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Source: *Conservation Biology*, Jun., 1995, Vol. 9, No. 3 (Jun., 1995), pp. 559-568
Published by: Wiley for Society for Conservation Biology
Stable URL: https://www.jstor.org/stable/2386610

Global Patterns of Mammalian Diversity, Endemism, and Endangerment

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Abstract: *To assess the conservation status of the world's land mammals, we compiled data on the number of total species, endemic species, recently extinct species, and currently endangered species for 155 countries. Total species richness was significantly correlated with territorial land area, whereas number of endemic species was only weakly correlated with both area and total number of species. The large amount of variation left unexplained by species-area regressions reflects the influence of other factors, such as latitude, topographic and habitat heterogeneity, and historical biogeography, on species richness and especially on patterns of endemism. Countries of particular conservation concern, because they have rich mammalian faunas containing many endemic species, are the large islands of Australia, Madagascar, Indonesia, and the Philippines, as well as continental Mexico. Patterns of recent extinctions and the current endangered status of species were difficult to interpret, largely because of inadequate and inconsistent data. The majority of officially listed endangered species are large, well known, and popular mammals, such as primates, ungulates, and carnivores, whereas the majority of species known to have gone recently extinct and likely to be currently threatened are small and inconspicuous, such as rodents and bats. Our work not only illustrates the role of ecological, evolutionary, and biogeographic processes in the origin and maintenance of land mammal diversity, it also presents the information at the level of biogeographic regions and political units where management and policy must be applied in order to slow the loss of this diversity.*

Patrones globales de la diversidad, endemismo y riesgo de extinción de los mamiferos

Resumen: *Para determinar el estado de conservación de los mamíferos del mundo, compilamos una base de datos para 155 países que incluyó al número total de especies, al de las endémicas y al de las en peligro de extinción o extintas recientemente. El número total de especies estuvo significativamente correlacionado con el área territorial; sin embargo, el número de especies endémicas mostró una débil correlación tanto con el área territorial como con el número total de especies. La considerable proporción de la variación que no fue explicada por las regresiones entre al área y el número de especies refleja la influencia de otros factores tales como la latitud, la heterogeneidad del hábitat y topografía, y la biogeografía histórica, en los patrones de diversidad y endemicidad. Países de especial interés para la conservación debido a su diversa fauna de mamíferos, que incluye a muchas especies endémicas, son las islas de gran extensión como Australia, Madagascar, Indonesia y Filipinas, y también México. Los patrones de extinciones recientes y de especies en peligro de extinción fueron difíciles de interpretar, principalmente por la calidad e inconsistencia de la información disponible. La mayoría de los mamíferos en peligro de extinción son de gran tamaño y estéticamente atractivos, tales como primates, ungulados y carnívoros. Sin embargo, la mayoría de las especies que se han extinguido son pequeñas, tales como murciélagos y roedores. El presente estudio además de ilustrar el papel de procesos ecológicos, evolutivos y biogeográficos en el origen y mantenimiento de la diversidad de mamíferos terrestres, presenta información a niveles de regiones biogeográficas y unidades políticas en donde se deben aplicar las políticas de conservación y manejo para reducir la pérdida de esta diversidad.*

Paper submitted January 25, 1994; revised manuscript accepted July 14, 1994.

Conservation Biology, Pages 559–568
Volume 9, No. 3, June 1995

Introduction

The effort to preserve the biological diversity of the earth must be based on a knowledge of the geographic patterns of richness, endemism, and endangerment at the levels of both species and higher taxonomic ranks. Until recently, studies of these patterns have focused on the ecological, biogeographic, and evolutionary processes that generate and maintain diversity, rather than explicitly on practical problems of conservation policy and management. Consequently, the major patterns of diversity and endemism, including latitudinal, elevational, and aridity gradients of species richness and historical effects of isolation and colonization on endemism, have been described, although the processes underlying them remain poorly understood (see Stebbins & Major 1965; May 1975; McCoy & Connor 1980; Kruckenberg & Rabinowitz 1985; Brown 1988; Magurran 1988; Rosenzwieg 1992; Ceballos & Rodriguez 1993). The distribution of life on earth is extremely heterogeneous, and many of the patterns reflect the operation of both local and regional processes (see Ricklefs & Schluter 1993).

Recently, these patterns of diversity and endemism have received increasing attention from conservation biologists. With the recognition that time and resources to avert loss of diversity are limited, conservation priorities have been changing. The rapid increase in the extinction rate of species during the last few decades has pointed to the impracticality of focusing on single species and to the need to preserve local and regional ecological systems that sustain diversity and endemism. Programs to preserve habitats, ecosystem processes, overall biodiversity, and centers of endemism have received increased priority (Noss 1983; Noss & Harris 1986; Scott et al. 1987; Mittermeier 1988; Myers 1988; McNeely et al. 1990; Woinarski & Braithwaite 1990; Brussard 1991; Rohlf 1991; World Conservation Monitoring Centre 1992; Franklin 1993).

Although the basic patterns and processes that characterize and control biological diversity do not recognize the boundaries of political units, the application of conservation science to the preservation of diversity must be conducted largely at a national level. It is necessary to maintain a global and therefore an international perspective, but in order to focus attention and resources effectively it is also necessary to affect policy and management at levels where they can be developed and implemented. Most of the practical activities must take place at regional and local scales, which are usually within the boundaries of individual countries. Thus, an important advance has been the recognition of "hot spots" of diversity (Myers 1988), megadiversity nations (Mittermeier 1988), and the compilation of large databases of country-level information on diversity (World Conservation Monitoring Centre 1992).

We assembled from the published literature current information on richness, endemism, recent extinctions, and current endangerment of species and orders of land mammals on a country-by-country basis. We analyzed these data to characterize the major ecological and biogeographic patterns. Then we considered the implications of these data for conservation policy and management at both international and national levels.

Mammals are an excellent group for such a study. The taxonomy and distribution of mammals are relatively well known. They could serve as a model system on which to base initial policy and management decisions because some patterns of diversity and many problems of conservation can be generalized to other groups of organisms. Mammals are important economically and because of their emotional appeal and effects on ecosystems. Finally, they are the subject of legitimate conservation concern, because many species have gone extinct and many more are endangered.

Methods

The data base for the 155 countries, including nearly all of the large ones, was compiled from the literature. Lists of extant, extinct, and threatened and endangered species of land mammals (including chiropterans but excluding cetaceans, sirenians, and pinnipeds) were compiled primarily from the World Conservation Union (IUCN) (1988), the World Conservation Monitoring Centre (1992), the U.S. Fish and Wildlife Service (1993), and Wilson and Reeder (1993). Information for each country included land area, total species richness, number of endemic species, number of species recently gone extinct (in the last 500 years), and number of endangered species. Although such information is relatively current and accurate, there is considerable unevenness in the completeness and consistency of data for different countries, especially with respect to recent extinctions and current endangered status.

Results

Magnitude of Variation in Species Richness and Endemism

There were approximately 4562 species of extant and recently extinct terrestrial mammals (including bats, excluding marine mammals). The distribution of these species among nations was extremely heterogeneous. Species richness ranged from over 400 in Indonesia, Mexico, and Zaire to fewer than 10 in some island nations. Fourteen countries harbored 300 or more species of mammals.

The number of endemic species varied from over 100 in Australia, Indonesia, and Mexico to zero in many countries, and only seven countries maintained 70 or more endemic species. These figures are somewhat misleading, however, because endemic species comprised a large proportion of the faunas of several island nations with low to moderate overall richness. The highest percentage of endemic species occurred on large islands or archipelagos, such as Madagascar (90%), Australia (74%), the Philippines (60%), and Indonesia (32%), followed by smaller islands, such as the Solomon Islands (38%), Cuba (35%), and Japan (33%). In contrast, the highest percentage for any continental country was for Mexico (33%), followed by the U.S. (27%), and the former Soviet Union (20%); the first two countries had a larger number of endemic species than expected from their land area. Some large countries had very low endemism. For example, Libya, Sudan, Angola, and Saudi Arabia are as large as Mexico and Indonesia but contained fewer than 2% endemic species.

In general, there was a relatively good correspondence between countries with high total species richness and those with high species richness within the different orders of mammals. For example, the highest numbers of insectivores, lagomorphs, carnivores, arctiodactyls, and perisodactyls were recorded in China, of rodents in Mexico, of bats in Columbia, and of primates and edentates in Brazil. Other countries with low to moderate numbers of species, however, had very high species richness in certain orders, such as edentates in Argentina and marsupials in Australia.

Richness-to-Area Relationships among Species

Both total species richness and number of endemic species were positively correlated (r^2 = 0.59 and 0.30, respectively; Table 1) with the land areas of countries (Fig. 1*a*). Area varied by five orders of magnitude (from about 100 km^2 for Monserrat and Anguilla to 22,000,000 km^2 for the former Soviet Union) and accounted for nearly 60% of the variation in species richness. The relatively high correlation between species richness and area is impressive, considering the enormous variation among the countries in latitude, biogeographic history, topographic relief, and habitat diversity.

Contributions of the first two of these factors were assessed to some extent by separate species-area analyses for temperate and tropical countries and for insular and continental countries. The slopes of the regressions for temperate and tropical countries were different (z = 0.18 and 0.42, respectively), with substantially higher numbers of species in the tropical countries (Fig. 2*a,c*). In contrast, the regression for islands had a higher slope (z = 0.36) than for continents (z = 0.21), and the relationships converged toward similar values of

Table 1. Correlations between mammalian species richness and area.*

Countries	*Species*	N	r^2	*Slope (z)*	p
All	all	155	0.59	0.35	0.0001
	endemic	155	0.30	0.32	0.0001
Temperate	all	48	0.41	0.18	0.0001
	endemic	48	0.31	0.28	0.0001
Tropical	all	93	0.67	0.42	0.0001
	endemic	93	0.28	0.25	0.0001
Mixed	all	14	0.40	0.21	0.01
	endemic	14	0.45	0.67	0.009
Continental	all	111	0.30	0.21	0.0001
	endemic	111	0.33	0.38	0.0001
Temperate	all	44	0.41	0.15	0.0001
	endemic	40	0.34	0.31	0.0001
Tropical	all	53	0.56	0.19	0.0001
	endemic	53	0.30	0.13	0.0001
Mixed	all	14	0.40	0.21	0.0001
	endemic	14	0.45	0.67	0.0001
Insular	all	43	0.55	0.36	0.0001
	endemic	43	0.59	0.43	0.0001
America	all	42	0.77	0.39	0.0001
	endemic	42	0.63	0.35	0.0001
Africa	all	49	0.47	0.35	0.0001
	endemic	49	0.18	0.25	0.002
Asia	all	28	0.45	0.21	0.0001
	endemic	28	0.20	0.30	0.02
Europe	all	28	0.25	0.12	0.007
	endemic	28	0.29	0.20	0.003
Oceania	all	9	0.80	0.55	0.001
	endemic	9	0.85	0.59	0.0004

**Results are presented for the entire global data set and then broken down by continent, tropical, temperate, and mixed countries and continental and insular countries. Analyses were performed using log-transformed data; the slope is the z-value referred to in the text.*

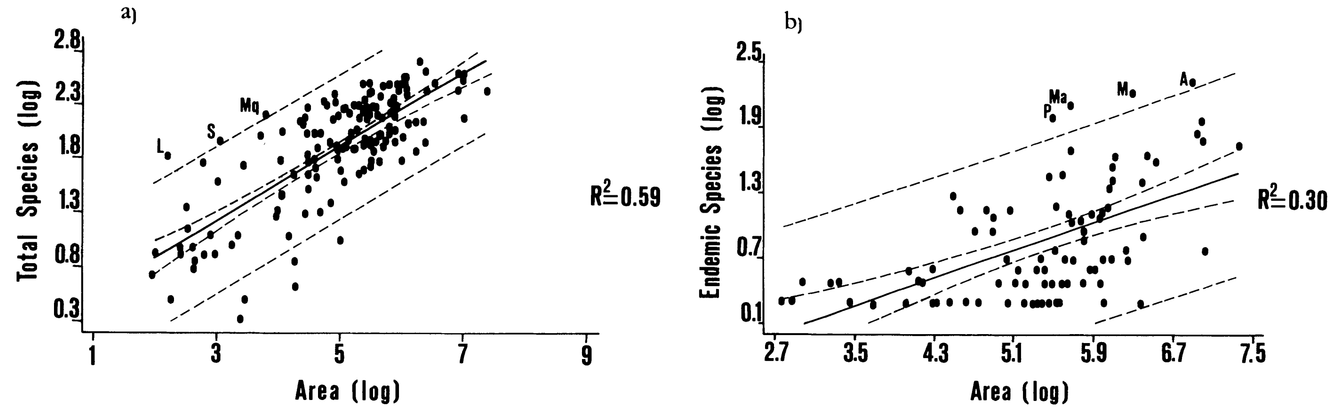

Figure 1. Global species richness-to-area relationships for terrestrial (a) and endemic (b) mammals. Data for 155 countries include bats and exclude cetaceans, pinnipeds, and sirenians. Outliers—countries with more species than expected by their land area—are Liechtenstein (L), Singapore (S), Martinique (Mq), the Philippines (P), Madagascar (Ma), Mexico (M), and Australia (A).

species richness in the largest areas (Fig. 3). Although these species richness-to-area relationships were highly significant, the variation around them was also considerable, reflecting in large part the contribution of other ecological and biogeographic variables.

Separate species richness-area regressions were also calculated for the Americas, Europe, Asia, Africa, and Oceania (Table 1). For the large continental land masses, the slopes varied from very low to moderate, and the regressions accounted for a modest amount of

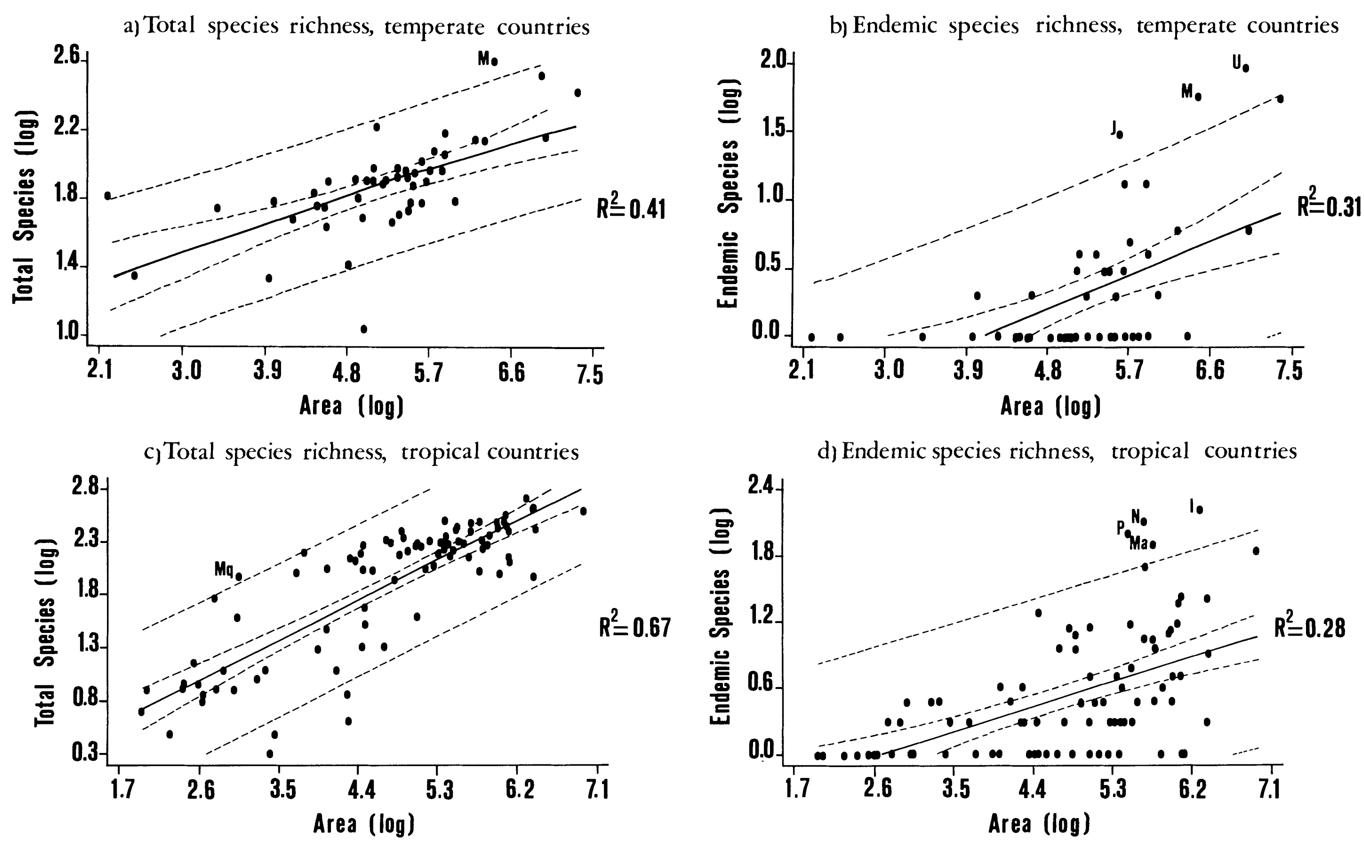

Figure 2. Species richness-to-area relationships for terrestrial mammals of tropical (n = 93) and temperate (n = 48) countries. Fourteen countries considered both tropical and temperate were not included in these analyses. Outliers—countries with more species than expected by their land area—are Mexico (M), Japan (J), the United states (U), Martinique (Mq), Indonesia (I), Madagascar (Ma), New Guinea (N), and the Philippines (P).

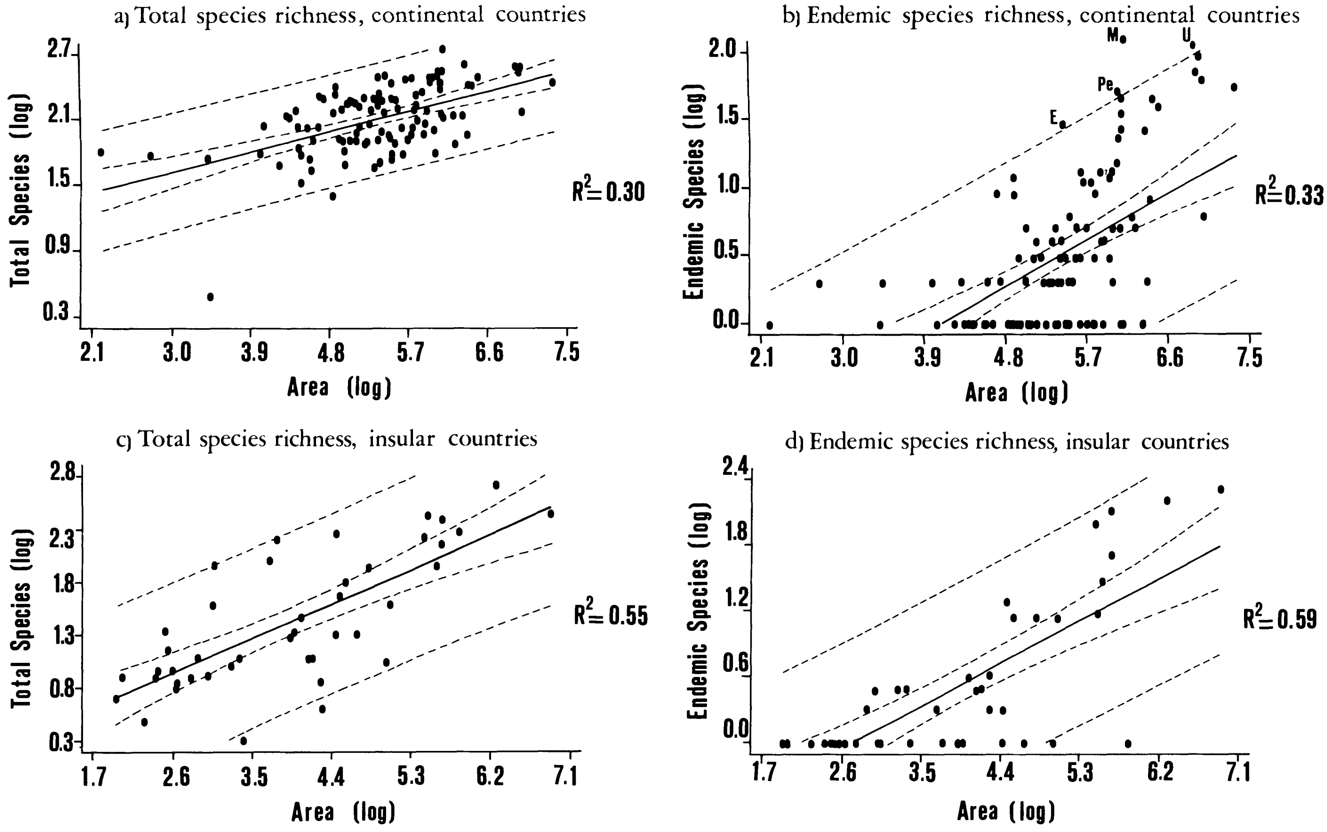

*Figure 3. Species richness-to-area relationships for terrestrial mammals of continental (*n = *111) and island (*n = *44) countries. Outliers—countries with more species than expected by their land area—are Ecuador (E), Peru (Pe), Mexico (M), and the United States (U).*

the variation. Two exceptions were America and Oceania, where the regression accounted for about 77 and 80% of the variation, respectively.

Of particular interest in the species-to-area analysis were the outliers, especially those countries that had a larger number of species than expected on the basis of their land masses. It is interesting that the only three outliers in the general correlation, Martinique, Liechtenstein, and Singapore, are small countries (Fig. 1*a*).

Patterns of Endemism

In general, patterns for endemic species were quite different from those for overall species richness. For all countries, there was a positive correlation with land area, but it accounted for only 30% of the variation (Fig. 1*b*).

When broken down by climate (tropical and temperate) and by geography (insular and continental), the correlations between number of endemic species and area were significant but quite variable. For example, area accounted for 31 and 28% of the variation in temperate and tropical countries, respectively, and 33 and 59% in continental and insular countries, respectively (Fig. 2*b,d;* Fig 3*b,d*). At a continental level, the lowest correlation was for Africa (r^2 = 0.18) and the highest for Oceania (r^2 = 0.85; Table 1).

A consequence of the wide variation in the number and the proportion of endemics is that the number of endemic species was only moderately correlated with total species richness (r^2 = 0.23, Fig. 4). Of particular interest are the outliers, countries that have a larger number of endemics than expected on the basis of total richness. There were seven such outliers (Australia, Indonesia, Madagascar, Mexico, New Guinea, Philippines, and the U.S.). The first six of these countries also have exceptionally high endemism for their areas and thus were outliers on the endemic species-to-area relationship as well (Fig. 1*b*). Endemism in taxonomic ranks higher than species is particularly high in the large, long-isolated island nations such as Madagascar and Australia.

Patterns of Extinction and Endangerment

In the last five centuries at least 80 species of terrestrial mammals have become extinct (Table 2). Extinctions have occurred in nine orders (50%) of land mammals, but the majority (51% of the total) have been in the Rodentia. On average, each order of mammals has lost 1.7% of its original species richness, but there is a wide

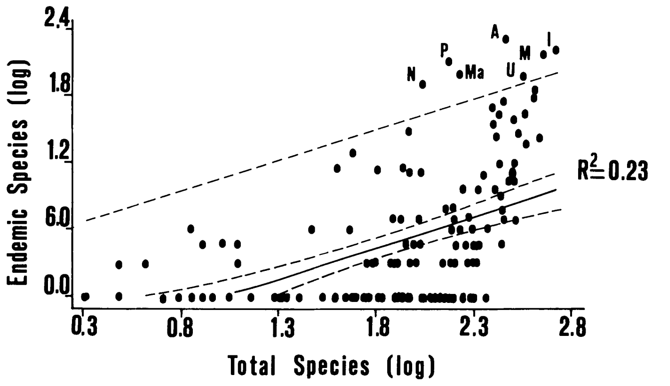

Figure 4. Relationship between total species richness and number of endemic land mammal species for 155 countries. Outliers, countries with more endemic species than expected by total species richness, are Australia (A), Indonesia (I), Madagascar (Ma), Mexico (M), New Guinea (N), the Philippines (P), and the United States (U).

range of variation, from zero in orders such as Macroscelididea and Hyracoidea to 6% in Perissodactyla (Table 2). The majority of all extinctions (65 species, 81%) have occurred on islands (including the large ones, such as Australia).

There are 619 species officially classified as threatened or endangered (Table 2). This figure is misleading, however, because local or unofficial lists—that are easier to update and reflect more realistically the magnitude of the extinction threat—contain many more species than the official lists (Table 3). For example, the average percentage of threatened or endangered mammals from six countries on the official international list is 8.3 (range from 5 to 13), but estimates for the same countries obtained from local or regional lists are two times higher, averaging 15% (range 9 to 30%).

Table 2. Species richness and conservation status of the mammals of the world.*

Order	Species Richness	Extinct Species (%)	Threatened/Endangered Species (%)
Monotremata	3	0	1 (33)
Marsupialia	282	10 (4)	31 (11)
Xenarthra	29	1 (4)	7 (24)
Insectivora	428	9 (2)	82 (19)
Scandentia	19	0	8 (42)
Dermoptera	2	0	0
Chiroptera	925	10 (1)	56 (6)
Primates	233	0	153 (66)
Carnivora	271	2 (1)	88 (32)
Proboscidea	2	0	2 (100)
Perissodactyla	18	1 (6)	17 (94)
Hyracoidea	6	0	1 (17)
Tubulidentata	1	0	0
Artiodactyla	220	6 (3)	83 (38)
Pholidota	7	0	0
Rodentia	2021	40 (2)	73 (4)
Lagomorpha	80	1 (1)	15 (19)
Macroscelidea	15	0	2 (13)
Total	4562	80 (2)	619 (14)

** For each order the number (and percentage) of extinct and threatened or endangered species is recorded. Data sources: Species richness, World Conservation Monitoring Centre (WCMC) (1992), Wilson & Reeder (1993); extinct species, WCMC (1992) updated with Ceballos & Navarro (1991), Mellink (1992a, 1992b), and Smith et al. (1993); and threatened or endangered species, World Conservation Union (1988), WCMC (1992), and U.S. Fish and Wildlife Service (1993).*

There are threatened and endangered species in all but three orders of mammals. The highest numbers of endangered species are found in Primates (153 species, 66%), Carnivora (88 species, 32%), Artiodactyla (83 species, 38%), and Insectivora (82 species; 19%). High percentages of species at risk are found in Perissodactyla (94%), Primates (66%), and Scandentia (42%). Interestingly, Rodentia and Chiroptera, orders that have experienced a large number of extinctions, have relatively low percentages of species classified as threatened or endangered.

Discussion

Even though all of our analyses were done on data at the country level, there is evidence for the basic ecological and biogeographic patterns of diversity: a positive correlation between species richness and land area, more species in tropical than temperate regions, more species on continents than on islands, more species in regions of diverse habitats, and more species where historically isolated faunas have come into contact. Thus, the countries with the highest species richness (Indonesia, Mexico, and Zaire) are relatively large countries with a variety of both tropical forest and several other habitat types. Indonesia and Mexico also lie in the area of interchange between historically isolated biogeographic provinces.

Equally apparent are the influences of historical biogeographic and evolutionary events that have promoted the differentiation and survival of distinctive endemic forms. Thus, while there was a moderate correlation between number of endemic species and land area, endemism was exceptionally high on islands, archipelagos, and long-isolated "island" habitats. For example, the countries with the highest levels of endemism for their area and overall species richness, Mexico and Indonesia, are relatively large countries containing many individual islands or patches of long-isolated habitats (see Ceballos & Navarro 1991; Ceballos & Rodriguez 1993 [for Mexico]; Lawlor 1986 [for Southeast Asia]). This illustrates the point that isolation of land or habitat, when maintained over evolutionary time scales, sometimes increases global diversity by promoting the differentiation

Table 3. Comparison of locally or regionally as opposed to globally extinct and threatened or endangered land mammals from selected countries around the world according to unofficial conservation lists.[a]

		Extinct (%)		*Threatened/Endangered (%)*	
	N	*Local*	*Global*	*Local*	*Global*
Australia	282	18(6)	10(3)	43(15)[b]	38(13)
Bolivia	316	2(<1)	0	30(9)	23(6)
Chile	88	0	0	26(30)	9(10)
Mexico	462	11(2)	2(<1)	76(16)	25(5)
Spain	75	1(1)	0	14(19)	6(8)
USA	346	1(<1)	1(<1)	38(15)	27(8)

[a] *Data sources for global species lists: World Conservation Union (1988), World Conservation Monitoring Centre (1992), and U.S. Fish and Wildlife Service (1993). For local species lists: Australia, Kennedy (1990); Bolivia, Salazar et al. (1995); Chile, Glade (1988); Mexico, Ceballos & Navarro (1991), Mellink (1992*a, *1992*b*), Smith et al. (1993), and Ceballos (1993); Spain, Instituto Nacional para la Conservation de la Naturaleza (1986).*
[b] An additional 28 species are considered potentially endangered.

of endemic forms (see Heaney 1986; Lawlor 1986; Brown 1988).

The differences in the correlates of species richness, on the one hand, and of endemism, on the other, point to the imperfect correspondence between these two important aspects of biological diversity. Although this is apparent in our analyses at the level of countries, it also occurs at smaller spatial scales—at the level of regions and habitats within countries (Ceballos & Rodriguez 1993; Terborgh & Winter 1983). At all scales this imperfect correspondence reflects the fact that the different ecological, biogeographic, and evolutionary processes discussed above play different roles in generating and maintaining species richness as opposed to endemism. At all scales there are important implications for conservation.

Issues related to endemism are illustrated by the example of Australia. First, even though this island continent has only moderate species richness (282 species, ranking fifteenth among countries) and low diversity at higher taxonomic ranks (only four orders of land-native mammals), it has the highest number (210) and the second highest percentage (74%) of endemic species of the countries for which we have data. Second, although some of these endemics are found in tropical rain forest, the majority are restricted to other, often drier or more temperate, habitats (Woinarski & Braithwaite 1990). Third, the majority of endemics are marsupials, the group that also has the highest species richness in Australia. Fourth, there is high endemism not only at the species level but also at the generic and family levels—again especially within marsupials, but also among rodents (see Kennedy 1990; Wilson & Reeder 1993). Similar examples include the high diversity and endemism of insectivores, lagomorphs, and carnivores in China, and of edentates, rodents, and marsupials in nonrainforest habitats in South America (see Redford et al. 1990; Mares 1992; Ceballos in press).

There is also an imperfect correspondence between the patterns of species richness and endemism and the proportions of these faunas that have already gone extinct or that are formally recognized as threatened or endangered (Table 3). There are several reasons for this. First, a large proportion of the known extinctions (65 of 80, or 81%) have occurred on islands, especially Australia, the West Indies, and many smaller islands, that have moderate species richness. Second, most formally recognized endangered species are at risk of global extinction. Many other species threatened with local, regional, and even country-wide extirpation have received no formal recognition.

Third, many species are at risk of global extinction, but their endangered status has not formally been recognized for several reasons. The faunas of many countries are poorly known, so there is insufficient information to document endangered status. For example, the mammal fauna of Mexico has received intensive ecological study only recently, and this is reflected in increasing recognition of endangered species. The number of officially recognized species has doubled in the last decade, but the current number, 25, is still far fewer than the 76 species that are estimated to be globally threatened or endangered (Ceballos & Navarro 1991). Even in the much better-studied fauna of the U.S., the listing of species has been deliberately slowed in recent years. As a result, 34 species of plants and animals (but no mammals) became extinct in the 1980s while they were waiting for federal listing (Cohn 1993).

Another factor is the emphasis on large, emotionally appealing species. To see the extent of this bias, contrast the proportion of endangered species with the number of species that have already gone extinct in four orders: Primates, Artiodactyla, Rodentia, and Chiroptera (Table 2). The first two contain some of the highest proportions of recognized endangered species (66 and 38%, respectively) but have experienced very few extinctions (0 and 6 species, respectively). The rodents and bats have few recognized endangered species (4 and 6%, respectively) but have already experienced many extinctions. This is not to say that many large, emotionally appealing species are not endangered—they are—but so are a much larger number of still unrecognized species of smaller, less appealing mammals.

Economic and other factors also influence the formal recognition of endangered species. In many countries carnivores, rodents, and bats are considered pests. In many cases they have been subject to deliberate campaigns of eradication without regard to their taxonomic identity and conservation status. For example, in India all fruit bats (Suborder Megachiroptera) are considered vermin, and none are recognized as endangered although only three of 12 species are common on the mainland (S. Mistry, personal communication). Another example is the influence of agricultural and pastoral interests in the failure of the U.S. to formally recognize the special status of the black-tailed prairie dog (*Cynomys ludovicianus*), despite an 89% reduction in area of distribution and numbers within the last century and despite the keystone role of this species in providing resources for many other species, including the endangered black-footed ferret (*Mustela nigripes*) and the Mountain Plover (*Charadrius montanus*) (Miller et al. 1990; Ceballos et al. 1992; Miller et al. 1994).

The data and analyses presented here have several implications for conservation. By pointing to country-level patterns of richness, endemism, extinction, and endangerment, they provide a basis for setting priorities for allocating limited resources. On the one hand, the data help to direct the attention of the international community to countries with exceptional biological resources and pressing conservation problems. For example, countries can be considered important areas for conservation if they have (1) high species richness and a large number of endemic species, (2) high species richness and low endemism, or (3) a large number of endemic species but low to moderate species richness. Also of particular concern should be countries, such as those in sub-Saharan Africa, that have only moderate species richness and low levels of endemism, but that collectively support a diverse mammalian fauna, especially rich in artiodactyls, perissodactyls, carnivores, and primates with wide geographic ranges that include several countries (see Cole et al. 1994). To preserve the spectacular African megafauna, international cooperation will be required.

These kinds of data and analyses provide countries with a first-level assessment of the current status of biodiversity within their borders. They call attention to the need to conserve both overall species richness and endemic forms. Information on recent extinctions and data to assess endangerment of species can provide a basis for acquiring additional, better data on which to base policy and management.

Although the data we have assembled are informative, the incompleteness and questionable quality of some of this information limits its applications. Even for a group as relatively well known as land mammals, many countries have not been adequately surveyed. New species of mammals are still being described, existing species are being reclassified, and new distributional records for countries are being added. For example, at least three new species of primates have been described in Brazil since 1989, and of the 316 species of mammals known in Bolivia, 50% have been described or added to the country list in the last decade (Salazar et al. in press). Even for countries where faunal lists are relatively complete, there is often insufficient information on ecology and biogeography to evaluate the conservation status of the species. Thus, the doubling of the number of recognized endangered species in Mexico in the last five years is largely a consequence of increasing research and resulting biological information.

Also needed is a greater sensitivity in many countries to the importance of trying to preserve all aspects of biodiversity. Even in scientific circles there is a view that ecosystems have a high degree of "redundancy" of organisms, owing largely to the co-occurrence of closely related or ecologically similar species. The lay person's version of this situation is that "a rat is a rat." We question the ecological basis of this view and prefer to regard similar species as complementary rather than redundant, recognizing the uniqueness and the unique ecological niche of each species. We emphasize the need to formally recognize all endangered species, not just those with special emotional appeal or economic importance. In many countries the list of endangered species clearly includes only a small fraction of those actually at risk of extinction. India and China have enormous human populations and resulting environmental problems. They also have high mammalian species richness and endemism, yet only about 9% of the species are currently recognized as threatened or endangered. Contrast this with Mexico and Australia, countries with lower human impacts but comparable diversity, where approximately 30% of the species are recognized as being at risk (Kennedy 1990; Ceballos & Navarro 1991; Ceballos 1993).

Because our data and analyses are restricted to mammals, it is appropriate to ask whether our approach and results can be generalized to other groups. We believe not only that the general approach has broad applicability (see also Mittermeier 1988; World Conservation Monitoring Centre 1992) but also that many of the results will hold—with important exceptions—for other kinds of terrestrial organisms (but see Prendergast et al. 1993). The reasons are straightforward. At least in relatively well-studied groups, such as vascular plants, butterflies, and the different classes of vertebrates, the ecological and geographic patterns of diversity and endemism are often similar, reflecting the roles of common ecological processes and biogeographic histories in the origin and maintenance of both species richness and endemism. The extent of similarity is limited, however, because of differences in the ecological requirements and evolutionary histories of the different taxa.

Because time and resources are limited, initial policy and management decisions will usually have to be based on limited information. On one hand, data on one or two groups provides a solid basis for such immediate action; on the other hand, it is important to obtain additional, taxon-specific data and apply this information to fine-tune conservation policy and management so as to insure preservation of other elements of diversity.

Acknowledgments

We thank Guadalupe Tellez and Kelly MacDonald for helping us to gather some of the data, and Cuauhtemoc Chavéz for aiding us with the correlation analysis. Brian Miller provided useful comments on the manuscript. J. H. Brown's research has been supported by the National Science Foundation and G. Ceballos's by the Centro de Ecología, Universidad Nacional Autónoma de Mexico.

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