THERYA, 2026, Vol. 17(2):307-326 DOI: 10.12933/therya.2026.6273 ISSN 2007-3364

Protected area effectiveness for conserving rodent diversity in the Sierra Madre Oriental under climate change

Diana López-Higareda[1*], Susette Castañeda-Rico[2,3,4], Elisa Paulina Zaragoza-Quintana[5], and Zamira A. Ávila-Valle[6,7,8]

[1]Dirección de Cooperación e Implementación en Biodiversidad, Comisión Nacional para el Conocimiento y Uso de la Biodiversidad, C.P. 14010, Ciudad de México, México.
[2]Smithsonian-Mason School of Conservation, C.P. 22630, Front Royal, Virginia, Estados Unidos.
[3]Center for Conservation Genomics, Smithsonian National Zoo and Conservation Biology Institute, C.P. 20008, Washington DC, Estados Unidos.
[4]College of Science, George Mason University, C.P. 22030, Fairfax, Virgina, Estados Unidos. E-mail: susetteazul@gmail.com, castanedaricos@si.edu (SCR)
[5]Facultad de Ciencias Forestales, Universidad Autónoma de Nuevo León, C.P. 67700, Linares, Nuevo León, México. E-mail: nasuanarik@yahoo.com.mx (EPZQ)
[6]Departamento de Biología, División de Ciencias Biológicas y de la Salud, Universidad Autónoma Metropolitana, Unidad Iztapalapa, C.P. 09340, Ciudad de México, México.
[7]Facultad de Ciencias, Universidad Nacional Autónoma de México, C.P. 04510, Ciudad de México, México.
[8]Carrera de Biología, Facultad de Ciencia y Tecnología, Universidad Simón Bolívar México, C.P. 03920, Ciudad de México, México. E-mail: zamira@xanum.uam.mx, zaav@ciencias.unam.mx (ZAAV)
[*]Corresponding author: d.lopezhigareda@gmail.com

Global biodiversity loss is accelerating, driven by multiple factors, including climate change. Protected areas are a cornerstone of conservation strategies; however, their effectiveness is often constrained by limited climate-resilience planning and taxonomic biases that often overlook ecologically important but non-charismatic groups, such as rodents. We analyzed rodent species richness in the Sierra Madre Oriental, Mexico, evaluating conservation effectiveness within protected areas (which cover 29% of the region) under climate change scenarios. Potential species richness for 85 rodent species was estimated using ensemble species distribution models under current conditions and future climate scenarios (RCP4.5 and RCP8.5) for projections to 2030, 2050, and 2070. Temporal trends in potential species richness were evaluated by Mann-Kendall trend test. Additional comparisons included bioclimatic corridors and functional groups (generalists and specialists). Results suggest that protected areas currently encompass all modeled rodent species in the Sierra Madre Oriental (excluding *Dipodomys spectabilis*, *Geomys personatus* and *Sigmodon mascotensis*), however, they do not fully overlap with areas of highest species richness, which are located in the southern Sierra Madre Oriental. Also, an overall decline in high-richness areas by 2070, particularly under the RCP8.5 scenario, where species losses in some protected areas could reach up to 35 species. Although generalist species exhibit relative stability, an overall decreasing trend in species richness is expected in most protected areas, with significant compositional changes projected for specialist species. Notably, bioclimatic corridors were found to host species currently absent from protected areas and to support the same proportion of species classified as at risk. Implementing climate-smart strategies, such as establishing and reinforcing bioclimatic corridors to improve connectivity, is recommended to mitigate biodiversity loss and enhance conservation resilience in the Sierra Madre Oriental.

Keywords: climate scenarios, conservation planning, Global Biodiversity Framework, Mexico, small mammals, species richness

La pérdida global de biodiversidad se está acelerando debido a factores como el cambio climático. Las áreas protegidas son la piedra angular de las estrategias de conservación, pero su efectividad se ve limitada por una planificación insuficiente de la resiliencia climática y por sesgos taxonómicos que omiten grupos ecológicamente importantes, como los roedores. Analizamos la riqueza de especies de roedores en la Sierra Madre Oriental, México, y evaluamos la conservación de las áreas protegidas (29% de la región) bajo escenarios de cambio climático. Se estimó la riqueza potencial de 86 especies de roedores mediante ensambles de modelos de distribución para condiciones actuales y escenarios climáticos futuros (RCP4.5 y RCP8.5), con proyecciones para 2030, 2050 y 2070. Se utilizó la prueba de tendencia de Mann-Kendall para evaluar tendencias temporales de la riqueza potencial de especies y se realizaron comparaciones entre corredores bioclimáticos y grupos funcionales (generalistas y especialistas). Los resultados sugieren que, si bien actualmente las áreas protegidas albergan casi todas las especies modeladas (salvo *Dipodomys spectabilis, Geomys personatus* y *Sigmodon mascotensis*), no se ubican en las zonas de mayor riqueza, al sur de la región. También hay un declive general en las áreas de alta riqueza para 2070, particularmente bajo el escenario RCP8.5, donde las pérdidas en algunas áreas protegidas podrían alcanzar 35 especies. Mientras las especies generalistas muestran estabilidad, se espera una tendencia decreciente en la mayoría de las áreas protegidas, con cambios composicionales significativos en las especies especialistas. También se encontró que los corredores bioclimáticos albergan especies actualmente ausentes en las áreas protegidas y la misma proporción de especies en riesgo. Es recomendable implementar estrategias climáticamente inteligentes, como establecer corredores bioclimáticos para mejorar la conectividad, mitigar la pérdida de biodiversidad y fortalecer la resiliencia de la conservación en la Sierra Madre Oriental.

Palabras clave: escenarios climáticos, mamíferos pequeños, Marco Mundial de Biodiversidad, México, planeación de la conservación, riqueza de especies

Biodiversity is declining at an unprecedented rate in human history, driven primarily by land-use change, resource extraction, pollution, invasive species, and climate change, which together have severely altered 75% of the Earth's land surface (IPBES 2019). Protected areas (PAs) have long been a cornerstone of global conservation policy, serving as a primary strategy for safeguarding ecosystems and species (PNUD and CONANP 2019). The strategic importance of PAs has reached a new milestone under the Kunming-Montreal Global Biodiversity Framework (KMGBF), adopted in December 2022 following significant progress by the Convention on Biological Diversity (CBD). The KMGBF sets an agenda to halt biodiversity loss and restore ecosystems by 2050 (McGowan *et al.* 2024; Zurrell *et al.* 2025). Its flagship objective, Target 3 (known as "30 × 30"), aims to conserve at least 30% of terrestrial, inland water, and marine areas by 2030 (CBD 2022; Rey *et al.* 2024; Steigerwald *et al.* 2024; Buenafe *et al.* 2025; Hutchinson *et al.* 2025).

Despite global consensus on the urgency of avoiding further biodiversity loss, a substantial implementation gap persists between academic research and policy implementation (Hutchinson *et al.* 2025), underscoring the need to integrate biodiversity conservation objectives with global climate challenges through climate-smart conservation planning (Buenafe *et al.* 2025). An important tool in this process is the use of Species Distribution Models (SDMs) to assess potential climate change impacts. Grounded in niche theory (Hutchinson 1957), these models utilize climate change scenarios (plausible, simplified representations of future conditions) derived from General Circulation Models (GCM) to identify shifting suitable ranges over time (McGowan *et al.* 2024; Rey *et al.* 2024; Buenafe *et al.* 2025; Zurrell *et al.* 2025). This approach highlights the importance of protecting both large-scale climate refugia and localized micro-refuges, and of establishing climate corridors that maintain connectivity between current and future suitable habitats (Buenafe *et al.* 2025).

The success of such modeling and connectivity efforts must also take into account the varying adaptive capacities of species, which are closely linked to their functional diversity. While generalist species with broad niches may adapt to or even benefit from climatic shifts by expanding their geographic ranges, specialists with restricted niches often face drastic range contractions (Bravo-Cadena *et al.* 2011; Munguía *et al.* 2016). These specialists are particularly vulnerable to extinction as their specific environmental requirements disappear or shift beyond their dispersal capabilities. The heightened vulnerability of these specialist taxa underscores the critical shortcomings of current conservation infrastructure.

Despite their importance, the overall effectiveness of current PA networks is often limited. Many PAs fail to adequately include rare species, threatened habitats, and unique evolutionary lineages (Beresford *et al.* 2011; Dinerstein *et al.* 2024; Mouillot *et al.* 2024; Revollo-Cadima and Salazar-Bravo 2024; Pulido-Chadid *et al.* 2025). Furthermore, while more than half of mammal habitats worldwide are highly threatened, PAs are frequently established in areas with low human pressure rather than in regions of high conservation priority, driven by the ease of establishment and management rather than systematic conservation planning (Nori *et al.* 2020; Chacón-Prieto *et al.* 2021; Pulido-Chadid *et al.* 2025). Beyond these representativeness gaps, these areas often remain isolated; the absence of mechanisms to reduce ecosystem fragmentation exacerbates connectivity loss and edge effects, negatively impacting preserved areas (SEMARNAT *et al.* 2025). Consequently, identifying complementary areas to enhance the effectiveness and climate resilience of existing PA networks is strongly recommended (Chacón-Prieto *et al.* 2021; Delso *et al.* 2021). The lack of representativeness is often rooted in the specific criteria used for PA design, particularly a strong taxonomic bias that focuses attention and resources on charismatic megafauna, using them as surrogates for general biodiversity (Urquiza-Haas *et al.* 2019; Steigerwald *et al.* 2024). This bias is especially problematic for small, non-charismatic mammals, even though groups such as rodents are among the most diverse and ecologically important taxa, playing key roles as seed dispersers, prey, and contributors to nutrient cycling (Verde-Arregoitia 2016; Formoso and Teta 2019; Zúñiga *et al.* 2021; Lindsø *et al.* 2025). Alarmingly, more than 25% of globally threatened rodent genera and species are not included within recognized biodiversity hotspots (Amori *et al.* 2011).

Furthermore, while conservation status is often assessed using national-level criteria, the impacts of habitat loss often operate at regional scales, indicating that the scale of analysis can influence estimates of threat intensity (Botello *et al.* 2015; Urquiza-Haas *et al.* 2019). Therefore, the effectiveness of conservation efforts depends on the selection of appropriate surrogates and targets. Addressing gaps in the global PA network and ensuring resilience under climate change, requires conducting regional-level assessments focused on underrepresented indicator groups, such as rodents, to identify critical areas, and inform local conservation planning (Amori *et al.* 2011; Formoso and Teta 2019; Revollo-Cadima and Salazar-Bravo 2024).

Given Mexico's environmental diversity, regional precision is essential for effective conservation, with PAs being the main public policy instrument for biodiversity protection since 1917 (SEMARNAT *et al.* 2025). The National Commission of Natural Protected Areas (CONANP) currently administers 232 federal PAs (192 terrestrial/freshwater) and 609 Voluntary Conservation Areas (ADVC; SEMARNAT *et al.* 2025). However, many PAs, particularly in Central Mexico, do not adequately address critical pressures such as climate and land-use changes. Although approximately 54% of established PAs overlap with top-priority conservation areas, 70% of high-priority areas remain entirely unprotected (Chacón-Prieto *et al.* 2021). Additionally, 78% of Mexico's marine, continental, and terrestrial ecosystems are underrepresented within federal and subnational PA networks, with less than 30%

of each ecosystem's area protected, as suggested by the KMGBF (SEMARNAT *et al.* 2025).

To address these systemic deficiencies, some studies suggest a shift toward species-specific impact assessments conducted at regional scales for anticipating local extinction risks and informing the design of targeted conservation actions (Botello *et al.* 2015; Rodríguez-Ruíz *et al.* 2025). This regional approach is particularly important for the Sierra Madre Oriental (SMO) of Mexico, a volcanic mountain range in the country's east, of exceptional biological importance due to its structural complexity and taxonomic richness, including a high mammalian diversity. The SMO hosts approximately 40% of the country's terrestrial mammals, and near 36% of Mexican rodent species (León-Paniagua *et al.* 2004). Although federal authority PAs in the region have increased by 200% over the past two decades (León-Paniagua *et al.* 2004; SEMARNAT *et al.* 2025), ecosystems and species remain highly vulnerable to the dual pressures of climate change and habitat fragmentation (CONANP and GIZ 2013).

Therefore, the objectives of the present study were: (1) evaluate the richness of rodent species currently represented within PAs relative to the overall richness of the SMO region; and (2) assess how well the PAs would perform to maintain rodent species richness under climate change scenarios.

Materials and methods

Study area. The SMO is the second largest mountain system in Mexico, encompassing the states of Coahuila, Guanajuato, Hidalgo, Nuevo León, Puebla, Querétaro, San Luis Potosí, Tamaulipas and Veracruz; this mountain range, with a wetter eastern side, has an irregular, elongated shape, spanning 800 km in length and varying in width from 80 to 100 km (CONANP and GIZ 2013; Goyenechea Mayer-Goyenechea *et al.* 2025). The three priority ecosystems for the SMO are temperate pine and oak forest, low forest and mesophilic mountain forest (CONANP and GIZ 2013). Given the lack of consensus regarding SMO boundaries, we adopted the mastofaunistic province of the SMO (Ramírez-Pulido and Castro-Campillo 1990) as the regionalization framework for this study (Figure 1), instead of the biogeographical provinces (CONABIO 1997; Morrone 2020), or the ecoregions (INEGI *et al.* 2008). Although biogeographic provinces aim to integrate multiple criteria, they exhibit the same methodological inconsistencies of each of these and do not necessarily constitute natural units (Ruíz-Jiménez *et al.* 2004), particularly for mammals whose patterns of endemism and distribution lack natural coherence within the biogeographic province (Goyenechea Mayer-Goyenechea *et al.* 2025). On the other hand, the mastofaunistic province is explicitly defined based on mammalian species distributions and represents a continuous polygon with simple edges that covers both slopes of the mountain range, delimited by the coordinates -101.7357 W, -97.38466 W, 19.63502 N, 26.53433 N, covering approximately 82,667 km^2 (Ramírez-Pulido and Castro-Campillo 1990).

Data. The occurrence records of 91 rodent species (Table 1) were obtained from the National System of Biodiversity Information (SNIB; CONABIO 2024), following the last accepted taxonomy for each species. The initial national-scale dataset was curated to include only records located within the SMO polygon (Ramírez-Pulido and Castro-Campillo 1990). Selection was restricted to records associated with voucher specimens identified to the species level. After removing fossil records and synonyms, the final curated dataset included 2,767 records.

Species distribution models. We used the cumulative projections of potential species distributions under current and climate change scenarios from Ureta *et al.* (2022), who applied ecological niche modeling to assess species exposure and adaptive capacity to climate change. Their SDMs incorporate two Global Circulation Models (GCMs) and corresponding Shared Socioeconomic Pathways (SSPs): a mid-optimistic representative concentration pathway (RCP) scenario (RCP4.5) and a pessimistic scenario (RCP8.5), for three time horizons (2030, 2050, and 2070). Because climate scenarios represent plausible future pathways rather than climate forecasts, we followed established recommendations to always use more than one GCM, more than one time horizon, and more than one RCP (INECC 2021). These data were selected due to the robustness of the modelling approach (Verde-Arregoitia 2016; Thuiller *et al.* 2019), the consistency of the data source with our occurrence dataset, and their thorough representation of Mexico (Urquiza–Haas *et al.* 2019).

Protected area polygons. The list of PAs was compiled from several sources, including the national authority (CONANP), the National Commission for the Knowledge and Use of Biodiversity (CONABIO), and state authorities. The dataset includes federal and subnational level PAs (state and municipal authorities) as well as ADVC, which are under federal authority but have a distinct legal status (CONABIO 2020; CONANP 2024; Garza-Torres *et al.* 2024). The final list comprised 46 PAs covering 23,838 km2 (Table 2). All PA polygons were merged into a single vector layer for spatial analyses.

Species richness. All analyses were performed in R v.4.5.1 (R Core Team 2021) using *terra* (Hijmans 2023), *sf* (Pebesma and Bivand 2023), and *Kendall* (McLeod 2022) packages. Binary ensembled rasters for each rodent species preliminarily identified for the SMO, were sourced from Ureta *et al.* (2022); these maps were binarized by maximizing the True Skill Statistic (TSS) value. The rasters were then cropped to the study area's extent under all scenarios and cropped to the SMO polygon. All maps used the WGS84 coordinate system.

Potential Species Richness (PSR) was calculated as the cross-species overlap value for rodents in the SMO, obtained by summing the cropped binary ensemble models (current potential distribution and under all climate change

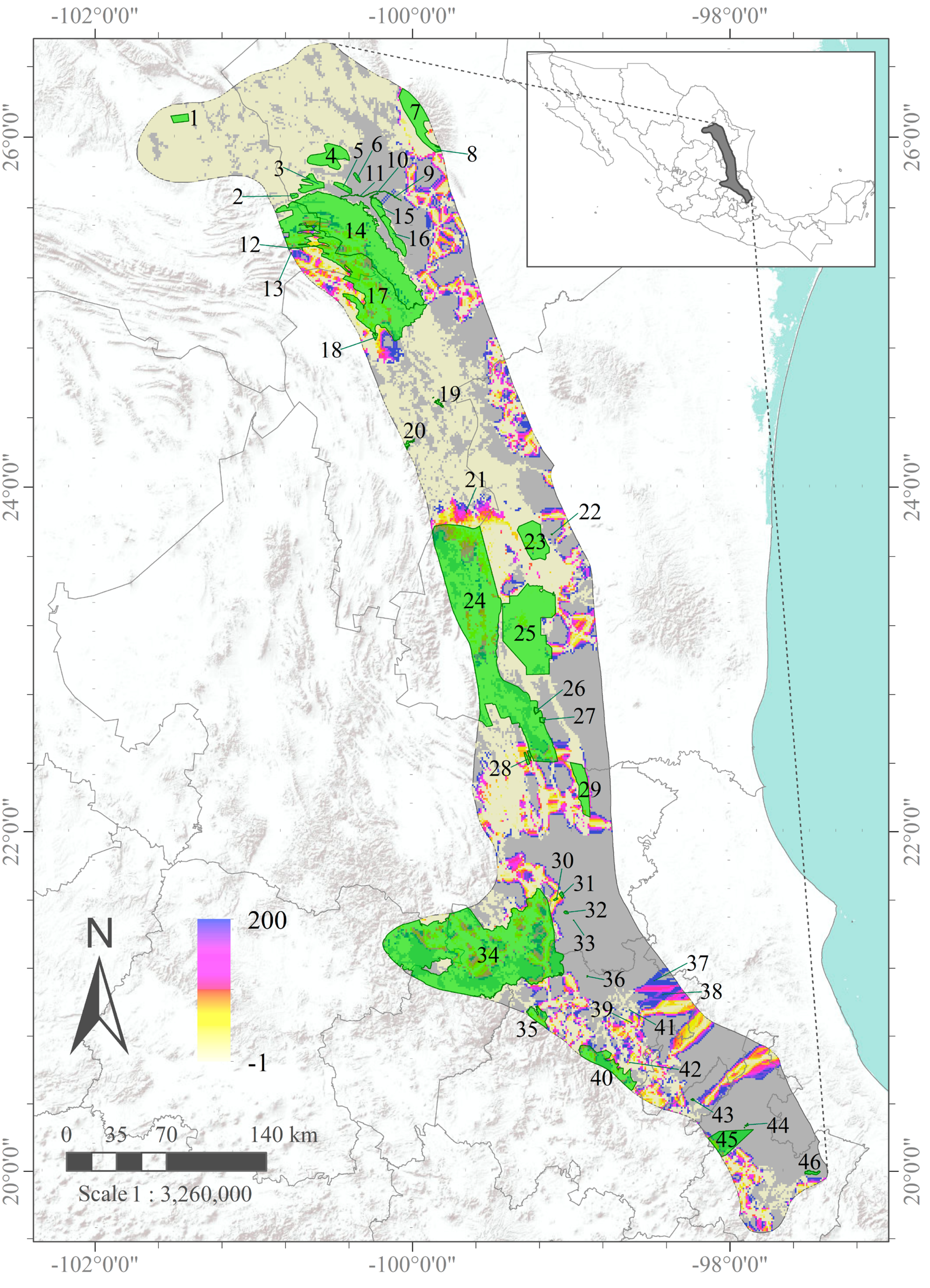

Figure 1. Location of the study area. The Sierra Madre Oriental (SMO) is shown in light grey, and protected areas (PAs) are highlighted in bright green (identified by the numbers provided in Table 2). The color gradient represents bioclimatic corridors (BCCs), with values ranging from -1 (areas with primary vegetation) to 200 (areas with the highest exposure). The inset in the upper-right corner shows a map of Mexico, indicating the location of the SMO (dark grey).

Table 1. Rodent species distributed in the Sierra Madre Oriental (SMO) based on occurrence records. Feeding versatility is classified as generalist (G) or specialist (S). Distribution status indicates that the species is endemic (En). Risk status follows NOM-059-SEMARNAT-2010 (A = threatened, P = endangered, and Pr = subject to special protection) and the IUCN Red List (EN = endangered, CR = critically endangered, and VU = vulnerable). Asterisk (*) denotes species with dispersal ability. Bold type indicates species whose modeled distribution does not show suitability.

id	Rodent species	id	Rodent species	id	Rodent species
1	*Baiomys musculus* (G), (En)	32	***Neotamias durangae*** **(S)**, (En)	63	*Peromyscus leucopus* (G)
2	*Baiomys taylori* (G)	33	*Neotoma albigula* (S) *	64	*Peromyscus levipes* (G), (En)
3	*Chaetodipus eremicus* (S)	34	*Neotoma angustapalata* (S), (En) *	65	*Peromyscus maniculatus* (G),
4	*Chaetodipus hispidus* (S)	35	*Neotoma goldmani* (S), (En) *	66	*Peromyscus melanocarpus* (G), EN
5	***Chaetodipus intermedius*** (S)	36	*Neotoma leucodon* (S) *	67	*Peromyscus melanophrys* (G), (En)
6	*Chaetodipus nelsoni* (S), (En)	37	*Neotoma mexicana* (S) *	68	*Peromyscus melanotis* (G), (En)
7	*Chaetodipus penicillatus* (S)	38	*Neotoma micropus* (S) *	69	*Peromyscus mexicanus* (G), (En)
8	*Coendou mexicanus* (S), A	39	*Neotomodon alstoni* (S), (En)	70	*Peromyscus ochraventer* (G), (En), EN
9	*Cratogeomys castanops* (S)	40	*Nyctomys sumichrasti* (S) *	71	*Peromyscus pectoralis* (G), (En)
10	*Cratogeomys fumosus* (S), (En), A	41	*Oligoryzomys fulvescens* (S)	72	***Peromyscus perfulvus*** (G), (En)
11	*Cratogeomys goldmani* (S), (En)	42	*Onychomys arenicola* (S)	73	*Peromyscus truei* (G)
12	*Cratogeomys merriami* (S), (En)	43	*Onychomys leucogaster* (S)	74	*Reithrodontomys chrysopsis* (S), (En)
13	*Cuniculus paca* (S)	44	*Onychomys torridus* (S)	75	*Reithrodontomys fulvescens* (S)
14	***Cynomys ludovicianus*** (S), P	45	*Heterogeomys hispidus* (S)	76	*Reithrodontomys megalotis* (S)
15	*Cynomys mexicanus* (S), (En), P, EN	46	*Casiomys alfaroi* (S)	77	*Reithrodontomys mexicanus* (S)
16	*Dipodomys merriami* (S)	47	*Casiomys chapmani* (S), (En), VU	78	*Reithrodontomys sumichrasti* (S), (En)
17	*Dipodomys nelsoni* (S), (En)	48	*Oryzomys couesi* (S)	79	*Sciurus alleni* (S), (En)
18	*Dipodomys ordii* (S)	49	*Casiomys melanotis* (S), (En)	80	*Sciurus aureogaster* (S)
19	*Dipodomys phillipsii* (S), (En), Pr	50	*Oryzomys palustris* (S),	81	*Sciurus deppei* (S)
20	*Dipodomys spectabilis* (S)	51	*Casiomys rostratus* (S)	82	***Sciurus griseus*** (S), A
21	*Geomys personatus* (S), A	52	*Otospermophilus variegatus* (S)	83	*Sciurus oculatus* (S), (En), Pr
22	***Geomys tropicalis*** (S), (En), A, EN	53	*Perognathus flavescens* (S)	84	*Sigmodon hispidus* (S)
23	*Glaucomys volans* (S), A	54	*Perognathus flavus* (S)	85	*Sigmodon leucotis* (S), (En)
24	*Habromys simulatus* (S), (En), Pr, CR	55	*Perognathus merriami* (S)	86	*Sigmodon mascotensis* (S), (En)
25	*Heteromys irroratus* (S)	56	*Peromyscus aztecus* (G), (En)	87	*Sigmodon toltecus* (S)
26	*Heteromys pictus* (S)	57	*Peromyscus beatae* (G)	88	*Thomomys bottae* (S)
27	*Ictidomys mexicanus* (G), (En)	58	*Peromyscus boylii* (G)	89	*Thomomys umbrinus* (S)
28	*Megadontomys nelsoni* (G), (En), A, EN	59	*Peromyscus difficilis* (G), (En)	90	*Tylomys nudicaudus* (S)
29	*Microtus mexicanus* (S)	60	*Peromyscus eremicus* (G)	91	*Xerospermophilus spilosoma* (S)
30	*Microtus quasiater* (S), (En), Pr	61	*Peromyscus furvus* (G), (En)		
31	*Neotamias bulleri* (S), (En), VU *	62	*Peromyscus gratus* (G)		

scenarios and projections). This quantifies the number of rodent species with potential distributions within each pixel of the analyzed area and serves as a proxy for species richness. Although this metric does not account for species-level interactions, it can yield reliable biodiversity information over extended periods (Coro *et al.* 2024). Raster cells with undefined values (NA) were replaced with 0.

For the PAs, the SMO species richness raster was cropped with the PAs vector; then raster values within each PA polygon were obtained with zonal statistics. To assess shifts in PSR across the different climate scenarios, the PA species richness raster was reclassified into high, medium, and low categories. These categories were defined using an equal-interval approach based on the maximum species richness observed for the current PSR. By maintaining these fixed interval thresholds across all future projections, we ensured a consistent basis for approximating the expansion or contraction of high-richness areas over time. To evaluate changes in the PSR of PAs across projected time periods, we applied a Mann–Kendall trend test which indicates the direction of the trend: positive, neutral or negative; a positive (*Tau*) value indicates an upward trend, and a negative value indicates a downward trend. While the test does not assess the magnitude of change, it evaluates whether the observed trend is statistically significant; given the limited length of the time series for the analysis (comprising the current projection and three-future time horizons), we adopted a significance level of $p = 0.1$ (corresponding to a 90% confidence interval) (Wang *et al.* 2020; McLeod 2022; Garcia *et al.* 2025).

Species gains and losses across the SMO and within PAs were evaluated by generating presence-absence matrices derived from zonal statistics calculated for each PA polygon under current and climate change scenarios. We then compared these matrices across scenarios. The same approach was applied to functional groups defined

Table 2. Protected areas within the Sierra Madre Oriental, their authority, and their states of location. Authority codes are: S = state; V = voluntary; E = ejidal; M = municipal; F = federal.

id	Protected areas	State	id	Protected areas	State
1	La Viga (E)	Coahuila	24	De la Mariposa Monarca (S)	Tamaulipas
2	Sierra Corral de los Bandidos (S)	Nuevo León	25	El Cielo (S)	Tamaulipas
3	Cerro La Mota (S)	Nuevo León	26	Rancho Regalo de Dios (V)	Tamaulipas
4	Sierra El Fraile y San Miguel (S)	Nuevo León	27	Rancho San Pedro (V)	Tamaulipas
5	Sierra Las Mitras (S)	Nuevo León	28	Sierra del Este y Sierra de Enmedio (S)	San Luis Potosí
6	Cerro El Topo (S)	Nuevo León	29	Sierra del Abra Tanchipa (F)	San Luis Potosí
7	Sierra Picachos (S)	Nuevo León	30	Cuevas de Mantetzulel (S)	San Luis Potosí
8	Cerro El Peñón (S)	Nuevo León	31	El Sótano de las Golondrinas (S)	San Luis Potosí
9	Parque Lineal (S)	Nuevo León	32	Cuevas Sagradas del Viento y de la Fertilidad (S)	San Luis Potosí
10	Nuevo Parque Ecológico La Pastora (S)	Nuevo León	33	La Hoya de las Huahuas (S)	San Luis Potosí
11	Cerro del Obispado (S)	Nuevo León	34	Sierra Gorda (F)	Querétaro, Guanajuato, San Luis Potosí
12	Las Delicias (S)	Coahuila	35	Los Mármoles (F)	Hidalgo
13	La Reforma (S)	Coahuila	36	Cerro el Aguacatillo (M)	Hidalgo
14	Cumbres de Monterrey (F)	Nuevo León, Coahuila	37	El Limonar (S, M)	Hidalgo
15	Cerro de la Silla (F)	Nuevo León	38	Pirámides de Ecuatitla (M)	Hidalgo
16	Sierra Cerro de la Silla (S)	Nuevo León	39	Zacatepec (M)	Hidalgo
17	C.A.D.N.R. 026 Bajo Río San Juan (F)	Coahuila, Nuevo León	40	Barranca de Metztitlán (F)	Hidalgo
18	Cerro El Potosí (S)	Nuevo León	41	Finca Tegolome (S)	Hidalgo
19	La Purísima (S)	Nuevo León	42	Plan Grande (M)	Hidalgo
20	Sandía El Grande (S)	Nuevo León	43	Chicamole (M)	Hidalgo
21	Santa Marta de Abajo (S)	Nuevo León	44	Carmen Serdán (F)	Puebla
22	El Refugio (S)	Tamaulipas	45	Z.P.F.V. la Cuenca Hidrográfica del Río Necaxa (F)	Hidalgo, Puebla
23	Altas Cumbres (S)	Tamaulipas	46	Kowtahyolo (F)	Puebla

by feeding versatility (generalists vs. specialists), following classifications previously used in studies of mammalian functional diversity (Munguía *et al.* 2016; Ureta *et al.* 2022). For each functional group, analyses were repeated using only species within that category.

Bioclimatic corridors. Bioclimatic corridors (BCCs) are shorter, low-impact routes that avoid abrupt climate transitions, thereby facilitating species movement as the climate changes. To assess their conservation potential relative to PAs, we utilized the BCC raster generated by CONABIO *et al.* (2019), which ranks landscape bioclimatic connectivity on a scale from -1 to 200. In this framework values of -1 correspond to fragments of primary vegetation; a value of 0 marks the central, optimal portions (or routes) of the corridors -areas with less climatic variation and less human impact- while values close to 200 occur at the periphery and represent the most exposed areas to anthropogenic pressures (CONABIO *et al.* 2019). The BCC raster was first cropped to the SMO extent and then reclassified into three categories (high, medium, and low). We then overlaid each PSR raster map with the reclassified BCC raster. Species richness within the SMO was analyzed by calculating zonal statistics for the PSR raster for each climate scenario and for the reclassified BCC raster. Finally, we compared species richness between PAs and BCCs.

Results

While 91 rodent species were initially identified through occurrence records from SNIB, the potential distribution models from Ureta *et al.* (2022) projected suitability for only 85 species in the SMO (Table 1). For the remaining six species (*Chaetodipus intermedius, Cynomys ludovicianus, Geomys tropicalis, Peromyscus perfulvus, Sciurus griseus* and *Neotamias durangae*) the models indicated no climatic suitability within the study area under the current projection, despite occurrence records. However, as suitability change in the future under climate change scenarios, *C. intermedius* and *P. perfulvus* gain shift into the SMO in 2070 under RCP4.5 scenario.

We identified 46 PAs comprising 10 under federal authority, 27 state, 5 municipal, 2 ADVC, 1 ejidal, and 1 state/municipal (Figure 1, Table 2) that represent 29% of the SMO total area. The spatial distribution of rodent PSR shows a latitudinal gradient, with richness increasing from north to south along the SMO. The highest PSR values are concentrated in the southern portion of SMO, below the 21° N latitude, primarily within the states of Hidalgo and Puebla, where PSR ranges from 31 and 46 species (Figure 2). The highest PSR do not fully coincide with the largest PAs, as the five most extensive (bigger than a thousand square kilometers) lie above 21° N latitude: C.A.D.N.R. 026 Bajo Río San Juan and Cumbres de Monterrey in state of Nuevo León (PSR of 28 and 38, respectively); De la Mariposa Monarca and El Cielo in state of Tamaulipas (PSR of 27 and 39, respectively); and Sierra Gorda in state of Querétaro, Guanajuato and San Luis Potosí (PSR of 30) (Figures 1 and 2). These large extension PAs, where the PSR is rather medium (between 15 and 30 species) on the

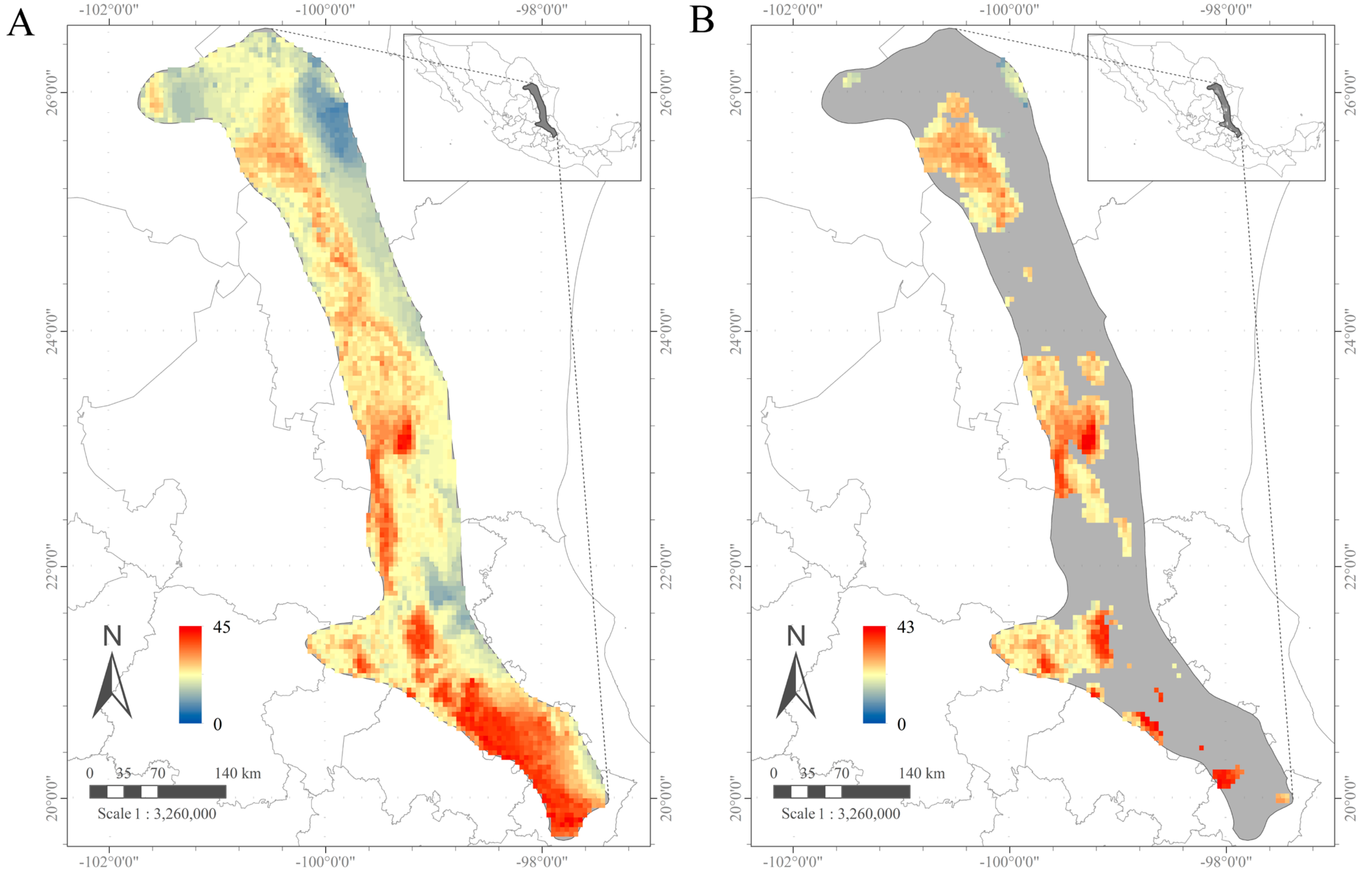

Figure 2. Potential species richness (PSR). A) Sierra Madre Oriental (SMO); B) protected areas (PAs). The color gradient (lower left) indicates the number of rodent species potentially present per pixel across the analyzed area.

western side of the SMO, coincide with areas of rugged topography and temperate forests.

The zone of maximum PSR in Hidalgo, Puebla and Veracruz coincides with BCCs that show intermediate to high exposure values (Figures 1 and 2). The BCCs exhibit also a latitudinal gradient in their landscape integrity, starting in the north of the SMO (states of Coahuila and Nuevo León) where PAs of federal authority Cumbres de Monterrey and C.A.D.N.R. 026 Bajo Río San Juan, are linked by large and optimal areas that facilitate the movement of species. This pattern extends slightly to the south, towards the central section of the SMO (states of Tamaulipas and San Luis Potosí), where a high density of BCCs is found, specifically around the polygons of the PAs De la Mariposa Monarca, El Cielo and Sierra del Este y Sierra de Enmedio, all of them under state authority.

Meanwhile, in the central section of the SMO, Sierra Gorda (states of Querétaro, Guanajuato and San Luis Potosí, federal authority) serves as a major anchor site that bridges the BCCs in the north with the increasingly fragmented southern sections, acting as a primary source for species dispersal. By contrast, the southern section of the SMO (states of Hidalgo, Puebla and Veracruz) reveals notably narrow and fragmented BBCs, with the prevalence of areas of high exposition to impact around polygons of the PAs Finca Tegolome, Plan Grande, Chicamole (the three under municipal authority), Carmen Serdán, Z.P.F.V. la Cuenca Hidrográfica del Río Necaxa, and Kowtahyolo (under federal authority), indicating intense anthropogenic pressure and a greater risk of isolation for local species.

Based on presence/absence data from their potential distribution, only three species with potential distribution in the SMO were not represented within any PA: *Dipodomys spectabilis, Geomys personatus*, and *Sigmodon mascotensis*. Regarding species richness per PA, Barranca de Meztitlán (state of Hidalgo) is the most diverse area, potentially hosting 72 species, whereas Santa Marta de Abajo (state of Nuevo León) hosts only 15 species. Almost 46% of the PAs (21) contain between 15 and 28 species, 71% of which are under state authority.

Regarding shifts in PSR under climate change projections, not only will species richness be reduced, but the area where high richness is maintained will also be reduced; high-richness areas within the SMO (those with PSR from 31-45 species) decline over time losing 50% of the area by 2030, 75% by 2050, and up to 87% in the distant horizon (2070) under RCP4.5 scenario, with a decrease on PSR from 45 to 42, 41 and 40 over the same period. These impacts are further intensified under the high-emission RCP8.5 scenario, where area losses reach 60% by 2030, 79% by 2050, and 97% in 2070, decreasing in PSR from 45, to 42, 39 up to 35 species, respectively. Whereas low-richness

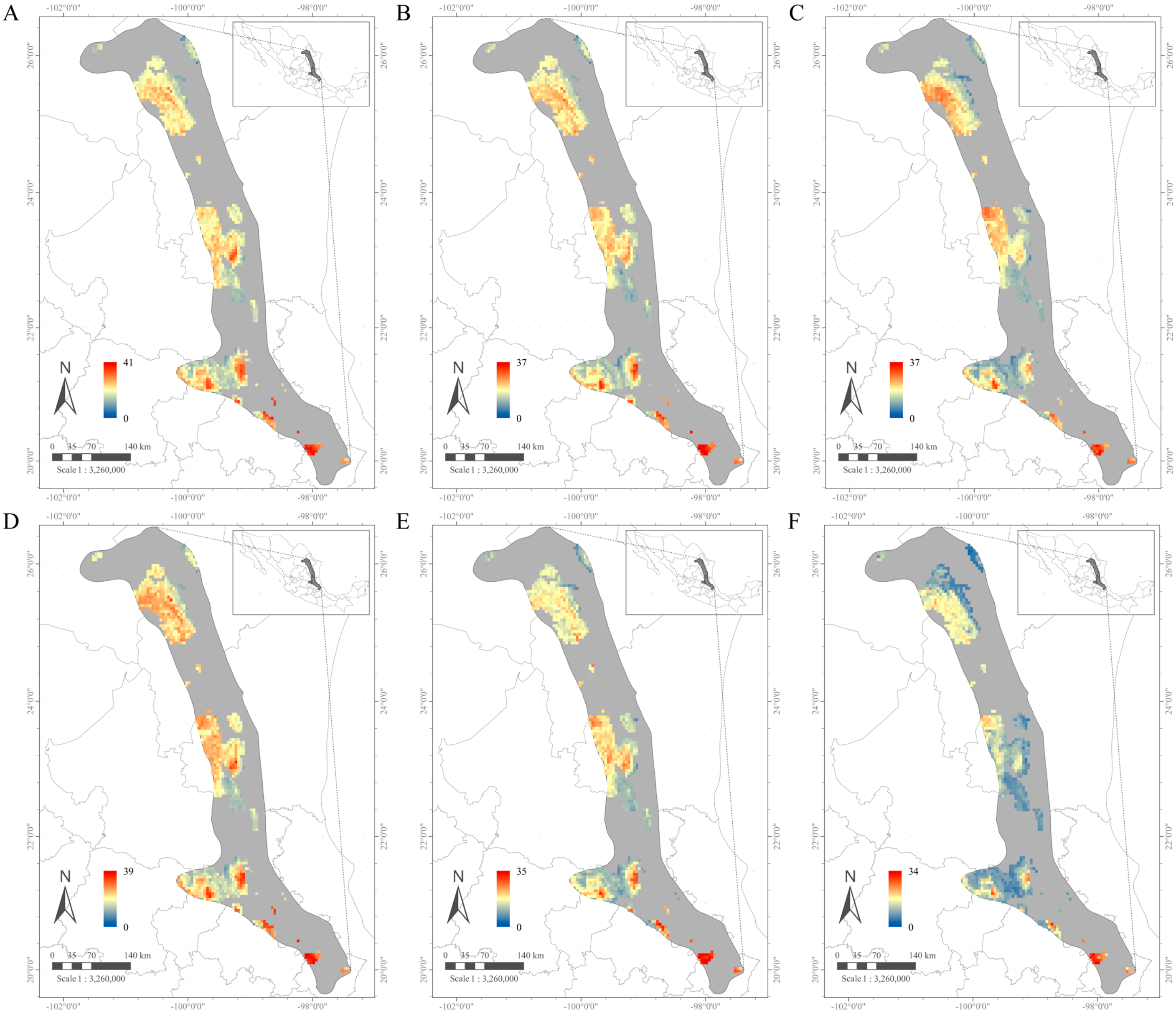

Figure 3. Potential species richness (PSR) under climate change scenarios. A) Representative conservation pathway (RCP) 4.5 in 2030; B) RCP4.5 in 2050; C) RCP4.5 in 2070; D) RCP8.5 in 2030; E) RCP8.5 in 2050; F) RCP8.5 in 2070. The color gradient (lower left) represents the number of rodent species potentially per pixel across the analyzed area.

areas (where PSR is of 16-30 species) expand under both climate scenarios (up to 813% for the 2070 projection under RCP4.5 and 1,149% for the same projected period under RCP8.5 scenario).

Similar trends are observed within PAs; however, in this case, the magnitude of the changes is greater. High-richness areas decline from 70% in 2030, and 85% by 2050, to 93% by 2070, with a decrease in PSR from 41 to 37 species under RCP4.5, while under RCP8.5 loses are 75% by 2030, 89% by 2050, and 98% by 2070, and a loss in PSR from 39 to 34. For both scenarios, the largest reductions in high-richness areas in PAs occur between current and 2030 projections (above 70% of the area), while in the SMO in general, the reduction is of 50-60% (Figures 3 and 4). These patterns of high-richness area contractions persist when generalist and specialist species are analyzed separately (Figure 4). Nevertheless, changes in PSR values over time for PAs, exhibit a difference when considering generalists species: PSR stay almost constant from 17 species under current projection to 18 by 2030, 16 by 2050, and 17 by 2070 under RCP4.5 scenario, and similar for RCP8.5 scenario, to 17 species by 2030, 16 by 2050 and 14 by 2070.

The Mann-Kendall test confirms significant decreasing trends in PSR for 63% of the PAs (*Tau* = -1, *p* = 0.089) under RCP4.5 scenario (Figure 5A); exceptions include Cerro El Potosí (*Tau* = 0.183, *p* = 1), Sierra Corral de Los Bandidos (*Tau* = 0.408, *p* = 1), and La Reforma (*Tau* = 0.183, *p* = 0.699), all located in the northwestern SMO (states of Nuevo León and Coahuila); however, these trends are non-significant ($p > 0.1$). Under RCP8.5, significant decreasing trends are observed for 76% of the PAs (*Tau* = -1, *p* = 0.089; Figure 5B). When considering only generalist species, under the RCP4.5 scenario, the Mann-Kendall test indicates significant negative PSR trends over time, in nine PAs (*Tau* = -1, *p* = 0.089):

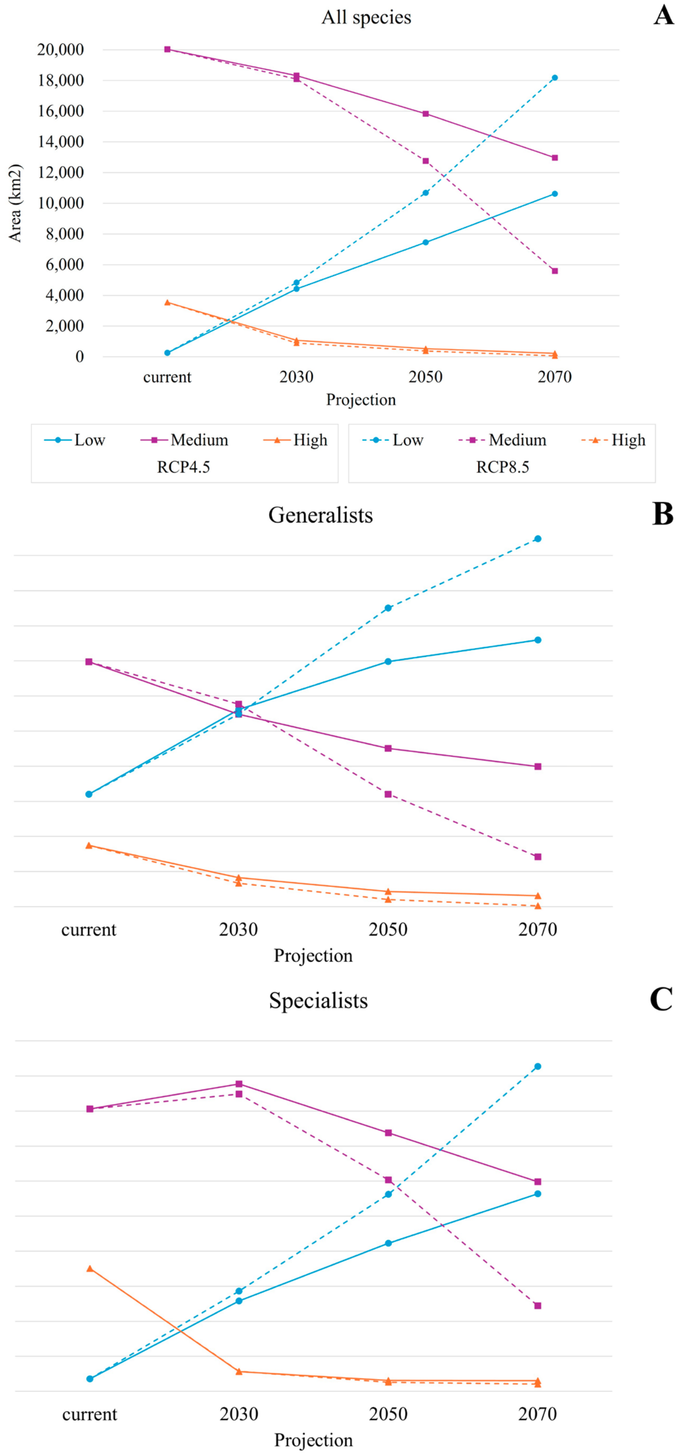

Figure 4. Changes in species richness under climate change scenarios. Increase or decrease in the extent of low (blue), medium (purple), and high richness (orange) areas across projected periods. Solid lines represent the Representative Concentration Pathway (RCP) 4.5 scenario, and dotted lines represent the RCP8.5 scenario. A) All species; B) generalists; C) specialists.

Sierra Las Mitras, Sierra Picachos (state of Nuevo León), El Refugio (state of Tamaulipas), La Hoya de la Huahuas, Sierra del Abra Tanchipa, Sierra del Este y Sierra de Enmedio (state of San Luis Potosí), Sierra Gorda (state of Querétaro), Z.P.F.V. la Cuenca Hidrográfica del Río Necaxa (state of Hidalgo), and Kowtahyolo (state of Puebla); although the positive trend is strong for Sierra Cerro de la Silla and Sierra Corral de los Bandidos (both in the state of Nuevo León), these trends are non-significant (*Tau* = 1, *p* = 1; Figure 6A). Under RCP8.5, the test shows negative values for all the PAs, while the trends are significant for 41% of them (*Tau* = -1, *p* = 0.089), 11 in the states of Coahuila, Nuevo León and Tamaulipas (Figure 6B). The test on specialist species shows a bigger percentage of PAs with decreasing PSR trends conversely generalist species; under the RCP4.5 scenario, trends are significant negative (*Tau* = -1, *p* = 0.089) for 76% of PAs, even though a neutral trend (Tau = 0) is observed for Zacatepec (state of Hidalgo), the trend is no significant (*p* = 1; Figure 7A). The same proportion of PAs with decrease of PSR is observed in specialist species under RCP8.5 scenario, where the 76% of the PAs show significant negative trends (*Tau* = -1, *p* = 0.089; Figure 7B). The test applied to BCCs show significant decreasing trends (*Tau* = -1, *p* = 0.089) across all scenarios, except for the conserved areas under RCP4.5 scenario (for both generalist and specialist species) where decreasing trends are statistically non-significant (*Tau* > -1, *p* > 0.1).

Comparisons of species presence within each PA between the current and 2070 projections, based on potential distribution models, show that under the RCP4.5 scenario, the largest species losses occur in Pirámides de Ecuatitla (12 species, municipal authority, state of Hidalgo) and El Refugio (11 species, state authority, state of Tamaulipas; on the other hand Barranca de Meztitlán (federal authority, Hidalgo), Carmen Serdán (federal authority, Puebla), Cerro de la Silla (federal authority, Nuevo León), and De la Mariposa Monarca (state authority, Tamaulipas), remain among the ones with the highest potential presence of species during the three periods projected. Under the RCP8.5 scenario, the PAs with largest potential species losses are El Limonar (35 species, state and municipal authority, state of Hidalgo), and Cuevas Sagradas del Viento y de la Fertilidad (27 species, state authority, state of San Luis Potosí). Regarding those that maintain the highest potential presence of species during the three projected periods under this pessimistic scenario, they are also Barranca de Meztitlán, and De la Mariposa Monarca.

While the total number of species potentially present in PAs remains relatively without change over time under the RCP4.5 scenario, species composition turnover occurs by 2070 (Table 3). At this horizon, *Cynomys mexicanus* and

Table 3. Projected gains and losses of rodent species within the study area under two climate scenarios (RCP4.5 and RCP8.5) for three period projections (2030, 2050, and 2070).

Scenario	Projection	Species lost	Species gained/regained
RCP4.5	2030	*Reithrodontomys chrysopsis* *Sigmodon leucotis*	*Sigmodon mascotensis*
	2070	*Chaetodipus intermedius* *Peromyscus perfulvus*	*Cynomys mexicanus* *Habromys simulatus*
RCP8.5	2030	*Reithrodontomys chrysopsis* *Sigmodon leucotis*	*Sigmodon mascotensis*
	2050	*Chaetodipus penicillatus* *Cratogeomys tylorhinus* *Neotomodon alstoni*	*Chaetodipus intermedius*
	2070	*Dipodomys phillipsii* *Neotamias bulleri* *Neotoma angustapalata* *Neotoma goldmani*	*Chaetodipus penicillatus*

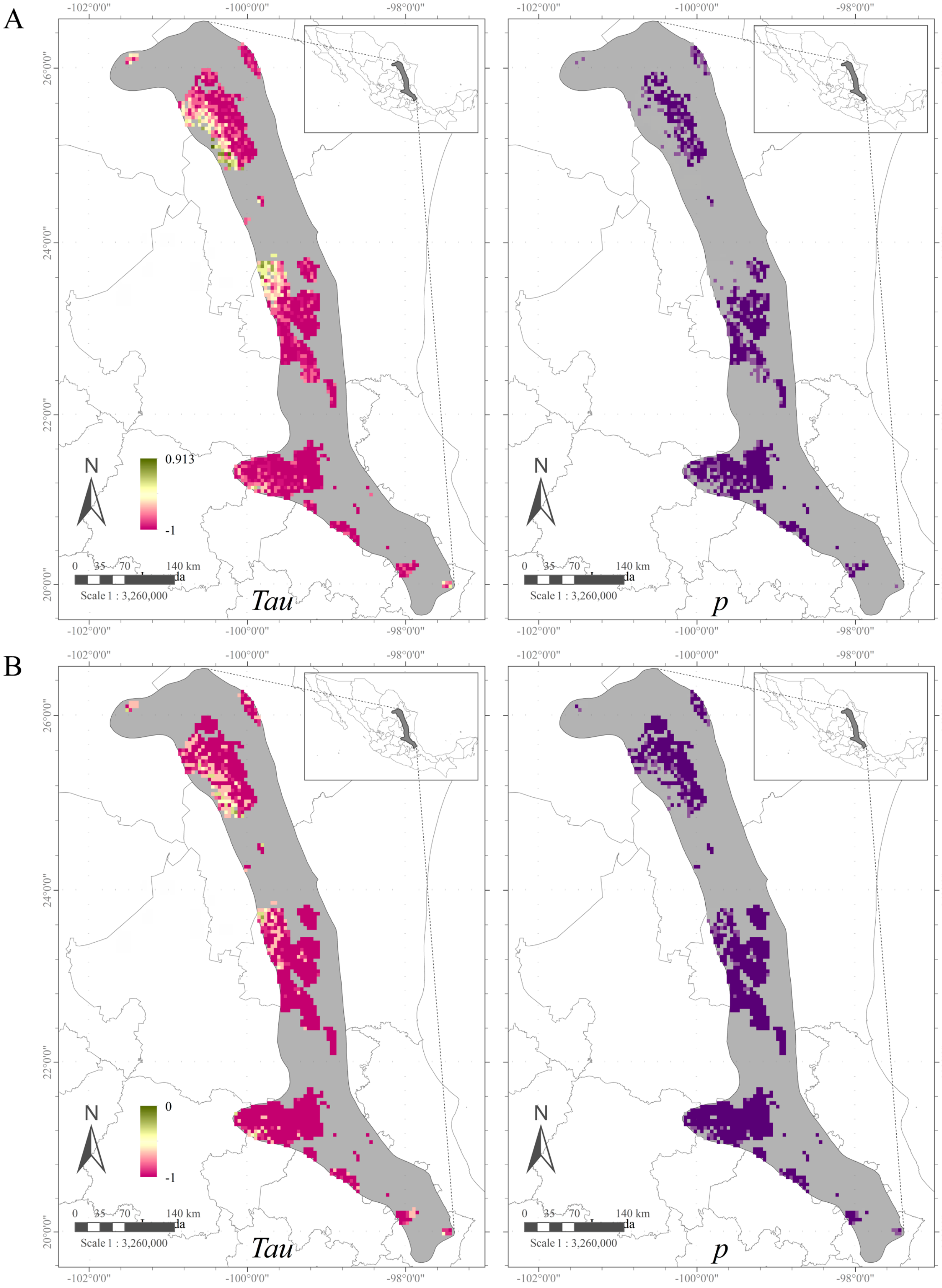

Figure 5. Temporal trends in potential species richness (PSR): Mann-Kendall test results, *Tau* values (left, trend direction indicated by the color scale), and *p*-values (right, purple areas denote statistical significance). A) Representative conservation pathway (RCP) 4.5 scenario; B) RCP8.5 scenario.

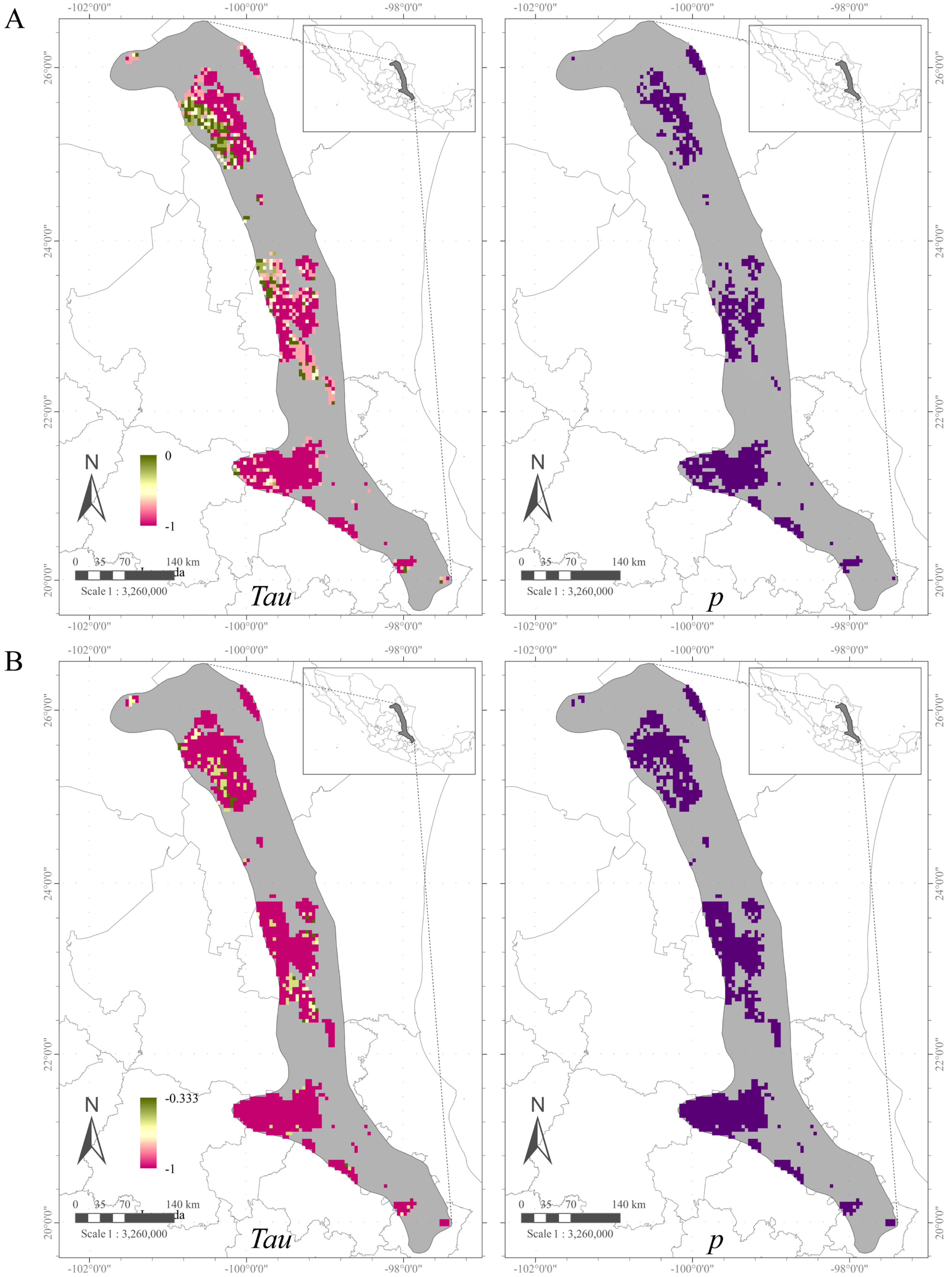

Figure 6. Temporal trends in potential species richness (PSR) for generalist species: Mann-Kendall test results, *Tau* values (left, trend direction indicated by the color scale), and *p*-values (right, purple areas denote statistical significance). A) Representative conservation pathway (RCP) 4.5 scenario; B) RCP8.5 scenario.

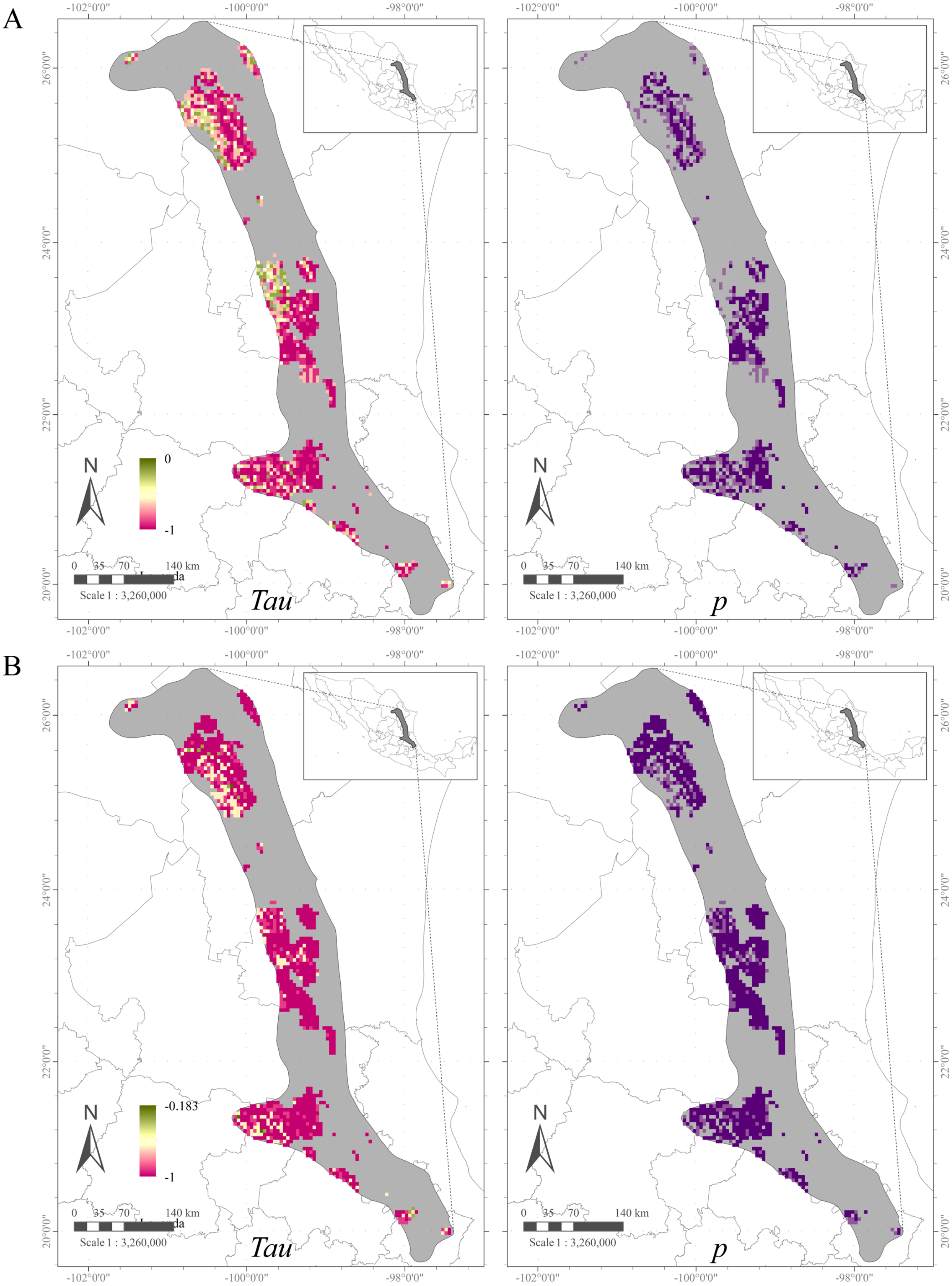

Figure 7. Temporal trends in potential species richness (PSR) for specialist species: Mann-Kendall test results, *Tau* values (left, trend direction indicated by the color scale), and *p*-values (right, purple areas denote statistical significance). A) Representative conservation pathway (RCP) 4.5 scenario; B) RCP8.5 scenario.

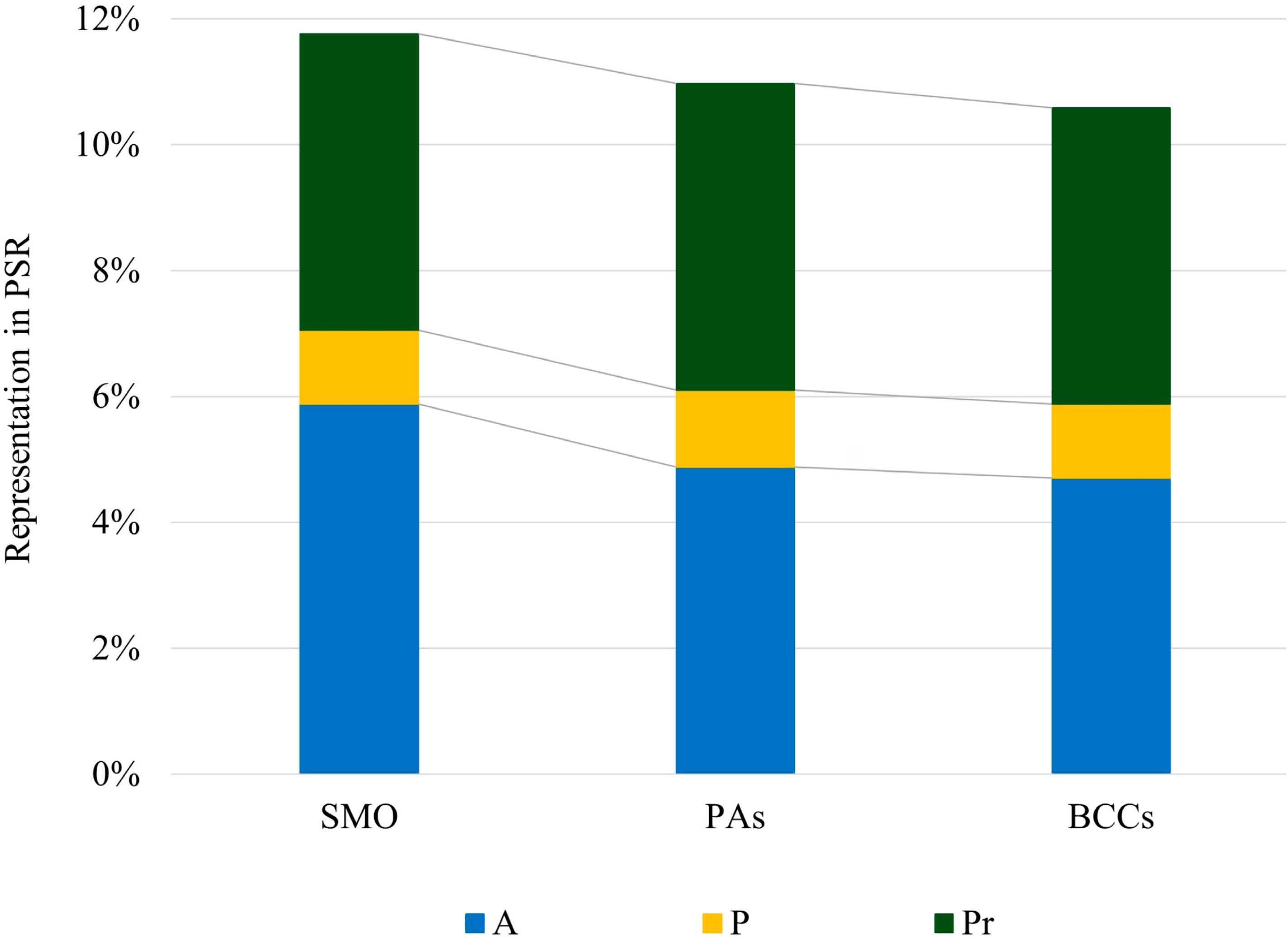

Figure 8. Percentage representation of species in each risk category according to the Official Mexican Standard NOM-059-SEMARNAT-2010 within the potential species richness (PSR) of the Sierra Madre Oriental (SMO), protected areas (PAs), and bioclimatic corridors (BCCs). Risk categories shown are threatened (A, blue), endangered (P, yellow), and subject to special protection (Pr, green).

Habromys simulatus (both specialists) are projected to be lost in the PAs. In contrast, the endemic species *C. intermedius*, is expected to regain presence within PAs: Nuevo Parque Ecológico La Pastora, Cerro del Obispado, and Sierra Picachos (all state authority, in state of Nuevo León), while *P. perfulvus* (which according to the modeled distribution has no climatic suitability under current conditions) regains presence withing Sierra Gorda (federal authority in states of Querétaro, Guanajuato and San Luis Potosí). Under the pessimistic RCP8.5 scenario, overall species presence in PAs declines. By 2050, *Chaetodipus penicillatus*, and *Neotomodon alstoni* (both specialists) are projected to be extirpated, while *C. intermedius* shows recovery in Parque Lineal, Nuevo Parque Ecológico La Pastora, and Cerro del Obispado (all state authority, in state of Nuevo León). By 2070, additional losses include *Dipodomys phillipsii*, *N. bulleri*, *Neotoma angustapalata*, and *N. goldmani*. Notably, *C. penicillatus* despite its initial loss, is projected to regain suitability in Sierra Las Mitras (state authority in state of Nuevo León).

It is important to mention that under all scenarios, *Reithrodontomys chrysopsis* and *Sigmodon leucotis* (both endemic and specialist species) are projected to be consistently lost from the PAs in the study area. Conversely, *S. mascotensis*, without suitability under current conditions, regains presence within the PA starting in 2030. Bioclimatic corridors (BCCs) support two additional species (*C. intermedius* and *P. perfulvus*) that according to the current projection, have no climatic suitability in the PAs or the region. The case of *S. mascotensis* is notable because, according to the modeled current projection, it is absent from PAs but has presence within BCCs. Notably, for future projections, the total potential number of species within BCCs remains constant under both scenarios.

Finally, only 10 rodent species within the SMO fall into any risk category of the Official Mexican Standard (NOM-059-SEMARNAT-2010; SEMARNAT 2010): 5 threatened, 1 endangered, and 4 subject to special protection. For PAs the species count is very similar: 4 threatened, 1 endangered, and 4 subject to special protection. Temporal variation across both climate change scenarios indicates loss of species from the SMO for all risk categories: under RCP4.5 scenario there potentially are one less threatened species by 2030, one less species endangered and one less subject to special protection by 2070; while under RCP8.5

there potentially are one less threatened species by 2030, and one less subject to special protection species by 2070. In regard BCCs, they potentially host same species under risk categories as PAs (and in the same categories): 4 threatened, 1 endangered, and 4 subject to special protection (Figure 8).

Discussion

Our results suggest that PAs contribute to the conservation of rodent species and the maintenance of species richness in the SMO, even under projected climate change scenarios. However, although overall species richness may persist, our projections indicate that community composition is likely to change over time as climatic conditions shift.

The PSR pattern is linked to the topographic axis of the mountain range, where high richness follows the mountainous elevations west of the SMO and decreases as the landscape transitions to the adjacent lowlands towards the east of the region. The highest PSR values (up to 46 species) are concentrated in the southern portion of the SMO, specifically across the states of Hidalgo, Puebla, and northern Veracruz, indicating that this region serves as the primary reservoir of rodent biodiversity. In contrast, the northern regions (states of Coahuila and Nuevo León) exhibit lower overall species richness, typically ranging from 2 to 22 species. Our findings regarding this differentiation of the north, center, and south based on PSR patterns and PA efficacy, is similar to the mammalian regionalization described by León-Paniagua *et al.* (2004) for the SMO, who identified a northern clade dominated by arid-adapted species (states of Coahuila and Nuevo León), a southern section characterized by humid mountain forest fauna (states of Querétaro, Hidalgo, Puebla and Veracruz), and a central section of the SMO (states of Tamaulipas and San Luis Potosí) dominated by tropical taxa.

Areas with higher rodent PSR species in the south, are also those facing greater pressure from climate change or fragmentation (CONANP and GIZ 2013). State and municipal PAs in southern SMO act like small islands in a matrix of high climate pressure; specialist species depend on these areas. The high exposure of the surrounding BCCs suggests that, in the event of a climatic shift, these specialist species will have highly degraded or non-existent dispersal pathways, increasing the risk of local extirpation. The PA Sierra Gorda (states of Querétaro, Guanajuato and San Luis Potosí) represents an important area of medium PSR in the center of the SMO where high BCCs values suggest well-preserved primary vegetation; here it is projected that *P. perfulvus* will potentially regain presence by 2070, while the effectiveness of any colonization may depend on maintaining connectivity at the PA boundaries, where limited BCCs zones must not become insurmountable barriers to dispersal. Although PAs in the northern SMO host lower species richness than those in the south, they are associated with BCCs characterized by high stability and low climate exposure. In Nuevo León, the intersection of PAs such as Cumbres de Monterrey, Sierra Picachos, Nuevo Parque Ecológico La Pastora and Cerro del Obispado with low-exposure BCCs suggests these areas may serve as critical refugia (Buenafe *et al.* 2025). While these findings are not novel, and it is well established that climatic trends influence species richness trends (Urquiza-Haas *et al.* 2019; Thompson 2025), they reinforce the need to conduct analyses at smaller spatial scales and improve connectivity between PAs.

When rodent functional groups were analyzed based on feeding versatility, differences between generalist and specialist species were not statistically significant. Nevertheless, generalist species tended to exhibit greater temporal PSR stability across projections. Under the RCP4.5 scenario, southern PAs retain specialist species in the higher parts of the topography at the south of the region, whereas under the pessimistic RCP8.5 scenario, generalist and widely distributed species persist in PAs. This pattern is consistent with expectations, as climatic changes often favor species with broader ecological tolerances, which are better able to colonize novel environments, potentially offsetting local extirpations (Bravo-Cadena *et al.* 2011; Munguía *et al.* 2016; Thompson *et al.* 2025).

We found that neither PA size nor authority (federal, state, municipal, or private) had a significant effect on species conservation outcomes. This result challenges the widespread assumption that only large PAs can conserve biodiversity, an assumption that may lead to suboptimal conservation strategies, particularly for taxa with restricted distributions (Buenafe *et al.* 2025). Although the authority category does not independently define PSR, it is a key determinant of landscape resilience. Notably, state-level PAs showed better performance in potential species recovery under climate change scenarios, highlighting their relevance in regional conservation planning. By shaping the capacity for adaptation and mitigation, these frameworks act as the primary architecture for the region's climate-smart conservation efforts (Amori *et al.* 2011; Formoso and Teta 2019; Revollo-Cadima and Salazar-Bravo 2024). The functional importance of these governance categories is further evidenced by their roles: while federal PAs function as primary anchors of climatic stability, state and municipal PAs, along with ADVC, serve as strategic refugia in areas of high climatic pressure (Bezaury-Creel 2024). Their capacity to facilitate species recovery is exemplified by the persistence of *C. intermedius* in the PAs of Nuevo León.

These findings related to PA size and authority, highlight the importance of subnational level PAs (including ADVC), and suggest the potential utility of other conservation figures, such as the Other Effective Area-Based Conservation Measures (OECM), which have not yet been implemented in Mexico and were therefore not considered in this study (Dinerstein *et al.* 2024; Mouillot *et al.* 2024; Pulido-Chadid *et al.* 2025). The OECM could exploit the climatic stability that functions as BCCs, enabling non-static conservation strategies that remain effective not only under current conditions but also under more adverse climate scenarios (Nori *et al.* 2020; Bezaury-Creel 2024; Steigerwald *et al.* 2024; Buenafe *et al.* 2025). Climate connectivity can further strengthen established PA networks by incorporating additional areas that link existing protected sites, thereby promoting better-connected, climate-smart conservation planning (Palfrey *et al.* 2022; Steigerwald *et al.* 2024; Buenafe *et al.* 2025).

Regarding the BCCs, our results confirm their key role in preserving habitat connectivity across future climate projections, maintaining their geographic orientation even under changing climatic conditions (CONABIO *et al.* 2019). Habitat connectivity is essential for mammal conservation because it facilitates gene flow, ecological processes, and climate-driven dispersal (Godínez-Gómez *et al.* 2020; Revollo-Cadima and Salazar-Bravo 2024; Buenafe *et al.* 2025; Pulido-Chadid *et al.* 2025). This connectivity allows conservation efforts to extend beyond PA boundaries, addressing threats at the landscape scale (Rey *et al.* 2024; Rahman *et al.* 2025).

Changes in species composition (gains/losses) across projections suggest that to be effective in mitigating the effects of climate change, conservation will require a dynamic approach: responsive management strategies tailored to address the evolving ways biodiversity reacts to environmental shifts, extending beyond the formal boundaries of PAs to ensure functional connectivity across the landscape. It is important to note, however, that while the present study focuses on climatic drivers, land-use change is an equally (or more) important factor to consider for the long-term conservation of rodents and the maintenance of associated ecosystem services (Munguía *et al.* 2016; Zuñiga *et al.* 2021; Ureta *et al.* 2022; Zurell *et al.* 2025). For example, *C. mexicanus* and *H. simulatus*, which are expected to be lost by 2070 under the RCP4.5 scenario (Table 3), are species closely linked to the condition of their habitats. This implies that their needs for resources, shelter, and reproduction are positively influenced by the greater ecosystem quality and stability, which are often more immediately threatened by land-use change than by climate alone (Castañeda-Rico *et al.* 2011; Zaragoza-Quintana *et al.* 2012; Zaragoza-Quintana *et al.* 2022).

Taking into account this link between rodents and their habitats is particularly relevant, not only due the threats these species face, but also because of their ecological importance. In general, the loss of connectivity in the south could affect the natural regeneration of cloud forests, since rodents are the primary seed dispersers of many tree species. However, rodents remain a non-charismatic taxonomic group that is often overlooked in systematic conservation planning (Delso *et al.* 2021). The limited assessment of this group, despite their important ecological and evolutionary roles in ecosystems, is unlikely to improve as emerging low-cost participatory monitoring approaches -such as citizen science- (Hanson *et al.* 2026) may be ineffective for monitoring this type of species. Effective conservation, therefore, requires moving beyond global targets to incorporate local ecological, social, and economic contexts (Mouillot *et al.* 2024). Site-specific, on-the-ground assessments are essential to ensure that PA networks are designed and implemented to address the unique needs and challenges of each region and taxonomic group (Pulido-Chadid *et al.* 2025). A better understanding of local opportunities, enabling conditions, and barriers would guide strategic interventions toward realistic, operationally feasible, and positive long-term conservation outcomes (Mouillot *et al.* 2024).

Our findings further suggest that strategies that combine multiple climate-smart approaches are advisable for mitigating the effects of climate change. These include facilitating climate connectivity through the establishment of corridors and stepping stones that allow species movement (McGowan *et al.* 2024; Buenafe *et al.* 2025). By overlaying current PSR with future climatic suitability, this study provides the empirical basis for these strategies; we demonstrate that BCCs currently overlap with high-PSR areas that lack formal protection under PAs. Consequently, this work could serve as a spatial blueprint for establishing connectivity, specifically identifying the northward and upward pathways required as southern niches become climatically unsuitable. However, climate-smart spatial prioritization is data-intensive and particularly challenging in data-poor regions (Buenafe *et al.* 2025).

It is also important to note that, although SDM may help link actions with outcomes, evaluate future scenarios, and guide decision-making toward achieving KMGBF objectives and targets (Rahman *et al.* 2025; Zurell *et al.* 2025), limited experience and technical capacity to develop such models, which is the common situation in subnational administrations (CONABIO 2016), can lead to inequities in conservation planning (Buschke *et al.* 2023; Zurell *et al.* 2025). This technical gap is particularly critical given the results of the present study, which demonstrate that state-level PAs and those of smaller spatial extent often outperform larger federal reserves in protecting high-richness areas and facilitating species recovery. Despite their smaller size and administrative challenges, these subnational areas act as refugia in the high-exposure zones.

While the roadmap launched by the national authority emphasizes the importance of ensuring that PAs and OECM represent the full range of Mexican ecosystems and thereby meet and exceed Mexico's commitments under the CBD (SEMARNAT *et al.* 2025), our findings indicate that current and future PAs and OECM must be not only representative but also functionally effective in addressing drivers of biodiversity loss, particularly climate change. This includes incorporating the ecological roles of rodents and their interactions with other species into conservation strategies (Formoso and Teta 2019; Zúñiga *et al.* 2021; Lindsø *et al.* 2025). The roadmap further recognizes that biological corridors should be established as mosaics of areas under integrated landscape management, with varying categories and functionalities, and incorporated into public policy (SEMARNAT *et al.* 2025). Well-connected PA networks facilitate gene flow and the continuity of ecological functions (Revollo-Cadima and Salazar-Bravo 2024; Buenafe *et al.* 2025). Our results suggest that rodent conservation in the SMO region cannot be achieved solely by expanding PAs in the north. Instead, conservation efforts should prioritize mitigating threats to southern corridors, specifically within the states of Hidalgo and Puebla, as previously established by León-Paniagua *et al.* (2004), to ensure the SMO's biodiversity retains functional dispersal pathways to the north.

Specifically, for the SMO, the Sierra Madre Oriental Ecological Corridor (CESMO) can support more effective conservation planning. This initiative focuses on landscape management through reforestation activities to improve connectivity, the promotion of alternative livelihoods to reduce and control the main pressures and threats to local fauna and flora, and the implementation of systematic field monitoring by trained members of local communities within the corridor. Involves collaboration among several states, including San Luis Potosí, Querétaro, Hidalgo, Puebla, Veracruz, and, more recently, Nuevo León (Moreno *et al.* 2015; Rodríguez-Ruiz *et al.* 2025). Beyond the sum of isolated conservation efforts to date, the reactivation of the CESMO could lead to a major regional conservation policy framework that integrates multiple stakeholders and local development plans, thereby enhancing management strategies to maintain landscape connectivity (Moreno *et al.* 2015). This approach would follow the example of the Biocultural Corridor of Central Western Mexico (COBIOCOM), where regional coordination has enabled the design and implementation of broader and more ambitious conservation strategies in western Mexico (Sosa and Ivanova 2025).

Overall, the design and establishment of PAs must evolve toward a functional network approach that addresses the challenges posed by climate change, data gaps, and governance constraints. Climate-smart strategies, dynamic conservation planning, and climate mitigation efforts are essential for building effective and equitable PA networks (Buenafe *et al.* 2025). By drawing on the best available science and evidence, conservation planning and management can better anticipate future challenges and ensure the long-term resilience of ecosystems in a rapidly changing climate.

Achieving the ambitious "30 × 30" target of the KMGBF (CBD 2022) requires coordinated actions across multiple governance levels, aligning local needs, national priorities, and global agreements (CBD 2022; McGowan *et al.* 2024; Zurell *et al.* 2025). These efforts must be grounded in the best available biodiversity data, particularly at local and subnational scales, which often provide more effective conservation strategies than broad global assessments (Sarukhán and Jiménez 2014; Botello *et al.* 2015; McGowan *et al.* 2024). This study demonstrates the use of open access high-quality subnational biodiversity data to develop the multi-scale analyses required to close these gaps and operationalize global targets at the local level. Integrating such evidence into national policy is essential for countries like Mexico, where although the National Biodiversity Strategy and its Action Plan (ENBioMex) includes specific actions to improve connectivity, a stronger legal framework is still needed to ensure connectivity among existing PAs, newly designated PAs, and soon the OECM (CONABIO 2016; SEMARNAT *et al.* 2025).

Acknowledgments

DLH thanks CONABIO for providing open access to high-quality data on Mexican biodiversity, including occurrence records, potential distributions, and GIS layers. EPZQ gratefully acknowledges financial support from the Secretaría de Ciencia, Humanidades, Tecnología e Innovación (SECIHTI) through a postdoctoral fellowship.

This paper is dedicated to Dr. Livia León-Paniagua, in recognition of her outstanding contributions to the study of Mexican mammals and her enduring influence as a mentor. As her students, we received invaluable knowledge about Mexican mammals and their study, including practical insights into species identification, field techniques, and trapping methods (in the most unexpected places). Her legacy, however, goes far beyond the number of specimens collected, articles published, or species described. The most important lesson was her example of life and science: the passion of being a female mammalogist and the inspiration to do science in a different way. She left a profound mark on our academic formation, such that regardless of the paths our careers have taken, we remain connected not only as colleagues, but as a community.

Declaration of Artificial Intelligence use

We declare that the authors have not used any Artificial Intelligence in the elaboration of this paper.

Author contributions

DLH: Conceptualization, design, data curation, analysis & writing-original draft; SCR: analysis, writing-review & editing; EPZQ: analysis, writing-review & editing; ZAAV: analysis, writing-review & editing.

Literature cited

Amori G, Gippoliti S, and Luiselli L. 2011. Do biodiversity hotspots match with rodent conservation hotspots? *Biodiversity and Conservation* 20:3693–3700. https://doi.org/10.1007/s10531-011-0131-z

Beresford AE, Buchanan GM, Donald PF, Butchart SHM, Fishpool LDC, and Rondinini C. 2011. Poor overlap between the distribution of protected areas and globally threatened birds in Africa. *Animal Conservation* 14:99–107. https://doi.org/10.1111/j.1469-1795.2010.00398.x

Bezaury-Creel JE. 2024. Privately protected areas in Mexico, a 2012–2023 update. *Frontiers in Conservation Science*

4:1304771. https://doi.org/10.3389/fcosc.2023.1304771

Botello F, Sánchez-Cordero V, and Ortega-Huerta MA. 2015. Disponibilidad de hábitats adecuados para especies de mamíferos a escalas regional (estado de Guerrero) y nacional (México). *Revista Mexicana de Biodiversidad* 86(1):226-237. https://doi.org/10.7550/rmb.43353

Bravo-Cadena J, Sánchez-Rojas G, and Gelviz-Gelvez SM. 2011. Estudio de la distribución de las especies frente al cambio climático. *Cuadernos de Biodiversidad* 35:12-18. http://dx.doi.org/10.14198/cdbio.2011.35.03

Buenafe KCV, Dunn DC, Metaxas A, Schoeman DS, Everett JD, Pidd A *et al.* 2025. Current approaches and future opportunities for climate-smart protected areas. *Nature Reviews Biodiversity* 1:284–297. https://doi.org/10.1038/s44358-025-00041-0

Buschke FT, Capitani C, Sow EH, Khaemba Y, Kaplin BA, Skowno A *et al.* 2023. Make global biodiversity information useful to national decision-makers. *Nature Ecology & Evolution* 7:1953–1956. https://doi.org/10.1038/s41559-023-02226-2

Castañeda-Rico S, León-Paniagua L, Ruedas LA, Vázquez-Domínguez E. 2011. High genetic diversity and extreme differentiation in the two remaining populations of *Habromys simulatus*. *Journal of Mammalogy* 92(5):963–973. http://dx.doi.org/10.1644/10-MAMM-A-171.1

Chacón-Prieto F, Rodríguez-Soto C, Cuervo-Robayo A, Monroy J, and Alagador D. 2021. Protected areas in Central Mexico - are they fit in promoting species persistence under climate and land use changes? *Biological Conservation* 260:109186. https://doi.org/10.1016/j.biocon.2021.109186

Chase JM, McGill BJ, Thompson PL, Antão LH, Bates AE, Blowes SA *et al.* 2019. Species richness change across spatial scales. *Oikos* 128:1079–1091. https://doi.org/10.1111/oik.05968

Comisión Nacional para el Conocimiento y Uso de la Biodiversidad [CONABIO]. 1997. *Provincias biogeográficas de México. Escala 1:4,000,000*. México, D. F. (MEX): CONABIO.

Comisión Nacional para el Conocimiento y Uso de la Biodiversidad [CONABIO]. 2016. *Estrategia Nacional sobre Biodiversidad de México (ENBioMex) y Plan de Acción 2016-2030*. México: CONABIO.

Comisión Nacional para el Conocimiento y Uso de la Biodiversidad [CONABIO]. 2020. Áreas Naturales Protegidas Estatales, Municipales, Ejidales, Comunitarias y Privadas de México 2020, edición: 1. México: CONABIO; June, 2020. [Accessed June 14th, 2025]. http://geoportal.conabio.gob.mx/metadatos/doc/html/anpest20gw.html

Comisión Nacional para el Conocimiento y Uso de la Biodiversidad [CONABIO]. 2024. *Sistema Nacional de Información sobre Biodiversidad. Registros de ejemplares de mamíferos*. México: CONABIO; February 2024. [Accessed February 7th, 2024]. http://geoportal.conabio.gob.mx/acceso/mamiferos/2024/02/07

Comisión Nacional para el Conocimiento y Uso de la Biodiversidad, Comisión Nacional de Áreas Naturales Protegidas, and Programa de las Naciones Unidas para el Desarrollo [CONABIO, CONANP and PNUD]. 2019. *Corredores bioclimáticos para la conservación de la biodiversidad*. México: CONABIO; May, 2020. [Accessed October 4th, 2025]. http://geoportal.conabio.gob.mx/metadatos/doc/html/clccrecgw.html

Comisión Nacional de Áreas Naturales Protegidas [CONANP]. 2024. Áreas Naturales Protegidas Federales de México, septiembre *de 2024*. México: CONABIO; October, 2024. [Accessed June 14th, 2025]. http://geoportal.conabio.gob.mx/metadatos/doc/html/anpsp2024gw.html

Comisión Nacional de Áreas Naturales Protegidas and Deutsche Gesellschaft für Internationale Zusammenarbeit [CONANP and GIZ]. 2013. *Programa de Adaptación al Cambio Climático Región Central de la Sierra Madre Oriental*. México D.F. (MEX): CONANP and GIZConvention on Biological Diversity [CBD]. 2022. *Decision adopted by the Conference of the Parties to the Convention on Biological Diversity 15/4. Kunming-Montreal Global Biodiversity Framework*. Montreal (CAN): CBD Secretariat; December 2022. [Accessed October 4th, 2025]. https://www.cbd.int/doc/decisions/cop-15/cop-15-dec-04-es.pdf

Coro G, Sana L, and Bove P. 2024. An open science automatic workflow for multi-model species distribution estimation. *International Journal of Data Science and Analytics* 20:1131–1150. https://doi.org/10.1007/s41060-024-00517-w

Delso Á, Fajardo J, and Muñoz J. 2021. Protected area networks do not represent unseen biodiversity. *Scientific Reports* 11:12275. https://doi.org/10.1038/s41598-021-91651-z

Dinerstein E, Joshi AR, Hahn NR, Lee ATL, Vynne C, Burkart K, Asner GP *et al.* 2024. Conservation Imperatives: securing the last unprotected terrestrial sites harboring irreplaceable biodiversity. *Frontiers in Science* 2:1349350. https://doi.org/10.3389/fsci.2024.1349350

Formoso A. and Teta P. 2019. Richness, endemism and conservation of sigmodontine rodents in Argentina. *Mastozoología Neotropical* 26:99–116. https://doi.org/10.31687/saremMN.19.26.1.0.17

Garcia N, Campos JC, Alírio J, Duarte L., Arenas-Castro S, Pôças I *et al.* 2025. Assessing spatial and temporal trends over time in potential species richness using satellite time-series and ecological niche models. *Biodiversity and Conservation* 34:429–446. https://doi.org/10.1007/s10531-024-02979-7

Garza-Torres HA, Zamora-Tovar C, and Requena-Lara GN. 2024. Áreas naturales protegidas. In: *La biodiversidad en Tamaulipas. Estudio de Estado*. Vol. III. Ciudad de México (MEX): CONABIO; p. 29–35.

Godínez-Gómez O, Schank C, Mas J, and Mendoza E. 2020. An integrative analysis of threats affecting protected areas in a biodiversity stronghold in Southeast Mexico. *Global Ecology and Conservation* 24:e01297. https://doi.

org/10.1016/j.gecco.2020.e01297

Goyenechea Mayer-Goyenechea I, Montiel-Canales G, Márquez J, Hornung-Leoni CT, Castillo-Cerón JM, and Manríquez-Morán NL. 2025. Unraveling Biogeographic Boundaries Within the Sierra Madre Oriental, México: An Endemicity Analysis Using a Taxonomically Diverse Dataset. *Ecology and Evolution* 15:e70779. https://doi.org/10.1002/ece3.70779

Hanson JO, McCune JL, Alamenciak T, and Bennett JR. 2026. Increasing the credibility of conservation plans through citizen science. *Biological Conservation* 313:111552. https://doi.org/10.1016/j.biocon.2025.111552

Hijmans RJ. 2023. *terra: Spatial data analysis*. https://CRAN.R-project.org/package=terra

Hutchinson A, Zito AR, and McGowan PJK. 2025. Pathways for transforming biodiversity governance: An examination of the Global Biodiversity Framework's Considerations. *Ambio* (2025). https://doi.org/10.1007/s13280-025-02215-8

Hutchinson GE. 1957. Concluding remarks. Concluding remarks. *Cold Spring Harbor Symposia on Quantitative Biology* 22:415-427. https://doi.org/10.1101/SQB.1957.022.01.039

Instituto Nacional de Ecología y Cambio Climático [INECC]. 2021. *México ante el cambio climático*. México D.F. (MEX): INECC; march, 2026. [Accessed March 24th, 2026]. https://cambioclimatico.gob.mx/escenarios-de-cambio-climatico/

Instituto Nacional de Estadística, Geografía e Informática, Comisión Nacional para el Conocimiento and Uso de la Biodiversidad and Instituto Nacional de Ecología [INEGI, CONABIO and INE]. 2008. *Ecorregiones Terrestres de México. Escala 1:1,000,000*. México, D. F. (MEX): CONABIO.

Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services [IPBES]. 2019. *Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*. Bonn (DEU): IPBES Secretariat. https://doi.org/10.5281/ZENODO.6417333

León-Paniagua L, García Trejo E, Arroyo-Cabrales J, and Castañeda-Rico S. 2004. Patrones biogeográficos de la mastofauna. In: Luna I, Morrone JJ, and Espinosa D, editores. *Biodiversidad de la Sierra Madre Oriental*. México D.F. (MEX): Las Prensas de Ciencias; p. 469–479.

Lindsø LK, Rivrud IM, König EA, Herland A, and Mysterud A. 2025. Diel Niche of Sympatric Small Mammals Revealed by Year-Round Camera Trapping. *Ecology and Evolution* 15:e71590. https://doi.org/10.1002/ece3.71590

McGowan PJK, Hutchinson A., Brooks TM, Elliott W, Hoffmann M, Mair L *et al.* 2024. Understanding and achieving species elements in the Kunming–Montreal Global Biodiversity Framework, *BioScience* 74(9):614–623. https://doi.org/10.1093/biosci/biae065

McLeod AI. 2022. Kendall: Kendall rank correlation and Mann–Kendall trend test. *R package version*. 2.2.1. https://CRAN.R- project.org/package=Kendall

Moreno C, Reyes JA, and Wallace G. 2015. Corredor ecológico de la Sierra Madre Oriental (CESMO): Conectando voluntades para el desarrollo sustentable en un territorio de alta biodiversidad. *Territorios* 3:23–24.

Morrone JJ. 2020. *The Mexican Transition Zone. A Natural Biogeographic Laboratory to Study Biotic Assembly*. Cham (CH): Springer Cham. https://doi.org/10.1007/978-3-030-47917-6

Mouillot D, Velez L, Albouy C, Casajus N, Claudet J, Delbaret V *et al.* 2024. The socioeconomic and environmental niche of protected areas reveals global conservation gaps and opportunities. *Nature Communications* 15:9007. https://doi.org/10.1038/s41467-024-53241-1

Munguía M., Trejo I, González-Salazar C, and Pérez-Maqueo O. 2016. Human impact gradient on mammalian biodiversity. *Global Ecology and Conservation* 6:79-92. https://doi.org/10.1016/j.gecco.2016.01.004

Nori J, Loyola R, and Villalobos F. 2020. Priority areas for conservation of and research focused on terrestrial vertebrates. *Conservation Biology* 34:1281–1291. https://doi.org/10.1111/cobi.13476

Palfrey R, Oldekop JA, and Holmes G. 2022. Privately protected areas increase global protected area coverage and connectivity. *Nature Ecology & Evolution* 6:730–737. https://doi.org/10.1038/s41559-022-01715-0

Pebesma E and Bivand R. 2023. *Spatial Data Science: With Applications in R*. Chapman and Hall/CRC. https://doi.org/10.1201/9780429459016

Programa de las Naciones Unidas para el Desarrollo and Comisión Nacional de Áreas Naturales Protegidas [PNUD and CONANP]. 2019. *Proyecto Resiliencia.* Áreas Naturales Protegidas. Soluciones naturales a retos globales. México: PNUD and CONANP.

Pulido-Chadid K, Rahbek C, and Geldmann J. 2025. Evaluating protected areas' coverage of threats to terrestrial biodiversity. *Conservation Biology* e70086. https://doi.org/10.1111/cobi.70086

Ramírez-Pulido J and Castro-Campillo A. 1990. Regionalización mastofaunística (mamíferos). Mapa IV. 8. A. In: *Atlas Nacional de México*. Vol III. México: Instituto de Geografía-UNAM

Rahman DA, Sutopo S, Giri MS, Surya RA, Muttaqin M, and Condro AA. 2025. Linking climate vulnerability and future distribution for the threatened lesser-known species, Sumatran serow: A spatial conservation perspective. *Environmental and Sustainability Indicators* 28:100915. https://doi.org/10.1016/j.indic.2025.100915

R Core Team. 2021. *R: A language and environment for statistical computing*. R Foundation for Statistical Computing. V. 2.14.2. Vienna (Austria). https://www.R-project.org/

Revollo-Cadima SG and Salazar-Bravo J. 2024. Identifying areas of conservation importance based on spatial patterns of evolutionary diversity for non-volant small mammals in the Andean Puna. *Journal of Arid Environments* 224:105230. https://doi.org/10.1016/j.jaridenv.2024.105230.

Rey PL, Martin C, and Guisan A. 2024. Conservation importance of non-threatened species through their direct linkages with nature's contributions to people. *Biological Conservation* 297:110733. https://doi.org/10.1016/j.biocon.2024.110733

Rodríguez-Ruíz ER, Arriaga-Flores JC, Márquez-Ruíz MJ, Garza-Torres HA, and Monroy Ojeda A. 2025. Potential geographic distribution of the ornate hawk-eagle (*Spizaetus ornatus*) in Northeastern Mexico: an assessment of environmental suitability and conservation implications. *The Southwestern Naturalist* 69:1–11. https://doi.org/10.1894/0038-4909-69.4.3

Ruíz-Jiménez C, Alcántara O, and Luna I. 2004. Límites. In: Luna I, Morrone JJ, and Espinosa D, editores. *Biodiversidad de la Sierra Madre Oriental*. México D.F. (MEX): Las Prensas de Ciencias; p. 7–24.

Sarukhán J and Jiménez R. 2016. Generating intelligence for decision making and sustainable use of natural capital in Mexico. *Current Opinion in Environmental Sustainability* 19:153–159. https://doi.org/10.1016/j.cosust.2016.02.002

Secretaría del Medio Ambiente y Recursos Naturales [SEMARNAT]. 2010. Modificación del Anexo Normativo III, Lista de especies en riesgo de la Norma Oficial Mexicana NOM-059-SEMARNAT-2010, Protección ambiental-Especies nativas de México de flora y fauna silvestres-Categorías de riesgo y especificaciones para su inclusión, exclusión o cambio-Lista de especies en riesgo, publicada el 30 de diciembre de 2010. In: *Diario Oficial de la Federación, 14 de noviembre de 2019*. Ciudad de México (MEX): Gobierno de México; p 32–134.

Secretaría del Medio Ambiente y Recursos Naturales, Comisión Nacional de Áreas Naturales Protegidas, and World Wildlife Fund Mexico [SEMARNAT, CONANP, and WWF Mexico]. 2025. *Roadmap to meet or exceed Target 3 of the Global Biodiversity Framework in Mexico*. Ciudad de México (MEX): SEMARNAT, CONANP and WWF Mexico.

Sosa M and Ivanova A. 2025. Assessment of financing for biodiversity conservation in Mexico: links between biodiversity and climate change adaptation funds. *Diversity* 17:2–24. https://doi.org/10.3390/d17030185

Steigerwald E, Chen J, Oshiro J, Vredenburg VT, Catenazzi A, and Koo MS. 2024. Microreserves are an important tool for amphibian conservation. *Communications Biology* 7:1177. https://doi.org/10.1038/s42003-024-06510-0

Thompson KL, Chase JM., Remelgado R, Meyer C. 2025. The interacting effects of climate and land-cover change on bird communities in the United States. *Ecography* e07949. https://doi.org/10.1002/ecog.07949

Thuiller W, Guéguen M, Renaud J, Karger DN, and Zimmermann NE. 2019. Uncertainty in ensembles of global biodiversity scenarios. *Nature Communications* 10:1446. https://doi.org/10.1038/s41467-019-09519-w

Ureta C, Ramírez-Barrón M, Sánchez-García EA, Cuervo-Robayo AP, Munguía-Carrara M, Mendoza-Ponce A *et al.* 2022. Species, taxonomic, and functional group diversities of terrestrial mammals at risk under climate change and land-use/cover change scenarios in Mexico. *Global Change Biology* 28:6992–7008. https://doi.org/10.5281/zenodo.7027856

Urquiza-Haas T, Tobón W, Kolb M, Lira-Noriega A, Contreras V, Alarcón J, and Koleff P. 2019. Assessing best practice for selecting surrogates and target–setting methods in a megadiverse country. *Animal Biodiversity and Conservation* 42:187–202. https://doi.org/10.32800/abc.2019.42.0187

Verde-Arregoitia LD. 2016, Investigating extinction risk in mammals. *Mammal Review* 46:17–29. https://doi.org/10.1111/mam.12049

Wang F, Shao W, Yu H, Kan G, He X, Zhang D *et al.* 2020. Re-evaluation of the Power of the Mann-Kendall Test for Detecting Monotonic Trends in Hydrometeorological Time Series. *Frontiers in Earth Science* 8:14. https://doi.org/10.3389/feart.2020.00014

Zaragoza-Quintana EP, Cotera-Correa M, Scott-Morales LM, and Pando-Moreno M. 2012. Uso histórico del pastizal en las áreas naturales protegidas para el perrito llanero mexicano (*Cynomys mexicanus*) en Nuevo León, México. In: Cervantes F and Ballesteros-Barrera C, editores. *Estudio sobre la biología de roedores silvestres mexicanos*. México D.F. (MEX): Universidad Nacional Autónoma de México, Universidad Autónoma Metropolitana. p. 105–115.

Zaragoza-Quintana EP, Cotera-Correa M, Scott-Morales LM, Pando-Moreno M, Estrada-Castillón AE, and González-Rodríguez H. 2022. Salud del ecosistema de pastizal y biomasa en áreas naturales protegidas para el perrito llanero mexicano (*Cynomys mexicanus*) en Nuevo León, México. *Acta Universitaria* 32:1–19. https://doi.org/10.15174/au.2022.3495

Zúñiga AH, Rau JR, Jaksic FM, Vergara PM, Encina-Montoya F, and Fuentes-Ramírez A. 2021. Rodent assemblage composition as indicator of fire severity in a protected area of south-central Chile. *Austral Ecology* 46:249–260. https://doi.org/10.1111/aec.12975

Zurell D, Bocedi G, Velazco SJE, Gonzalez A, Purvis A, Wintle B *et al.* 2025. Predicting the way forward for the Global Biodiversity Framework. *Proceedings of the National Academy of Sciences* 122:e2501695122. https://doi.org/10.1073/pnas.2501695122

Associated editors: Giovani Hernández Canchola and Pablo Colunga Salas
Submitted: January 5, 2026; Reviewed: March 5, 2026
Accepted: May 8, 2026; Published online: May 29, 2026