model, a binary model was generated from the tenth percentile as a cut-off threshold to discriminate between suitable and unsuitable areas for the species. All analyses were performed in ArcMap 10.3 (Esri 2014) in R version 4.2.2 (R Core Team 2018).

Field confirmation of Neotropical otter presence. The presence of otters was confirmed through field interviews and transects. To this end, we selected nine sites based on habitat suitability predicted by the potential distribution model in the State of Mexico. These nine sites were visited during 2024 and 2025 to confirm the presence of *Lontra annectens*. The local inhabitants were interviewed in each site to obtain information about possible sightings or indirect evidence of the species. At each site, records were georeferenced using a GPS receiver (Garmin GPSmap 64s) and fed into a database.

Results

Potential Neotropical otter distribution. A total of 310 candidate models were evaluated, whose parameters reflect all combinations of 10 regularization multiplier configurations, 30 fitting-model combinations, and 15 environmental variables (SD4 and SD5). Of this set, only one model (M_2_F_lp) met the established performance parameters.

The potential distribution area for otters in the calibration region corresponds to 23.97% (Figure 2). Specifically in the State of Mexico, the potential distribution area covers approximately 6162 km². However, considering the semiaquatic behavior of the species, we estimate that the area effectively usable for the Neotropical otter corresponds to nearly 5300 km of water bodies, approximately equivalent to the total length of the rivers running across the state, which represents only a small fraction of the state territory.

According to the potential distribution model, suitable regions for otters include the Temascaltepec sub-basin in

the southwest and the Malinalco region in the southeast of the State of Mexico. In turn, the Temascaltepec sub-basin is part of the “Valle de Bravo, Malacatepec, Tilostoc, and Temascaltepec River Basins” Natural Resource Protection Area (APRN, in Spanish) ([CEPANAF 2023](#)), which includes the municipalities of Amanalco, Donato Guerra, Ixtapan del Oro, Oztoloapan, San Simón de Guerrero, Santo Tomás, Temascaltepec, Valle de Bravo, Villa de Allende, Villa Victoria, and Zinacantepec (Figure 2).

Field confirmation of the presence of the Neotropical otter. In 2024 and 2025, field interviews and field trip were conducted at nine sites to verify the potential distribution model for *Lontra annectens* in the State of Mexico. During fieldwork, the Telpintla, El Vado, Chilero, Temascaltepec, and Grande rivers were sampled by walking along their banks in search of direct and indirect evidence of the species, including sightings, footprints, spraints, and latrines (Figure 3). In other sites, we verified the existence of rivers that showed channel transfer, such as Arroyo Grande, Malacatepec River, and Ixtapan del Oro-Santo Tomás de los Plátanos River, all within the Cutzamala Plan (Figure 3).

We confirmed the presence of the Neotropical otter in the State of Mexico, particularly in the municipality of Temascaltepec (Table 1). We found that the species is preferentially associated with river stretches that maintain good water quality, riparian vegetation coverage, and food availability, even in areas where fish farming is practiced (Table 2).

Table 2. Characteristics of sampled rivers in the Temascaltepec region with evidence of the presence of *Lontra annectens*.

River	Sampling effort (km)	Amount and type of records	Site characteristics	River depth (m)	River width (m)
Chilero	6	12 spraints (scats) and one feeder	Clear water Big rocks Presence of pools Rugged river channels	0.2–1.1	3–4
Telpintla	3	7 spraints	Narrow and rocky Small rocks Turbid water Scarce pools	0.3	2
Vado	3	10 spraints	Clear water Big rocks Presence of pools Rugged river channels	0.2–0.4	4
Grande	7	7 spraints	Clear water Presence of pools Big rocks Rugged river channels	0.3–0.7	5–10
Temascaltepec*	2	7 spraints and one feeder	Sewage odor Scarce pools Turbid water Scarce water flow Presence of garbage Abundant small rocks	0.3	4

The evaluated sites have favorable conditions for maintaining local subpopulations, including clear water,

riverbank vegetation, rocky substrates that form pools and waterfalls that provide shelter and facilitate movement, and abundant aquatic prey, such as trout (*Oncorhynchus mykiss*), which can sustain local subpopulations. Together, these conditions constitute highly favorable habitats for the establishment and persistence of *L. annectens* in the area (Table 2).

During field trips, we obtained records from previously explored areas in which no evidence of Neotropical otter presence had been found, such as the Vado River (Simón-Martínez 2003). Based on indirect evidence, including interviews, spraints, and feeders, we confirmed the presence of the species in the municipalities of Santo Tomás de los Plátanos, Ixtapan de la Sal, Tonatico, and Temascaltepec, and possible presence in Malinalco and its surroundings. Similarly, we found no evidence of its presence in the area comprising Villa Victoria, Villa de Allende, Donato Guerra, and Ixtapan del Oro (numbers 1, 2, 3, 4; Figure 3).

Discussion

The modeling identified areas that are highly suitable for the presence of the Neotropical otter (*Lontra annectens*) in the State of Mexico and surrounding regions. In addition, field sampling confirmed its presence in places where it had not been previously recorded, such as the Vado River in Temascaltepec or the Platanar region in Malinalco, in addition to areas with historical records such as Malinaltenango, confirming its permanence over time ([Simón-Martínez 2003](#); [Monroy-Vilchis and Mundo 2009](#); [Guererro Flores et al. 2013](#)).

Our results clarify the distribution of the Neotropical otter (*Lontra annectens*) in central Mexico, which had been underestimated by the IUCN ([Rheingantz et al. 2021](#)). The persistence of the species in this region has been questioned due to anthropogenic impact on its habitat ([Gallo-Reynoso 1997](#), [Moreno Barrera et al. 2025](#)). This has led to the omission of documented records in entities such as the State of Mexico and other areas where multiple recent sightings and suitable habitats have been confirmed ([Sierra-Huelz and Vargas-Contreras 2002](#)).

Although progress has been made in understanding the distribution of *Lontra annectens* in Mexico, the studies conducted to date are scarce and geographically limited. These studies have focused on specific regions, such as the Apatlaco-Tembembe basin, in the state of Morelos ([Cirelli Villanova 2005](#)), the Yucatan Peninsula ([Ortega-Padilla et al. 2022](#)), the Huicila River hydrological basin, in Nayarit ([Luna Aranguré 2015](#)), and the state of Michoacán ([Monterrubio-Rico and Charre-Medellín 2014](#)). In these studies, the presence of otters has been associated with variables such as altitude, vegetation type, and hydrological characteristics. The results indicate that the Neotropical otter is present mainly in perennial rivers with habitat continuity and that the protected areas that host the species have limited coverage.

The limited geographic coverage and the lack of comprehensive studies at the regional and national scales

make it difficult to fully understand the distribution and ecology of the species (Gallo-Reynoso 1989; 1997; Gallo-Reynoso and Meiners 2018). Furthermore, fragmentation of aquatic habitats, urbanization, and topography may be leading to basin-differentiated population structure (Guerrero-Flores 2014, Hernández-Romero et al. 2018; Latorre-Cardenas et al. 2021), suggesting that populations in the State of Mexico may be locally genetically isolated (Rivera-Ortiz et al. 2014).

The combination of environmental variables, geographical barriers, and hydrography promotes population divergence in *L. annectens*, with important genetic and morphological implications (Hernández-Romero et al. 2017). Alterations to the natural landscape, such as dam construction and the loss of riparian vegetation, disrupt the dispersal of Neotropical otter populations, reducing genetic connectivity between them (Latorre-Cardenas et al. 2021). Therefore, otters inhabiting the center of the country may be genetically closer to central populations of Oaxaca, Guerrero, Jalisco, or Veracruz than to populations from the northern Pacific or the Atlantic slope (Guerrero et al. 2015).

The absence or scarce presence of otters in the area of the northern State of Mexico adjacent to the state of Hidalgo, as suggested by the potential distribution model, is explained by the lack of suitable perennial aquatic habitats, unfavorable altitude and climate, and environmental degradation of riverbanks essential for Neotropical otter survival (Botero-Botero et al. 2017). Although otters have been recorded in mountainous areas of Mexico and Colombia at altitudes of up to 2000 and 3000 m a.s.l., these populations are very localized and sparse (Andrade-Ponce and Angarita-Sierra 2017; Esparza-Carlos et al. 2022). Otters require perennial rivers with high dissolved oxygen levels and adequate prey availability (Casariego Madorell et al. 2006). On the other hand, mountainous areas of the eastern State of Mexico have cold ecosystems and high altitudes (2500–3000 m a.s.l.), with intermittent or very small waterways that lack dense riparian vegetation required by otters for shelter and food (Lavariega et al. 2020).

In the northern State of Mexico, hydrological systems are characterized by low flows and fragmented waterways, which preclude the establishment of stable Neotropical otter populations (CAEM 2025). In addition, river piping and the Cutzamala plan have eliminated channels through which otters could move (CAEM 2025). Anthropogenic effects such as urbanization, agriculture, and pollution have degraded riverbanks in mountainous volcanic areas, thereby preventing otters from establishing burrows and reducing food availability (Gallo-Reynoso 1997).

The Temascaltepec region, in which the greatest evidence of the presence of otters in the State of Mexico has been reported, still shows adequate riparian vegetation and rivers with permanent water flows that sustain local Neotropical otter populations (Arellano Nicolás et al. 2012). We documented the presence of the Neotropical otter at a new location in the area and confirmed that it occurs in the

Vado River, where no previous evidence had been found (Guerrero-Flores et al. 2013). Furthermore, we confirmed previous records of the species in the Telpintla, Grande, and Chilero rivers (Simón-Martínez 2003; Monroy-Vilchis and Mundo 2009; Guerrero-Flores et al. 2013) 19 years after the last evidence was reported.

The Neotropical otter populations in Temascaltepec live in highly modified environments where their diet consists mainly of trout (*Oncorhynchus mykiss*; Monroy-Vilchis and Mundo 2009), a species introduced to central Mexico, in contrast to less disturbed populations elsewhere in the country. The Amacuzac River, which runs through the state of Morelos, partly derived from the Lerma River and flowing into the Balsas River through its tributary through the Chontalcoatlán River that crosses the Cacahuamilpa Caves, is an important system of basins that could have historically facilitated the mobility of otters; however, they are currently fragmented by dams and human alterations (Arellano Nicolás et al. 2012; González-Christen et al. 2013; Guerrero-Flores et al. 2013; Lavariega et al. 2020).

The potential distribution model identified adequate habitats in localities near Temascaltepec, including Cañadas de Nanchititla, within the Sierra de Nanchititla State Park in the southwestern area of the State of Mexico. This region is covered by natural vegetation and crossed by major waterways suitable for otter populations (CEPANAF 2023). Although these areas have been identified as potentially adequate for the species, field validation is necessary. However, access is limited by the insecure conditions associated with organized crime, a significant obstacle to fieldwork.

The otter population living in the Temascaltepec region may move to, or be linked to, populations in the southern parts of the state, adjacent to Tingambato, Michoacán, due to the flow of waterways, although there are no records of otters in Tingambato (Monterrubio-Rico and Charre-Medellín 2014). Therefore, it is essential to continue the search for *L. annectens* in all rivers and streams that connect with the Temascaltepec River and other main rivers, such as Tilostoc, to determine the mobility or migration of otters across the sub-basin.

The distribution of the Neotropical otter in the State of Mexico and central Mexico is poorly known. Although its presence is mentioned in the list of fauna of the “Valle de Bravo, Malacatepec, Tilostoc and Temascaltepec River Basins” Natural Resources Protection Area, there are no management plans or conservation strategies for the species. In this context, the present study is a valuable contribution to planning the monitoring and conservation of the Neotropical otter in central Mexico, by identifying areas with high ecological suitability that can host undocumented populations.

The results of the present study set the basis for defining priority areas for conservation and shelter determined by the potential distribution model. Monitoring programs must consider environmental variables that affect the presence of the species, such as the pollution of water bodies and the

conservation status of riparian vegetation (Botero-Botero *et al.* 2016; Lavariega *et al.* 2020). Therefore, management and monitoring strategies aimed at protecting *L. annectens* must adopt a comprehensive approach that integrates spatial analysis with detailed ecological and environmental assessments to ensure the effectiveness of long-term conservation actions. Finally, the lack of genetic studies on otters inhabiting the State of Mexico makes it difficult to evaluate connectivity between otter populations, a key factor in understanding the dynamics and viability of the species in this entity.

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Supplementary material

This article contains Supplementary Material or Data Files, which can be downloaded from the journal website.

SD1. Terrestrial ecoregions of Mexico included in the calibration area polygon (M) constructed for *Lontra annectens*.

SD2. States, localities, and rivers with records of Neotropical otter in central Mexico collected for the present study.

SD3. Results of the Variance Inflation Factor (VIF) analysis applied to the environmental variables to minimize the environmental noise in the resulting models.

SD4. Estimates of the relative contributions of environmental variables to the resulting model.

SD5. Performance statistics of candidate models. The final model is highlighted.