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CONSERVATION PRIORITIES FOR MAMMALS IN MEGADIVERSE MEXICO: THE EFFICIENCY OF RESERVE NETWORKS

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Abstract. A major goal of conservation biologists is to identify critical areas for the conservation of biological diversity and then strategically include them in an efficient system of reserves. In general, however, reserve networks have been selected for different objectives, and most countries lack an evaluation of their reserves' ability to represent a percentage of the national diversity. This paper evaluates the effectiveness of a network of reserves to represent the species of mammals in Mexico. The focus of the analyses is on species and site level, evaluating the representation of all terrestrial mammals in the 30 most important reserves. The representation of all species, endemic species, endangered species, and species with restricted distributions in the reserves was assessed and compared. Endemic or endangered species with restricted distributions were expected to be less represented in reserves than were widespread species. The most important reserves for the conservation of mammals were determined with the use of complementarity analyses. Priority sites for the representation of all the species currently absent from the reserve network were then selected.

The results have broad applications for conservation. First, 82% of the mammal species from Mexico were represented in the reserve network, which covers a small portion (3.8%) of the country. Second, this percentage is certainly larger as several reserves were not evaluated due to a lack of data. A priority for a national conservation strategy could be to conduct biological surveys in those reserves lacking inventories to evaluate their contribution to conservation. Third, in spite of its demonstrated value, Mexico's reserve network can be improved by designating complementary areas. Additional priority sites, where reserves are required to represent most gap species in the network, were identified. Finally, it is clear that this reserve network has limitations for maintaining biodiversity and ecosystem services at regional scales. A comprehensive conservation strategy has, therefore, to incorporate mechanisms that enhance the value of human-dominated landscapes for the maintenance of biodiversity.

Key words: biological diversity; complementarity analysis; conservation of mammalian diversity; endemism; Mexican mammals; nature reserves; priorities for conservation; reserve networks; restricted geographic ranges; species distribution trends; species endangerment.

INTRODUCTION

The explosive growth of human population is causing a major global environmental crisis: the loss of biological diversity. Extinction rates have steadily increased in recent decades, and thousands, perhaps hundreds of thousands, of populations and species could become extinct unless effective conservation strategies are implemented (Ehrlich and Ehrlich 1981, Chanell and Lomolino 2000, Ceballos and Ehrlich 2002, Millenium Ecosystem Assessment 2005). A major strategy implemented by most countries to protect ecosystems and species, has been the establishment of protected areas such as national parks, biosphere reserves, and wildlife sanctuaries. In most cases, protected areas have been selected on an ad hoc basis, taking advantage of available opportunities, so the effectiveness of the strategy in terms of percentage of a country's protected species is usually unknown (Rodrigues et al. 2004, Ceballos et al. 2005).

In recent years, considerable efforts have been made to develop methods to select priority areas for conservation. The results of prioritization studies have been used as guidelines to allocate limited funds and other resources in strategic ways (Caldecott et al. 1996, Dobson et al. 1997, Ceballos et al. 1998, Margules and Pressey 2000, Fairbanks et al. 2001, Rodrigues and Gaston 2002, Faith et al. 2003, Kerley et al. 2003). Patterns of species distribution provide an underlying framework to determine priorities for conservation. Two examples are mentioned here. First, the distribution of life on Earth is not homogeneous and certain environmental features correlate to species richness, therefore some regions have more species than are others (e.g., Rosenzweig 1996, Brown and Lomolino 1998). Second, most species have relatively restricted geographic ranges, and those species are more prone to extinction than are widespread species (Terborgh and Winter 1980, Lawton 1993, Gaston and Blackburn 1996). When biodiversity protection is the main goal, areas are selected as top

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TABLE 1. Species richness and numbers of endemic species, area-restricted species, endangered species, and protected species in the orders of Mexican terrestrial mammals.

Order	Inventoried mammalian species					
	Species richness	Endemic species†	Area-restricted species‡	Extinct species	Endangered species§	Protected species (%)
Didelphimorphia	8	1	0	0	2	8 (100)
Insectivora	24	11	11	0	5	15 (62)
Chiroptera	138	15	9	0	5	126 (91)
Lagomorpha	14	7	7	0	3	12 (86)
Rodentia	227	109	88	6	42	148 (65)
Xenarthra	4	0	1	0	2	4 (100)
Primates	3	0	0	0	3	3 (100)
Carnivora||	33	3	2	4	14	27 (81)
Artiodactyla	10	0	0	1	4	9 (90)
Perissodactyla	1	0	0	0	1	1 (100)
Total	462	146	118	11	81	353 (76)

† Distribution exclusive to Mexico.
‡ Geographic range in Mexico $< 20\,000$ km^2.
§ Endangered species include all species classified as endangered and threatened species in the Mexican official list (SEMARNAT 2002) and critically endangered, endangered, and threatened species from IUCN (2005).
|| Excludes marine (pinniped) species, of which the Caribbean monk seal (*Monachus tropicalis*) is extinct.

priorities for conservation because of their high species richness or high concentrations of endemic, geographically restricted, or endangered species (e.g., Pressey et al. 1993, Sisk et al. 1994, Williams et al. 1996, Van Jaarsveld et al. 1998, Margules and Pressey 2000, Rodrigues et al. 2004, Ceballos et al. 2005).

Biodiversity loss is severe in tropical and developing countries. Mexico is not an exception. It is considered a *megadiverse* country because it maintains populations of ~10% of all extant species (Mittermeier et al. 1997), and it ranks second or third in the number of species of mammals (Ceballos and Brown 1995, Ceballos et al. 2002). However, the country faces severe environmental problems that have caused the extirpation (i.e., extinction within Mexico, but the species is present elsewhere) or extinction of at least 44 vertebrates, including at least 12 species of mammals (Ceballos and Navarro 1991, Ceballos and Oliva 2005). In Mexico, conservation strategies to minimize the loss of biodiversity have focused on protecting both locations and species, through the National Protected Areas System (NAPAS) and the National Endangered Species Act (SEMARNAT 2002), respectively. However, there has been no evaluation of the effectiveness of the NAPAS in terms of the percentage of the country's mammalian species represented in its 140 nature reserves.

In order to assess the effectiveness of the NAPAS to protect the mammal fauna of Mexico, a data set of the mammals in 30 major reserves was compiled. Previous studies (Ceballos et al. 1998) found that endemic, restricted, and endangered species had, on average, smaller geographic ranges than other Mexican mammals, so differences among various groups of species were expected. Second, an evaluation of the mammalian species richness of the 30 chosen reserves was made, and the priorities for conservation among these reserves were determined. It was expected that a small set of reserves would maintain most of the mammal species, and that additional reserves would represent few species and would be necessary to maintain more than one occurrence of every species of mammal. Finally, the distribution of non-protected species (also termed "gap species," Rodrigues et al. 2004) was analyzed, and additional priority areas to increase the representation of gap species of mammals in Mexico were identified. This paper addresses the following issues: (1) How effective is the reserve network in representing all Mexican mammalian species? (2) Are priority species (i.e., endangered, endemic, and area-restricted species) well represented in those reserves? (3) Which are the most important established reserves? (4) Which additional, currently unprotected regions, should be prioritized for selection as reserves to represent the gap mammal species?

METHODS

A database of the 462 Mexican species of terrestrial mammals was compiled from the literature (Ceballos et al. 2002, Ceballos and Oliva 2005; Table 1). Eleven species considered extinct or extirpated were excluded from all analyses. Endemic species were those with a distribution exclusive to Mexico. Species were classified as either "restricted" (referred hereafter as "area-restricted species") or "widespread" if their geographic range in Mexico was smaller or larger than 20 000 km^2, respectively; this represents the first quartile in the mammals of Mexico species-range distribution. The first quartile is often used to determine area-restricted species (Gaston 1994). Endangered species included all species classified as threatened and endangered in the official endangered species act (Ceballos and Navarro 1991, SEMARNAT 2002). Species in the different group categories overlap. Some endemic and/or endangered species are also area-restricted species, and some endangered species are also endemic and/or area-restricted species.

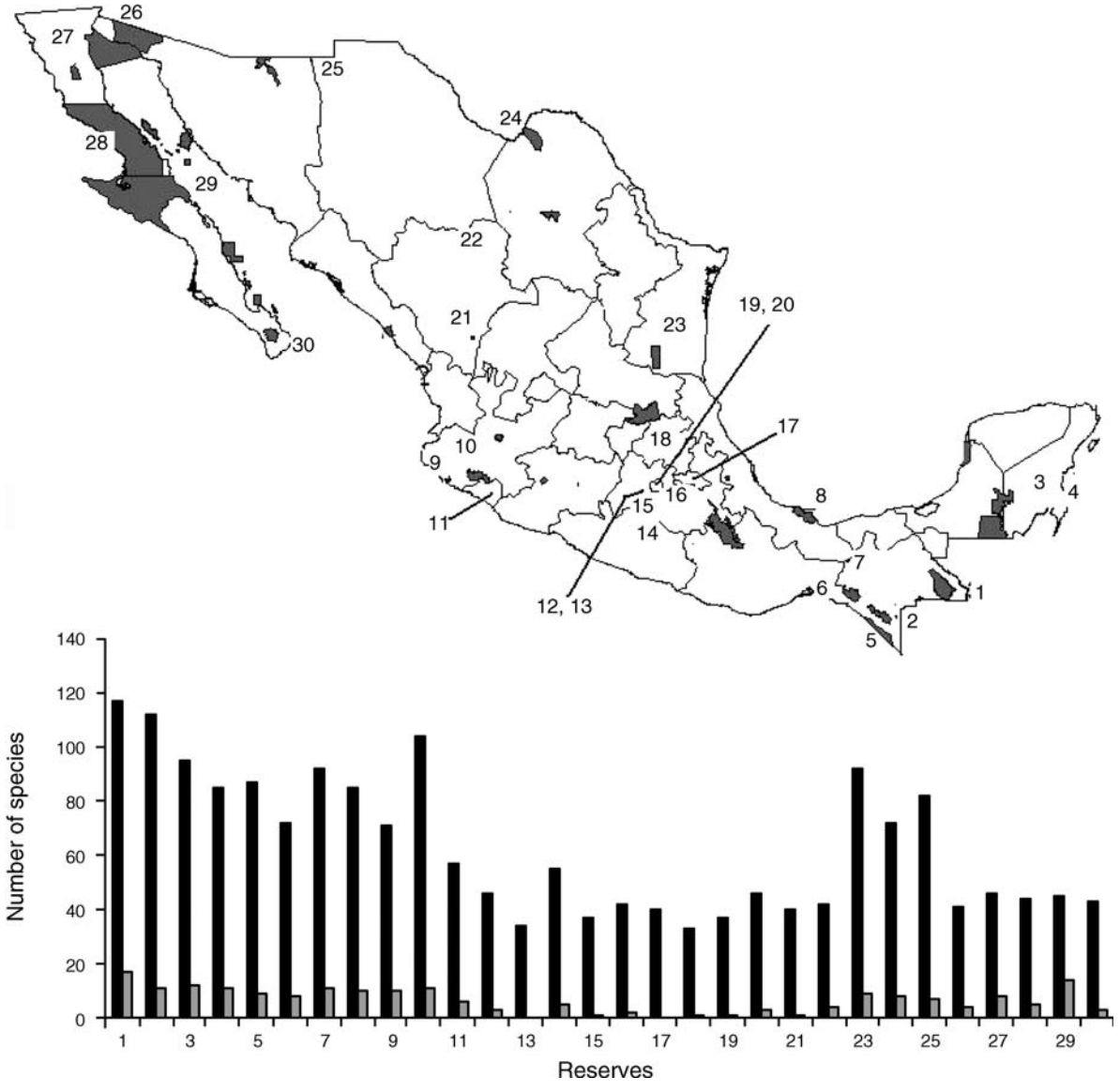

FIG. 1. Geographic location in Mexico of the 30 reserves assessed in this study (see Table 3 to identify the reserves by name). The bottom graph indicates both the total number of species (black bars) and species at risk (gray bars) in each reserve.

A compilation of checklists from the literature of mammals from 30 major reserves that have field inventories was made (Fig. 1). These 30 reserves were also selected because both the Ministry of the Environment (SEMARNAT) and the National Commission on Biodiversity (CONABIO) consider them among the most important to protect the biodiversity of Mexico.

To evaluate the effectiveness of the reserve network in representing the mammalian fauna of Mexico, the number of species either present or absent in the 30 selected reserves was compared. Once the species absent from these reserves were determined, we assessed if these species were represented in additional reserves without complete mammal inventories, using a 100 000 locality-record database of Mexican mammals (Ceballos and Oliva 2005). Finally, the distribution ranges of the species absent from all reserves from an atlas of Mexican mammals were digitalized (Ceballos and Oliva 2005) and a GIS project was created using ArcView 3.1 (ESRI 1998) to identify the regions where these species are concentrated.

The 30 evaluated reserves were compared in terms of species richness, endemic species, area-restricted species, and species at risk, determining their conservation priority. Using the MARXAN algorithm (*available online*),[2] (Kirpatrick et al. 1983, Possingham et al. 2000, Leslie et al. 2003); we analyzed the complementarity of reserves to protect at least one occurrence of the different categories of mammals; i.e. all species, endemic

[2] ⟨http://www.ecology.uq.edu.au/index.html?page=27710⟩

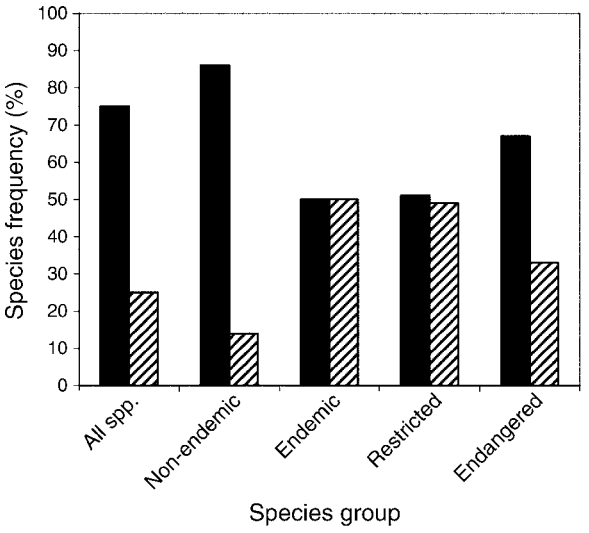

FIG. 2. Mammal species represented (solid bars) and not represented (hatched bars) in 30 reserves in Mexico. Altogether, 353 species were represented in these reserves. Endemic species, endangered species, and species with restricted distributions were underrepresented when compared to non-endemic, non-endangered, and widespread species, respectively.

species, restricted species, and endangered species. Under a complementarity analysis, reserves are chosen iteratively with the goal of efficiently achieving representation of all species in a particular target group (see Justus and Sarkar [2002] for a review). In the complementarity analysis for all species, for example, the first area chosen was the most species rich. The second area chosen contained the greatest number of species not already represented in the first area (the most complementary), and so on until all species were represented. In case of a tie among two or more reserves, the reserve that had either more endemic, restricted, or endangered species was selected. The same procedure was followed to select reserves for endemic, restricted, or endangered species exclusively. Finally, additional priority areas for conservation (i.e., areas not currently protected) were identified using data on distribution patterns of species not represented in existing reserves. Distribution maps of these species were overlaid on a grid of 50-square-kilometer cells. All species occurring in each cell were recorded. The most important areas required as reserves to maximize the inclusion of gap species in the reserve network were selected using a complementarity analysis.

RESULTS

Effectiveness of the reserve network

Mexican mammals include 462 non-marine species representing 10 orders (Table 1). The number of endemic species is 146, while the number of species with restricted distributions is 118. There are 81 endangered species. The effectiveness of the reserve network in representing all species of Mexican mammals was surprisingly high, because 353 species, representing 76% of the country's terrestrial mammals, were recorded in reserves covering only 3.8% of the national territory (Fig. 2, Table 1). An additional 26 species were located in reserves lacking complete mammalian inventories, raising the number of known mammals in the National Protected Areas System (NAPAS) to 82% (Table 2). The percentage of protected species per order varied from 100% (e.g., primates) to 62% (i.e., insectivores). Rodents had the largest number of species not represented in protected areas (79 spp., 35%). Each protected species was found, on average, in five of all the reserves, but there was considerable variation (Fig. 3). Thirty percent of all protected species were found in only one reserve, whereas two species (the raccoon, *Procyon lotor*, and the gray fox, *Urocyon cinereoargenteus*) were recorded in 28 reserves. Medium-bodied and large species like the coyote (*Canis latrans*) were represented in more reserves than the smaller species, and most (94%) of the species not represented in reserves had low body masses (<1 kg). At a generic level, most taxa were protected in reserves. However, four genera (including three bats and one rodent), and 74 species, including 57 (77%) endemic species, were not represented in any reserve. There were 80 endemic (55% of the total endemic species), 53 (45%) restricted, and 87 (59%) endangered species represented in reserves (Table 2).

Which are the most important established reserves?

There was substantial disparity in the number of species protected in each reserve, varying from a minimum of 33 in El Chico to a maximum of 117 in Montes Azules, with an average of 63 (SD = 25; Table 2). Reserves with the highest species richness (e.g., Calakmul) were located in tropical forests in southern Mexico, while reserves with medium and low species richness (e.g., Vizcaino, Ajusco) were located in temperate ecosystems in central and northern Mexico. Reserves that contain both tropical and temperate species (e.g., El Cielo, Janos, El Triunfo, and Maderas

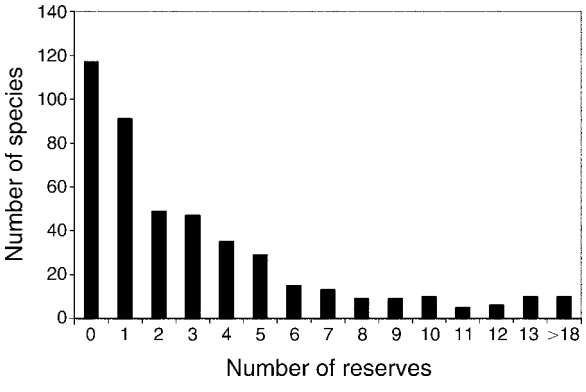

FIG. 3. Frequency distribution of mammal species represented in different numbers of reserves. Note that many species were represented in few reserves and few species were represented in many reserves.

TABLE 2. Characteristics and mammalian species inventory information for the 30 major reserves in Mexico, in order of decreasing species richness.

Reserve					Inventoried species		
Name	I.D. no.†	Area (ha)	Biome‡	Species richness	Endangered species	Endemic species	Restricted species
Tropical reserves							
Montes Azules	1	331 200	TRF	117	17	2	15
El Triunfo	2	119 177	CLF	112	11	5	11
Manantlan	10	139 577	TDF/TCF	104	11	18	6
Calakmul	3	723 185	TRF	95	12	1	4
El Cielo	23	144 530	CLF	92	9	6	4
El Ocote	7	101 288	TRF	92	11	3	5
La Sepultura	5	167 310	TDF	87	9	5	4
Los Tuxtlas	8	155 122	TRF	85	10	4	3
Sian Ka'an	4	528 148	TRF	85	11	2	6
La Encrucijada	6	144 868	MWE	72	8	2	8
Chamela-Cuixmala	9	13 142	TDF	71	10	17	3
Temperate reserves							
Janos	25	500 000	GRS	82	7	1	3
Maderas del Carmen	24	208 381	TCF	72	8	2	3
Nevado de Colima	11	9600	TCF	57	6	10	3
Omiltemi	14	4000	TCF	55	5	4	3
Ajusco	20	920	TCF	46	3	9	4
Nevado de Toluca	12	46 784	TCF	46	3	9	5
San Pedro Martir	27	72 911	TCF	46	8	2	10
Islas del Golfo	29	321 631	TES	45	14	20	18
Vizcaino	28	2 493 091	TES	44	5	4	6
La Laguna	30	112 437	TCF	43	3	3	2
Mapimi	22	342 388	TES	42	4	2	0
Popo-Izta	16	90 284	TCF	42	2	9	4
El Pinacate	26	714 557	TES	41	4	0	3
La Malinche	17	45 711	TCF	40	0	5	3
Michilia	21	9325	TCF	40	1	5	2
Zempoala	15	4790	TCF	37	1	9	4
Zoquiapan	19	19 418	TCF	37	1	9	4
Desierto de los Leones	13	1529	TCF	33	0	5	3
El Chico	18	2739	TCF	33	1	2	0
Total				353§	87	80	53

† The identification number refers to the Fig. 1 map showing locations of the 30 analyzed reserves.

‡ Tropical biomes are: TDF, tropical dry forest; TRF, tropical rain forest; MWE, mangroves and wetlands; and CLF, cloud forest. Temperate biomes are: TCF, temperate conifer forest; TES, temperate scrubs; and GRS, temperate grasslands.

§ There were 26 species found in additional reserves lacking complete mammal inventories.

del Carmen) had higher species richness than other reserves in the same geographic region. The evaluated reserves comprise an area of more that 7×10^6 ha, equivalent to 3.8% of the country's territory. The size of the reserves varied from $>2.5 \times 10^6$ ha in Vizcaino to <1000 ha in El Ajusco. Most reserves were larger than 50 000 ha (Table 2). Reserve area was not correlated with species richness, mainly because there are large reserves in temperate regions (e.g., Vizcaino) with few species and small reserves in tropical regions (e.g., Chamela-Cuixmala) with a relatively large number of species ($r^2 = 0.27$).

The number of endemic and restricted species in the reserves was quite variable also. Although the average number of endemic species in each reserve was 6 species, the number of endemic species ranged from 0 species in one reserve to 18 species in both the dry forest reserves of Chamela-Cuixmala and Manantlan reserves (Table 2). Altogether 53 (45%) restricted species were found in reserves. The number of restricted species in a reserve varied from 0 in places such as El Pinacate to 14 species in the Islas del Golfo reserve. Endangered species were found in almost all reserves but the number in a specific reserve varied from 0 in places such as La Malinche to 17 species in Montes Azules (Table 2).

Comparison of reserve priority, using both species richness and endemic and endangered species

Complementarity analysis using species richness showed interesting trends. First, most (95%) of the protected mammal species were concentrated in 10 reserves (Fig. 4, Table 3). An additional 14 reserves that contained <5 additional species each are needed to represent all protected species in at least one reserve. The five reserves contributing the greatest number of species collectively represented the major Mexican biomes, i.e., tropical rain forests (Montes Azules), temperate grasslands (Janos), tropical dry forests (Manantlan), temperate dry scrubs (Islas del Golfo), and temperate conifer forests (Ajusco).

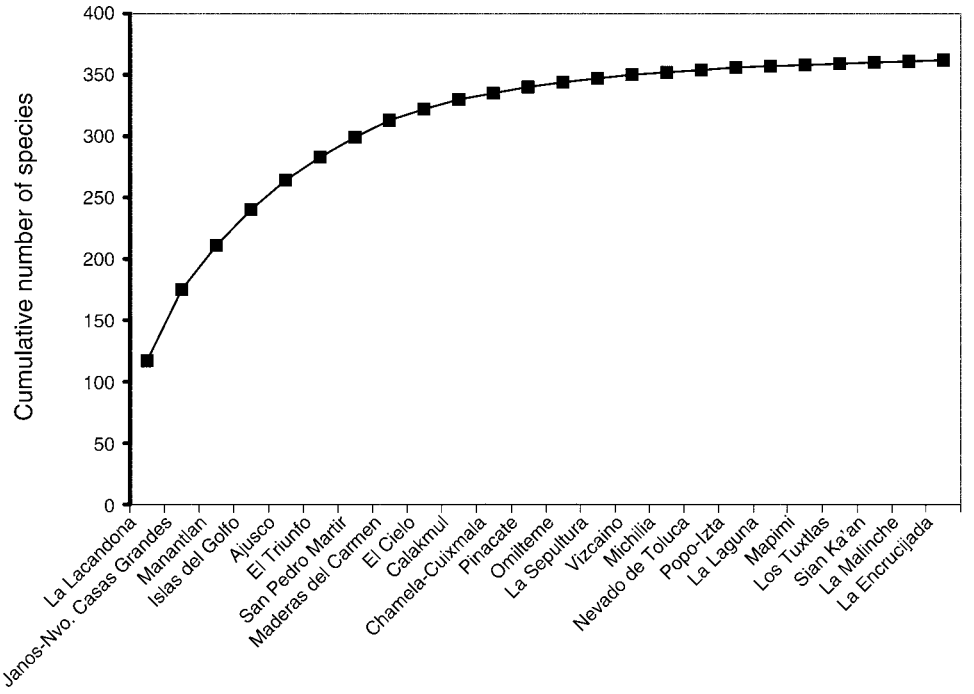

FIG. 4. Results of complementarity analyses of major reserves in Mexico based on their mammalian species richness.

The 17 reserves required to represent all endemic species at least once was fewer than the 24 reserves needed to represent all species. Similar to the pattern observed with species richness, the set of reserves that contributed the largest number of endemic species represented the major biomes in Mexico. Tropical dry forests, represented by reserves such as Chamela-Cuixmala, had the largest number of endemic species, followed by insular temperate scrubs (i.e., Islas del Golfo; see Plate 1), temperate forests (i.e., Nevado de Toluca), and tropical rain forests (i.e., Los Tuxtlas). With the exception of Islas del Golfo, the five most important reserves in terms of representation of endemic species were also among the most important reserves in terms of representation of total species richness.

Fifteen reserves were needed to represent the full complement of species with restricted distributions. The five reserves contributing the greatest number of restricted species slightly overlap with the reserves that contributed the greatest number of species or endemic species. Only one reserve (Islas del Golfo) was among the five most important in all three analyses, and one (Nevado de Toluca) fell among the top five in analyses of both endemism and restricted species.

All endangered species were represented by a set of 10 reserves, which included five reserves consistently

TABLE 3. Reserves lacking comprehensive mammal inventories, but harboring species of mammals in addition to those in the reserves listed in Table 2.

Reserve name and location (state)	Biome†	Species
Bonampack (Chiapas)	TRF	*Micronycteris nicefori*
Cofre de Perote (Veracruz)	TCF	*Neotoma nelsoni, Peromyscus mekisturus*
Cozumel (Quintana Roo)	TRF	*Procyon pygmaeus*, *Reithrodontomys spectabilis*
Islas Marias (Nayarit)	TDF	*Myotis findleyi, Oryzomys nelsoni, Peromyscus madrensis, Sylvilagus graysoni*
Lagunas de Montebello (Chiapas)	TCF	*Cryptotis goodwini, Peromyscus guatemalensis, P. zarhynchus, Reithrodontomys tenuirostris*
Laguna Madre (Tamaulipas)	MWE	*Dipodomys compactus, Geomys personatus, Oryzomys palustris, Lutra canadensis*
Mariposa Monarca (Michoacán, México)	TCF	*Nelsonia goldmani*
Tancitaro (Michoacán)	TCF	*Cratogeomys fumosus*, *Zygogeomys thrichopus*, *Peromyscus sagax*
Salamayuca (Chihuahua)	TES	*Geomys arenarius, Perognathus flavescens*
Sierra de Juárez (Baja California)	TCF	*Scapanus latimanus*, *Sciurus griseus*
Sierra de los Ajos (Sonora)	TCF	*Sciurus arizonensis*

† The main biome where each reserve is located. Tropical biomes are: TDF, tropical dry forest; TRF, tropical rain forest; MWE, mangroves and wetlands; and CLF, cloud forest. Temperate biomes are: TCF, temperate conifer forest; TES, temperate scrubs; and GRS, temperate grasslands.

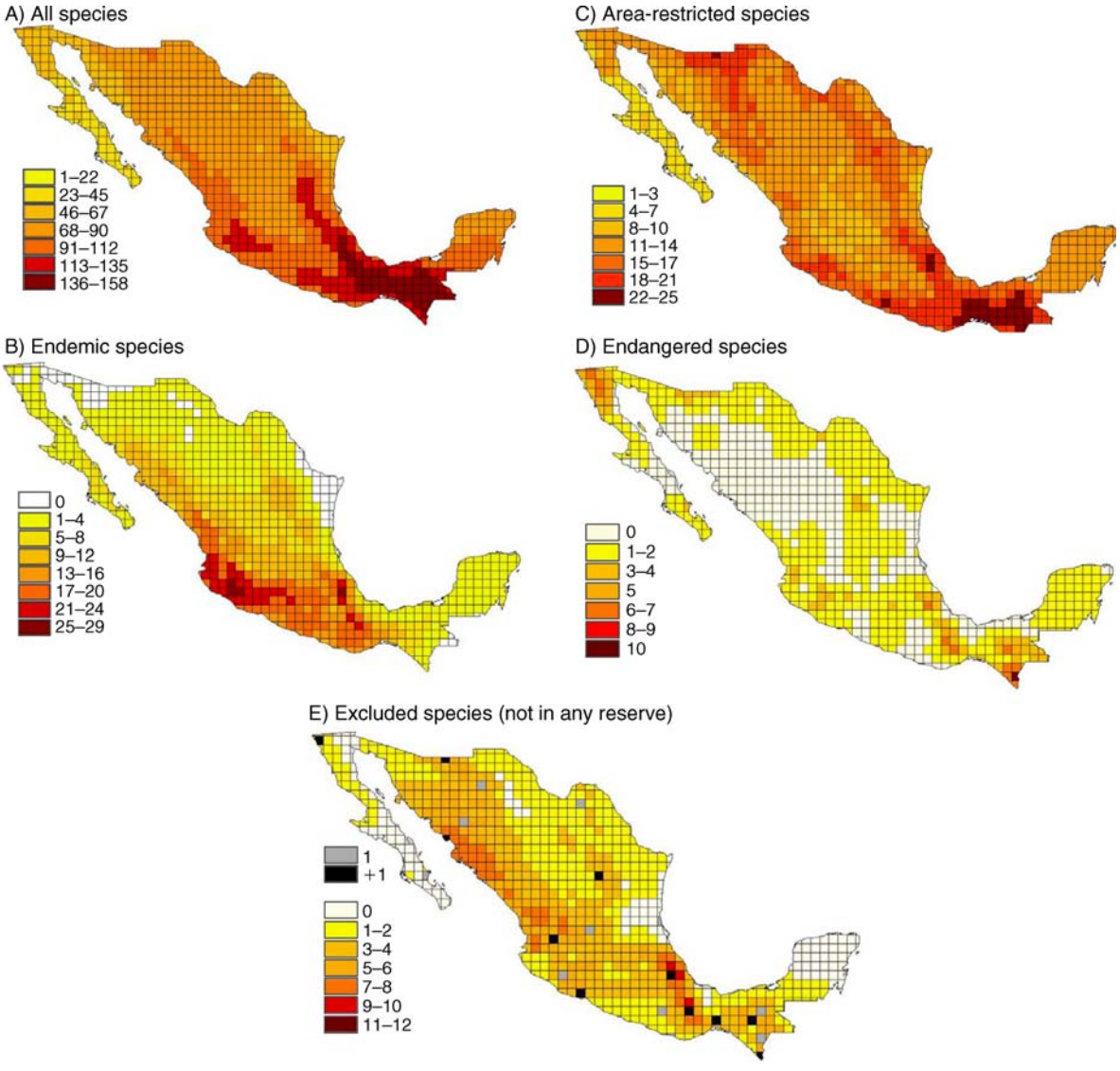

FIG. 5. Distribution patterns of Mexican species of mammals: (A) all 462 species; (B) 146 endemic species; (C) 118 area-restricted species; (D) 81 endangered species; (E) 74 species not currently represented in any of the analyzed reserves in Mexico. Different shades on the map indicate the number of species per grid cell (0.5° latitude × 0.5° longitude), which, for unrepresented species, varied from 0 to 12 species. In (E), priority areas for the conservation of the 74 currently unrepresented mammal species are indicated by gray and black squares; the 12 cells in black would protect 80% of these species.

appearing in other complementarity analyses. The latter five reserves were located in tropical rain forests (Montes Azules), insular arid scrubs (Islas del Golfo), temperate forests and grasslands (San Pedro Martir and Janos, respectively), and tropical dry forests (Chamela-Cuixmala).

Which additional unprotected regions should be a priority for selection as reserves to represent the gap mammal species?

Species without protection were distributed throughout Mexico with the exception of both the lower Baja California and Yucatan peninsulas (Fig. 5). Several regions were, however, outstanding in terms of their high concentration of species without protection. It was predicted, and later confirmed, that because of the restricted distributions of many species not represented in reserves, the number of additional areas required to represent all of the unprotected species would be high. Complementarity analyses showed that 25 (0.5° × 0.5°) cells were required to represent the 74 species currently not represented in reserves (Fig. 5D). Interestingly, the 12 most diverse cells (Fig. 5E: black cells) represented 80% of the species, and were located in the Baja California Peninsula, Chihuahua, Sinaloa, Zacatecas, Nayarit, Jalisco, Veracruz, Oaxaca, and Chiapas. A few

PLATE 1. (Left) Isla Espiritu Santo, located in the Gulf of California, is part of the Islas del Golfo Biosphere Reserve. The island is covered with scrubland and maintains two endemic species of mammals, including (right) the Espiritu Santo jackrabbit (*Lepus insularis*). Photo credit: G. Ceballos.

cells maintain a large number of species (Table 4); for example, Valle del Oriental, a cell in the states of Puebla and Veracruz, maintained populations of the Perote ground squirrel (*Spermophilus perotensis*), a deer mouse (*Peromyscus bullatus*), and the Phillips kangaroo rat (*Dipodomys phillipsi*). Another cell in Sierra de Juárez, Oaxaca, represented 8 species (*Habromys chinanteco*, *H. ixtlani, H. lepturus, Rheomys mexicanus, Megadontomys cryophilus, Microtus oaxacensis, Microtus umbrosus,* and *Peromyscus melanocarpus*).

DISCUSSION

Are ad hoc reserve networks useful for conservation?

This study has shown that Mexico's reserve network (NAPAS) provides protection to a large number of mammal species. This is a very important finding regarding conservation, especially when considering that the NAPAS has been put together over more than seven decades, a period during which the objectives, data availability, and methodologies to assess conservation priorities have changed dramatically. Similar trends have been found in other countries and regions in Africa, Australia, America, and Europe (e.g., Lombard et al. 1995, Howard et al. 2000, Justus and Sarkar 2002, Deguise and Kerr 2006). Some conservation lessons are straightforward. First, national strategies for networks of protected areas can be improved or complemented by using the existing nature reserves as a baseline. Second, the biodiversity of such reserves has to be evaluated with quantitative methods. Third, in the absence of data, a priority for a national conservation strategy could be to conduct biological surveys in the existing reserves. For example, in Mexico there are more than 80 additional reserves in the NAPAS network that would certainly contribute to increase the number of species and populations of mammals in the matrix of habitats protected in the country. Conservation "must" direct funds to promote inventories in these reserves (see also Ceballos et al. 1998). Finally, as more data on mammal (or other taxa) inventories for some of these reserves become available, additional evaluations and analyses can be carried out to redefine conservation priorities.

Can the selection of priority sites for conservation be improved?

Despite its demonstrated value, it is clear that Mexico's current NAPAS network has gaps. The protection of several populations of each species, focusing on the representation of the taxa most prone to extinction, should be the major goal of a comprehensive conservation strategy of Mexican mammals. Presently the NAPAS include 82% of the country's mammal species, and most species are represented by only one or two occurrences. The species best represented in reserves, like the coyote, have widespread distributions and their populations are generally favored by human activities.

TABLE 4. Most relevant sites needed for increasing the number of mammal species represented in Mexico's NAPAS (National Protected Areas System).

Site	State	Species
Pacific lowlands	Sonora, Sinaloa	*Neotoma phenax, Chaetodipus artus, C. pernix, Reithrodontomys burti*
San Cristóbal de las Casas	Chiapas	*Sorex stizodon, S. sclateri, Oryzomys rhabdops, O. saturatior, Peromyscus aztecus, Microtus guatemalensis*
Sierra de Juárez	Oaxaca	*Habromys chinanteco, H. ixtlani, H.lepturus, Rheomys mexicanus, Megadontomys cryophilus, Microtus oaxacensis, M. umbrosus, Peromyscus melanocarpus*
Valle del Oriental	Puebla, Veracruz	*Spermophilus perotensis*, *Peromyscus bullatus*, *Dipodomys phillipsi*

The two groups of species of high conservation priority are endangered species and endemic and non-endemic species with restricted geographic ranges (Mungo et al. 1995, Arita et al. 1997, Ceballos et al. 1998). A sound conservation strategy should try to maximize the number of these species represented in the NAPAS (e.g., Kerr 1997, Margules and Pressey 2000, Deguise and Kerr 2006). The implementation of such a strategy is complex because these species have, in general, extremely small geographic ranges, little overlap among their distributions, and are dispersed throughout the country. How can this scenario be improved under severe financial and social constraints? The analyses presented here have important implications in the design of a general conservation strategy. In terms of species richness, endemism, and threat, it is possible to determine solid priorities to complement the existing reserve network, and to identify a set of potential reserves to increase the number of protected mammal species. I believe that this is a major breakthrough for developing countries like Mexico, because the efficient selection of additional protected areas can be done on the basis of solid, quantitative data.

Are reserves enough to preserve biodiversity?

Protecting biodiversity in reserves is not enough because biodiversity (e.g., populations) also lies outside protected areas. Any conservation strategy needs, therefore, to consider protected areas as one of several complementary approaches required to maintain mammals in particular and biodiversity in general. The results presented here indicate that most species have few representations in protected areas. Clearly, including more mammal species and other taxa will only reinforce this trend. Networks of protected areas have to be complemented with sound management of regions outside the reserves, which could increase the number of surviving populations, and the provision of ecosystem services (Daily 1997). There are currently many examples of the potential of human-dominated landscapes to maintain a percentage of the historic biodiversity (Daily et al. 2003). However, it is still not clear if this trend of surviving species will hold for many decades.

Concluding remarks

In Mexico, a sound conservation strategy should include the consolidation of the existing network of reserves, complementing it with additional reserves, and recognizing that reserves are not enough and that, therefore, the management of the seminatural matrix (i.e. countryside biogeography or human dominated landscapes) is required. Perhaps we still are in time to avert a major population and extinction crisis and its consequences on human well-being.

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