Science AAAS

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Science **322**, 225 (2008);
DOI: 10.1126/science.1165115

The Status of the World's Land and Marine Mammals: Diversity, Threat, and Knowledge

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Knowledge of mammalian diversity is still surprisingly disparate, both regionally and taxonomically. Here, we present a comprehensive assessment of the conservation status and distribution of the world's mammals. Data, compiled by 1700+ experts, cover all 5487 species, including marine mammals. Global macroecological patterns are very different for land and marine species but suggest common mechanisms driving diversity and endemism across systems. Compared with land species, threat levels are higher among marine mammals, driven by different processes (accidental mortality and pollution, rather than habitat loss), and are spatially distinct (peaking in northern oceans, rather than in Southeast Asia). Marine mammals are also disproportionately poorly known. These data are made freely available to support further scientific developments and conservation action.

Mammals play key roles in ecosystems (e.g., grazing, predation, and seed dispersal) and provide important benefits to humans (e.g., food, recreation, and income), yet our understanding of them is still surprisingly patchy (*1*). An assessment of the conservation status of all known mammals was last undertaken by the International Union for Conservation of Nature (IUCN) in 1996 (*2*). These IUCN Red List classifications of extinction risk (fig. S1) for mammals have been used in numerous studies, including the identification of traits associated with high extinction risk (*3*, *4*), and prioritization of species for conservation action (*5*). However, the 1996 assessment was based on categories and criteria that have now been superseded, and the assessments are officially outdated for about 3300 mammals never assessed since. Previously compiled global distribution maps for terrestrial mammals (*6*, *7*) have been used in a variety of analyses, including recommending global conservation priorities (*7*–*9*), and analyzing the coverage of protected areas (*10*). However, nearly 700 currently recognized species, including marine mammals, were not covered in previously published analyses.

Here, we present the results of the most comprehensive assessment to date of the conservation status and distribution of the world's mammals, covering all 5487 wild species recognized as extant since 1500. This 5-year, IUCN-led collaborative effort of more than 1700 experts in 130 countries compiled detailed information on species' taxonomy, distribution, habitats, and population trends, as well as the threats to, human use of, ecology of, and conservation measures for these species. All data are freely available for consultation and downloading (*11*).

Diversity. Mammals occupy most of the Earth's habitats. As in previous studies (*8*, *12*), we found that land species (i.e., terrestrial, including volant, and freshwater) have particularly high levels of species richness in the Andes and in Afromontane regions in Africa, such as the Albertine Rift. We also found high species richness in Asia, most noticeably in the Hengduan mountains of southwestern China, peninsular Malaysia, and Borneo (Fig. 1A). The ranges of many large mammals have recently contracted substantially in tropical Asia (*13*), so local diversity was once undoubtedly even higher. Overall, the species richness pattern for land mammals is similar to that found for birds and amphibians (*12*), which suggests that diversity is similarly driven by energy availability and topographic complexity (*14*, *15*).

Marine mammals concentrate in tropical and temperate coastal platforms, as well as in offshore areas in the Tasman and Caribbean seas, east of Japan and New Zealand and west of Central America, and in the southern Indian Ocean. As with land species, marine richness seems to be associated with primary productivity: Whereas land species' richness peaks toward the equator, marine richness peaks at around 40° N and S (*16*) (fig. S4), corresponding to belts of high oceanic productivity (*17*). An interesting exception is the low species richness in the highly productive North Atlantic Ocean (*17*). Only one species' extinction [Sea Mink, *Neovison macrodon* (*18*)] and one extirpation [Gray Whale, *Eschrichtius robustus* (*19*)] are recorded from this region, yet evidence for many local extinctions comes from historical records of species exploitation where they no longer occur ([e.g., Harp Seal, *Phoca groenlandica*, in the Baltic Sea (*20*); Bowhead Whale, *Balaena mysticetus*, off Labrador (*21*); Walrus, *Odobenus rosmarus*, in Nova Scotia (*22*)]. Past human exploitation may therefore have depleted natural species richness in the North Atlantic—as it probably did with land mammals in Australia (*23*) and the Caribbean (*24*).

Phylogenetic diversity is a measure that takes account of phylogenetic relationships (and hence, evolutionary history) between taxa (*16*, *25*) (fig. S3). It is arguably a more relevant currency of diversity and less affected by variations in taxonomic classification than species richness. Species richness (Fig. 1A) and phylogenetic diversity (Fig. 1B) are very closely related for land species ($r^2 = 0.98$) (fig. S5), but less so in the marine environment ($r^2 = 0.73$). Disproportionately high phylogenetic diversity in the southern oceans suggests that either species here are less related than elsewhere, or that current species may in fact be poorly known complexes of multiple species, with new species awaiting discovery (consistent with the poor species knowledge in this area, see below).

The size of land species' ranges varies from a few hundred square meters (Bramble Cay Melomys, *Melomys rubicola*; Australia), to 64.7 million km^2 (Red Fox, *Vulpes vulpes*; Eurasia and North America). For marine species, ranges vary from 16,500 km^2 (Vaquita, *Phocoena sinus*; Gulf of California), to 350 million km^2 (Killer Whale, *Orcinus orca*; all oceans). Despite these extremes, most species have small ranges (fig. S6): Most land taxa occupy areas smaller than the UK, and the range of most marine mammals is smaller than one-fifth of the Indian Ocean (fig. S6).

Among land mammals, restricted-range species (those 25% of species with the smallest ranges) are concentrated on highly diverse islands (e.g., Madagascar, Sri Lanka, and Sulawesi) and tropical mountain systems (e.g., Andes, Cameroonian, and Ethiopian Highlands) (Fig. 1C). Marine restricted-range species are almost entirely found around continental platforms, particularly in the highly productive waters off the Southern Cone of South America (Fig. 1C) (*17*). Both land and marine patterns of endemism are thus apparently associated with highly productive areas subject to strong environmental gradients (altitudinal in land; depth in marine).

A different perspective on patterns of species' endemism is obtained by mapping global variation in median range size (Fig. 1D). For land species, there is a strong association between landmass width and median range size: The

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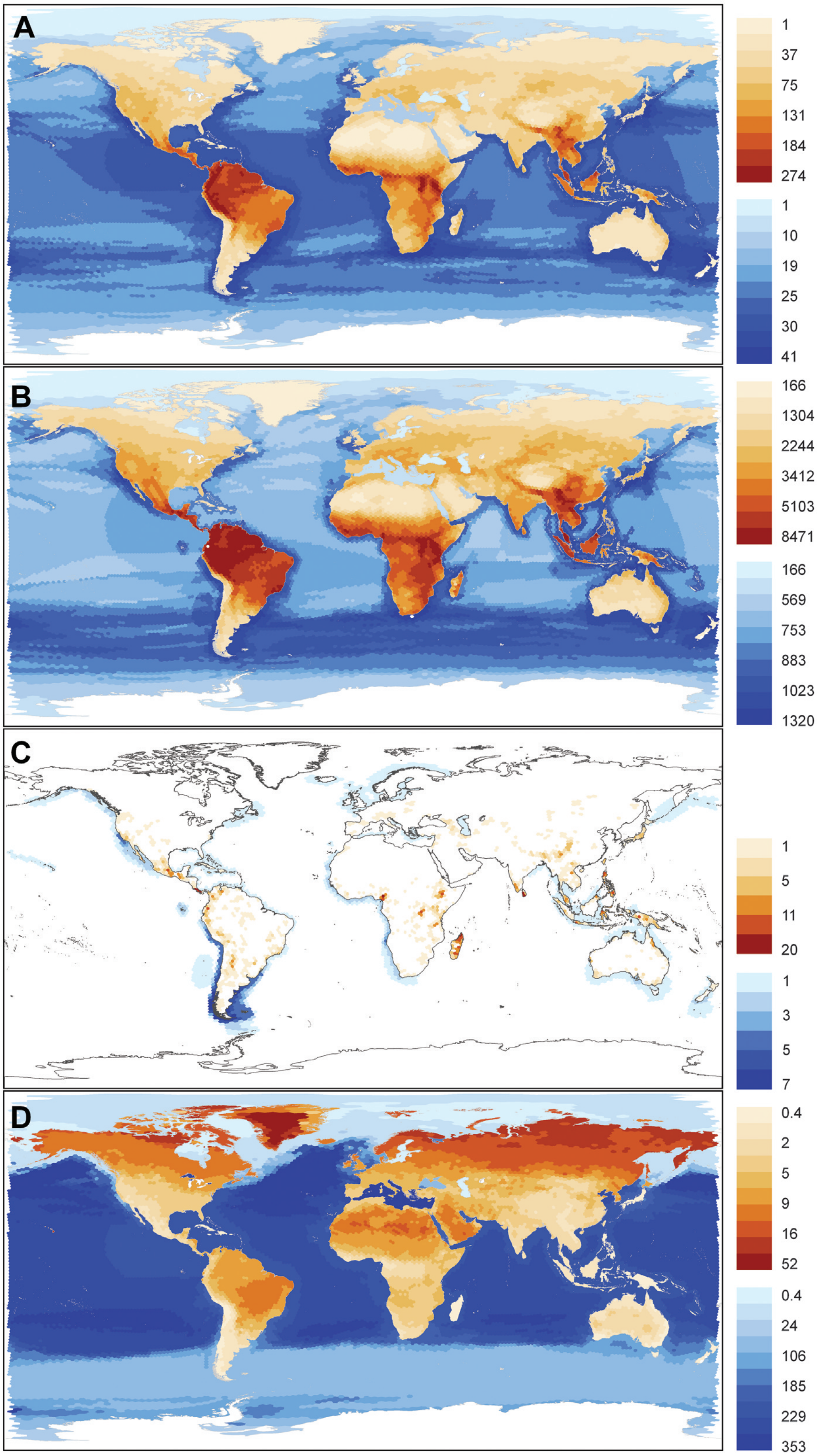

Fig. 1. Global patterns of mammalian diversity, for land (terrestrial and freshwater, brown) and marine (blue) living species, on a hexagonal grid (fig. S2). (**A**) Species richness. (**B**) Phylogenetic diversity (total branch length of the phylogenetic tree representing those species in each cell in millions of years). (**C**) Number of restricted-range species (those 25% species with the smallest ranges). (**D**) Median range size of species in each cell (in million km^2).

largest ranges tend to be found across the widest part of each continent, particularly in northern Eurasia, whereas islands (e.g., in Southeast Asia and the Caribbean) and narrow continental areas (e.g., southern North and South America) tend to have narrowly distributed species. Superimposed on this general pattern, ranges also tend to be small in topographically complex areas (e.g., the Rockies, Andes, and Himalayas). These results agree with those for birds, which suggest that range sizes are constrained by the availability of land area within the climatic zones to which species are adapted (*14*, *26*). Among marine species, small median range sizes are found around the continental platforms, which also suggests that steep environmental gradients (here, associated with depth) determine species' distributions. However, the global marine pattern is dominated by a latitudinal effect, with ranges generally declining toward both poles (fig. S7), which may reflect the latitudinal gradient in the overall ocean area. As with previous studies (*14*, *26*), we found no support for the Rapoport rule (*27*) that the sizes of species' ranges increase with latitude.

Threat. Twenty-five percent (n = 1139) of all mammals for which adequate data are available (data sufficient) are threatened with extinction (Table 1). The exact threat level is unknown, as the status of 836 species having insufficient information for evaluation (Data-Deficient species) is undetermined, but is somewhere between 21% (assuming no Data-Deficient species threatened) and 36% (assuming all Data-Deficient species threatened). The conservation status of marine species is of particular concern, with an estimated 36% (range, 23 to 61%) of species threatened.

Critically Endangered species (n = 188) (Table 1) face a very high probability of extinction. For 29 of them, it may already be too late: Species like the Baiji (*Lipotes vexillifer*), flagged as "Possibly Extinct," have only a very small chance of still persisting (*28*). For the 76 species classified as Extinct (since 1500), no reasonable evidence suggests that they still exist. Two Extinct in the Wild species, Scimitar-horned Oryx (*Oryx dammah*) and Père David's Deer (*Elaphurus davidianus*), persist only in captivity.

Species not classified as threatened are not necessarily safe, and indeed, 323 mammals are classified as "Near Threatened" (Table 1). Many species have experienced large range and population declines in the past (e.g., Grey Wolf, *Canis lupus*, and Brown Bear, *Ursus arctos*), which are not accounted for in their current Red List status (*13*). Moreover, 52% of all species for which population trends are known are declining, including 22% of those classified as of Least Concern. These trends indicate that the overall conservation status of mammals will likely deteriorate further in the near future, unless appropriate conservation actions are put in place. On a positive note, at least 5% of currently threatened species have stable or increasing populations (e.g., European

Bison, *Bison bonasus*, and Black-footed Ferret, *Mustela nigripes*), which indicates that they are recovering from past threats.

Among land mammals, threatened species are concentrated in South and Southeast Asia (Fig. 2A). Among primates, for example, a staggering 79% (range, 76 to 80%) of species in this region are threatened with extinction. Other peaks of threat include the tropical Andes, Cameroonian Highlands, Albertine Rift, and Western Ghats in India, all regions combining high species richness (Fig. 1A), high endemism (Fig. 1, B and C), and high human pressure (*29*). Threatened marine species are concentrated in the North Atlantic, the North Pacific, and Southeast Asia, areas of high endemism (Fig. 1C) and high human impact (*30*). Low threat levels in the southern hemisphere may reflect history—as these oceans became heavily exploited much more recently—and/or knowledge gaps (see below).

Worldwide, habitat loss and degradation (affecting 40% of species assessed) and harvesting (hunting or gathering for food, medicine, fuel, and materials, which affect 17%) are by far the main threats to mammals (table S2). Yet, the relative importance of different threats varies geographically and taxonomically (Fig. 2, B and C). Among land species, habitat loss is prevalent across the tropics, which coincides with areas of high deforestation in the Americas, Africa, and Asia (Fig. 2B) (*31*). Harvesting is having devastating effects in Asia, but African and South American species are also affected (Fig. 2C). Harvesting affects large mammals (Cetartiodactyla, Primates, Perissodactyla, Proboscidea, and Carnivora) disproportionately: 90% in Asia, 80% in Africa, and 64% in the Neotropics (compared with 28, 15, and 11% of small mammals, respectively).

Among marine mammals, the dominant threat is accidental mortality (which affects 78% of species), particularly through fisheries by-catch and vessel strike (table S2). Although coastal areas are the most affected (Fig. 2D), accidental mortality also threatens species in off-shore waters (e.g., from purse seines in the eastern tropical Pacific). Pollution (60% of species) is the second most prevalent threat (Fig. 2E), but this designation includes a diversity of mechanisms, such as chemical contaminants, marine debris, noise, and climate change. Sound pollution (military sonar) has been implicated in mass strandings of cetaceans (*32*), and climate change is already impacting sea ice–dependent species (e.g., Polar Bear, *Ursus maritimus*, and Harp Seal, *Pagophilus groenlandicus*). Despite progress through international agreements, harvesting remains a major threat for marine mammals (52% of species).

Disease affects relatively few mammals (2%), but it has led to catastrophic declines in some, most dramatically the Tasmanian Devil (*Sarcophilus harrisii*) on account of facial tumor disease (*33*).

Threat levels are not uniform across mammalian groups (Fig. 3 and table S1). Those with disproportionately high incidence of threatened or extinct species include tapirs (Tapiridae), hippos (Hippopotamidae), tarsiers (Tarsiidae), bears (Ursidae), potoroids (Potoroidae), pigs and hogs (Suidae), and golden moles (Chrysochloridae). Families less threatened than expected include moles (Talpidae), dipodids (Dipodidae), opossums (Didelphidae), and free-tailed bats (Molossidae).

A positive association has been reported between body size and threat among mammals (*3*, *4*), and indeed, we found that the most threatened families are dominated by large species, such as primates and ungulates, whereas the least threatened include small mammals, such as rodents and bats. Larger species tend to have lower population densities, slower life histories, and larger home ranges and are more likely to be hunted—factors that put them at greater risk (*4*). For smaller mammals, mostly threatened by habitat loss (*34*), conservation status is mainly determined by range size and location (*4*). However, some families of small mammals (e.g., golden moles) are also highly threatened (Fig. 3). Furthermore, although large mammals have a significantly higher fraction of threatened or extinct species ($\chi^2 \approx 0$; $P < 0.0001$), large and small mammals have suffered similar levels of extinction ($\chi^2 = 0.74$; not significant) (*34*).

Table 1. Number of species in each IUCN Red List category and threat level for all mammals, and for land and marine species. Categories: EX, Extinct; EW, Extinct in the Wild; CR, Critically Endangered; EN, Endangered; VU, Vulnerable; NR, Near Threatened; LC, Least Concern; DD, Data Deficient. Threat level = [(VU+EN+CR)/(Total – DD)] × 100. The range is between [(VU+EN+CR)/Total] × 100 and [(VU+EN+CR+DD)/Total] × 100. NA, not applicable because they are not mapped.

Total and Red List category	Mammal species by habitat		
	All	Land	Marine
Number of species (% of total)			
Total	5487	5282	120
EX	76 (1.4)	NA	NA
EW	2 (0.04)	NA	NA
CR	188 (3.4)	185 (3.5)	3 (2.5)
EN	448 (8.2)	436 (8.3)	12 (10.0)
VU	505 (9.2)	497 (9.4)	12 (10.0)
NT	323 (5.9)	316 (6.0)	7 (5.8)
LC	3109 (56.7)	3071 (58.1)	40 (33.3)
DD	836 (15.2)	777 (14.7)	46 (38.3)
Threat level (%)			
Threat level	25	25	36
(range)	(21 to 36)	(21 to 36)	(23 to 61)

Knowledge. Although mammals are among the best-known organisms, they are still being discovered at surprisingly high rates (*1*). The number of recognized species has increased by 19% since 1992 (fig. S8) and includes 349 newly described species and 512 taxa that were elevated to species level. The spatial pattern of new species description (Fig. 4A) reflects the interaction between the local state of knowledge and taxonomic effort. Peaks in Madagascar and the Amazon result from relatively high, recent taxonomic activity in these poorly known areas, whereas the lack of new species in Africa (particularly in the poorly surveyed Congo Basin) may reflect more limited efforts there.

Newly described mammals are generally poorly known (44% are Data Deficient; 13% for pre-1992 species) and disproportionately threatened [51% (29 to 73%); pre-1992 species: 23% (20 to 33%)]. These factors reinforce the concern that species may be vanishing even before they are known to science.

Newly described species have been named in areas where knowledge has increased in the recent past (Fig. 4A), whereas Data-Deficient species are concentrated in regions in need of future research (Fig. 4B). Most Data-Deficient species on land are in tropical forests (Fig. 4B), which reflects species' richness patterns (Fig. 1A); in regions where these forests are vanishing very rapidly (e.g., Atlantic Forest, West Africa, Borneo) (*31*), many Data-Deficient species may be dangerously close to extinction.

Marine species are less well studied than land mammals, with 38% Data Deficient (Table 1). Species that breed on land tend to be better understood, but whales, dolphins, porpoises, and sirenians are so difficult to survey that declines that should result in a Vulnerable listing would go undetected at least 70% of the time (*35*). Marine Data-Deficient species are particularly concentrated along the Antarctic Convergence (Fig. 4B), largely driven by the beaked whales, 19 of which are Data Deficient. A relative absence of Data-Deficient species in the northern Atlantic and Pacific Oceans may reflect higher research effort and expertise—as well as a longer history of exploitation.

Conclusion. Our results paint a bleak picture of the global status of mammals worldwide. We estimate that one in four species is threatened with extinction and that the population of one in

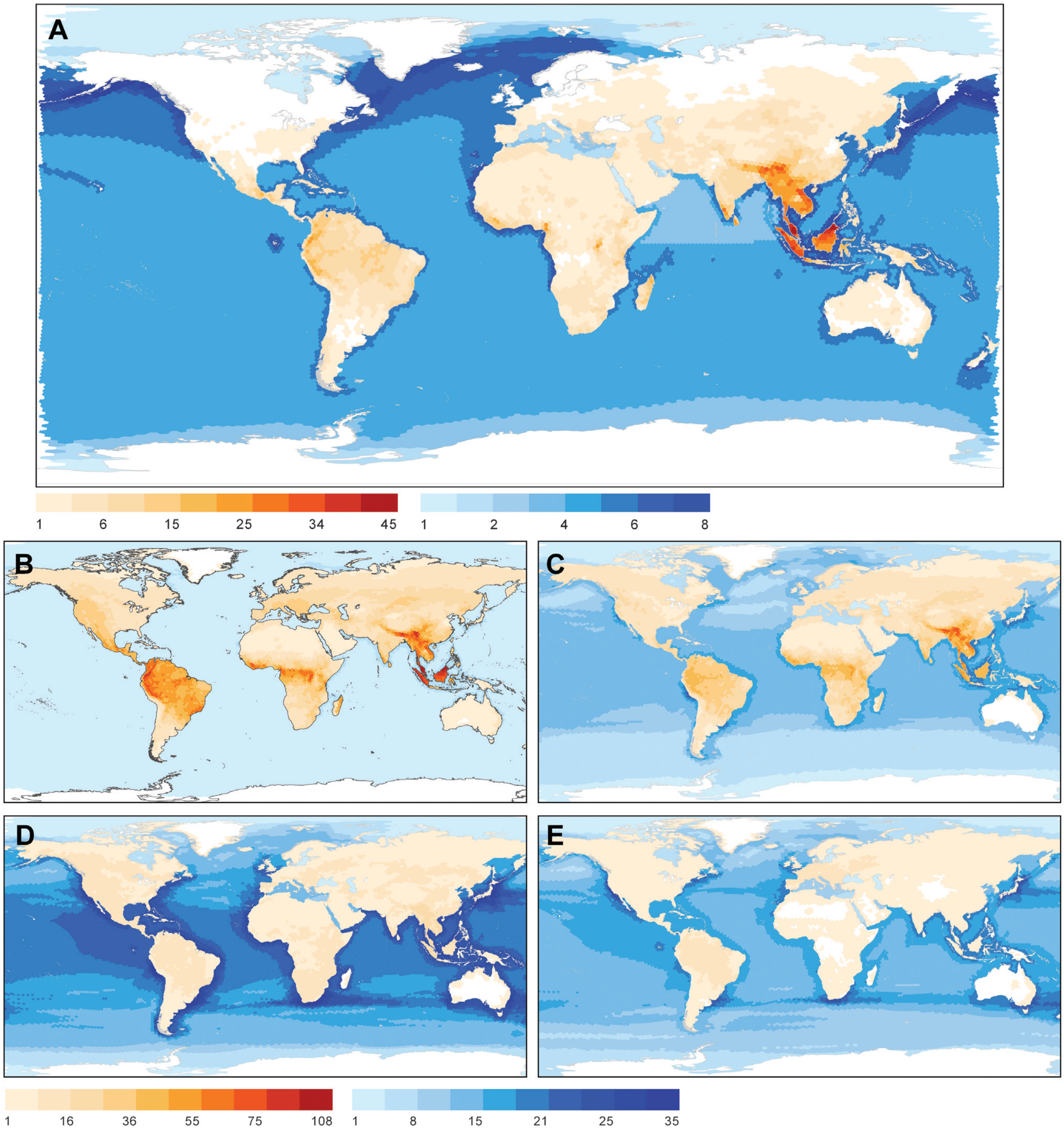

Fig. 2. Global patterns of threat, for land (brown) and marine (blue) mammals. (**A**) Number of globally threatened species (Vulnerable, Endangered or Critically Endangered). Number of species affected by: (**B**) habitat loss; (**C**) harvesting; (**D**) accidental mortality; and (**E**) pollution. Same color scale employed in (B), (C), (D) and (E) (hence, directly comparable).

two is declining. The situation is particularly serious for land mammals in Asia, through the combined effects of overharvesting and habitat loss, and for marine species, victims of our increasingly intensive use of the oceans. Yet, more than simply reporting on the depressing status of the world's mammals, these Red List data can and should be used to inform strategies for addressing this crisis (*36*), for example to identify priority species (*5*) and areas (*8*, *10*) for conservation. Further, these data can be used to indicate trends in conservation status over time (*37*). Despite a general deterioration in the status of mammals, our data also show that species recoveries are possible through targeted conservation efforts.

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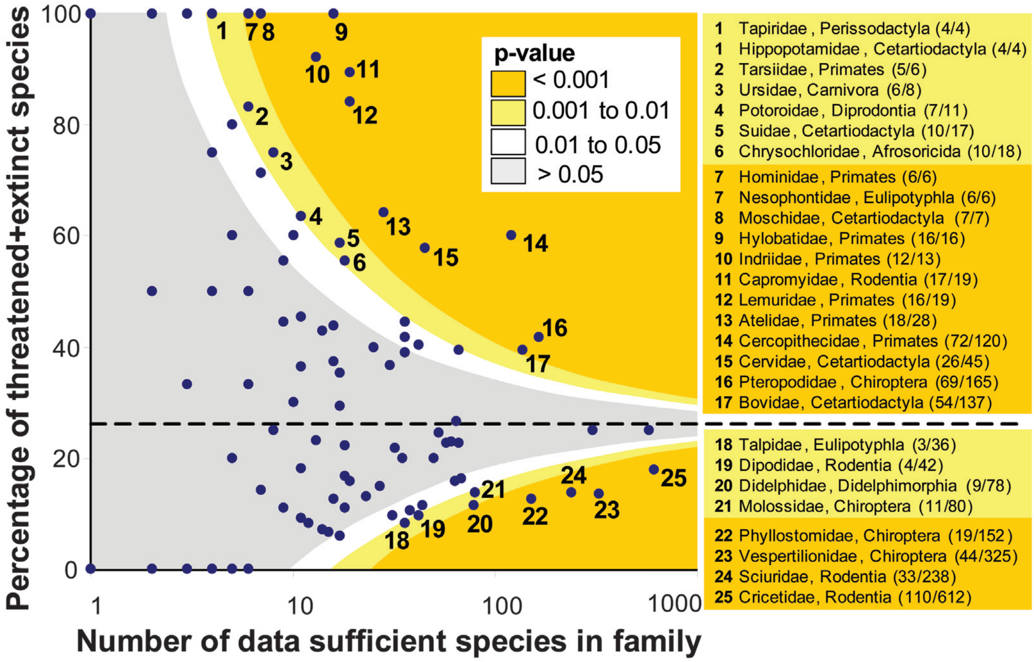

Fig. 3. Threat status of each mammalian family in relation to overall threat levels across all mammals (dashed line, 26%). Each family represented by a dot, indicating the percentage of threatened or extinct species, in relation to the total number of data sufficient species in the family. Colored bands indicate significance levels (one-tailed binomial test). Families 1 to 25 have threat levels significantly ($P <$ 0.01) different from expected (between brackets, number of threatened or extinct species/number of data sufficient species).

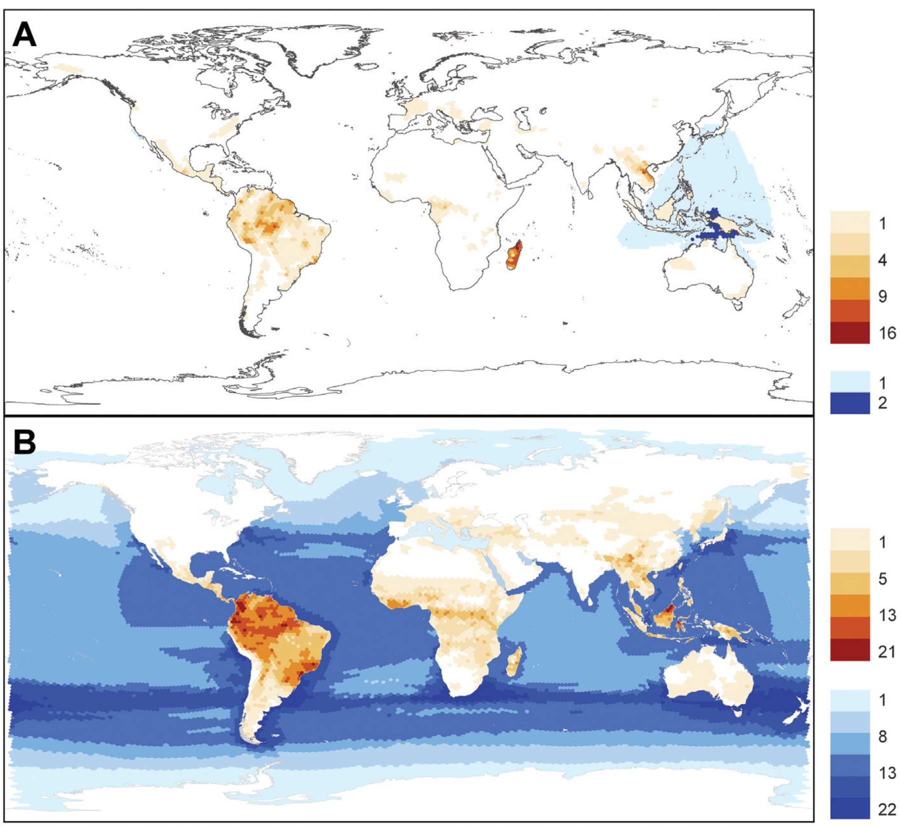

Fig. 4. Global patterns of knowledge, for land (terrestrial and freshwater, brown) and marine (blue) species. (**A**) Number of species newly described since 1992. (**B**) Data-Deficient species.

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38. Full acknowledgments are provided in the supporting material available at *Science* Online.

Supporting Online Material

www.sciencemag.org/cgi/content/full/322/5899/225/DC1
Materials and Methods
Figs. S1 to S8
Tables S1 and S2
References
Acknowledgments

26 August 2008; accepted 16 September 2008
10.1126/science.1165115