The Impact of Conservation on the Status of the World’s Vertebrates


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Using data for 25,780 species categorized on the International Union for Conservation of Nature (IUCN) Red List, we present an assessment of the status of the world’s vertebrates. One-fifth of species are classified as Threatened, and we show that this figure is increasing: on average, 52 species of mammals, birds and amphibians move one category closer to extinction each year.

However, this overall pattern conceals the impact of conservation successes, and we show that the rate of deterioration would have been at least one-fifth as much again in the absence of these. Nonetheless, current conservation efforts remain insufficient to offset the main drivers of biodiversity loss in these groups: agricultural expansion, logging, over-exploitation, and invasive alien species.

In the past four decades, individual populations of many species have undergone declines and many habitats have suffered losses of original cover (1, 2) through anthropogenic activity. These losses are manifested in species extinction rates that exceed normal background rates by two to three orders of magnitude (3) through anthropogenic activity. These losses are manifested in species extinction rates that exceed normal background rates by two to three orders of magnitude (3) with substantial detrimental societal and economic consequences (4). In response to this crisis, 193 Parties to the Convention on Biological Diversity (CBD; adopted 1992) agreed “to achieve by 2010 a significant reduction of the current rate of biodiversity loss at the global, regional, and national level as a contribution to poverty alleviation and to the benefit of all life on Earth” (5). That the target has not been met was borne out by empirical testing against 31 cross-disciplinary indicators developed within the CBD framework itself (I). However, this does not mean that conservation efforts have been ineffective. Conservation
actions have helped prevent extinctions (6, 7) and improve population trajectories (8), but there has been limited assessment of the overall impact of ongoing efforts in reducing losses in biodiversity (9, 10). Here, we assess the overall status of the world’s vertebrates, determine temporal trajectories of extinction risk for three vertebrate classes, and estimate the degree to which conservation actions have reduced biodiversity loss.

Described vertebrates include 5,498 mammals, 10,027 birds, 9,084 reptiles, 6,638 amphibians, and 31,327 fishes (table S1). Vertebrates are found at nearly all elevations and depths, occupy most major habitat types, and display remarkable variation in body size and life-history. While they comprise just 3% of known species, vertebrates play vital roles in ecosystems (11) and have great cultural significance (12). Under the auspices of the IUCN Species Survival Commission, we compiled data on the taxonomy, distribution, population trend, major threats, conservation measures and threat status for 25,780 vertebrate species, including all mammals, birds, amphibians, cartilaginous fishes, and statistically representative samples of reptiles and bony fishes (~1,500 species each (13)).

The IUCN Red List is the widely accepted standard for assessing species global risk of extinction according to established quantitative criteria (14). Species are categorized in one of eight categories of extinction risk, with those in the categories Critically Endangered, Endangered or Vulnerable classified as Threatened. Assessments are designed to be transparent, objective, and consultative, increasingly facilitated through workshops and web-based open-access systems. All data are made freely available for consultation (15), and can therefore be challenged and improved upon as part of an iterative process toward ensuring repeatable assessments over time.

**Status, trends and threats.** Almost one-fifth of extant vertebrate species are classified as Threatened, ranging from 13% of birds to 41% of amphibians, which is broadly comparable with the range observed in the few invertebrate and plant taxa completely or representatively assessed to date (Fig. 1 and table S2). When we incorporate the uncertainty that Data Deficient species (those with insufficient information for determining risk of extinction) introduce, the proportion of all vertebrate species classified as Threatened is between 16% and 33% (mid-point=19%; table S3). [Further details of the data and assumptions behind these values are provided in (16) and tables S2 and S3.] Threatened vertebrates occur mainly in tropical regions (Fig. 2), and these concentrations are generally disproportionately high even when accounting for their high overall species richness (fig. S4, A and B). These patterns highlight regions where large numbers of species with restricted distributions (17) coincide with intensive direct and indirect anthropogenic pressures, such as deforestation (18) and fisheries (19).

To investigate temporal trends in extinction risk of vertebrates, we used the IUCN Red List Index (RLI) methodology (20) that has been adopted for reporting against global targets (1, 2). We calculated the change in RLI for birds (1988, 1994, 2000, 2004 and 2008), mammals (1996 and 2008) and amphibians (1980 and 2004); global trend data are not yet available for other vertebrate groups, although regional indices have been developed (21). The RLI methodology is explained in detail in (16), but in summary the index is an aggregated measure of extinction risk calculated from the Red List categories of all assessed species in a taxon, excluding Data Deficient. Changes in the RLI over time result from species changing categories between assessments (Table 1). Only real improvements or deteriorations in status (termed “genuine” changes) are considered; recategorizations attributable to improved knowledge, taxonomy, or criteria change (“non-genuine” changes) are excluded (22). Accordingly, the RLI is calculated only after earlier Red List categorizations are retrospectively corrected using current information and taxonomy, to ensure that the same species are considered throughout and that only genuine changes are included. For example, Greater Red Musk Shrew Crocidura flavescens was classified as Vulnerable in 1996 and as Least Concern in 2008; however, current evidence indicates that the species was also Least Concern in 1996 and the apparent improvement is therefore a non-genuine change. In contrast, Hose’s Broadbill Calyptomena hosii was one of 72 bird species to deteriorate one Red List category from Least Concern to Near Threatened due to accelerating habitat loss in the Sundaic lowlands in the 1990s. Such deteriorations in species’ conservation status lead to declines in the RLI (corresponding to increased aggregated extinction risk), while improvements lead to increases in the RLI.

Temporal trajectories reveal declining RLIs for all three taxa. Among birds, the RLI (Fig. 3A) showed that their status deteriorated during 1988-2008, with index values declining by 0.49%, an average of 0.02% per year (table S4). For mammals, the RLI declined by 0.8% during 1996-2008, a faster rate (0.07% per year) than for birds. Proportionally, amphibians were more threatened than either birds or mammals, and index values declined 3.4% during 1980-2004 (0.14% per year). While the absolute and proportional declines in RLIs for each taxonomic group were small, these represent considerable biodiversity losses. For example, the deterioration for amphibians was equivalent to 662 amphibian species each moving one Red List category closer to extinction over the assessment period. The deteriorations for birds and mammals equate to 223 and 156 species, respectively, deteriorating at least one category. On average,
52 species per annum moved one Red List category closer to extinction during 1980–2008. Note that the RLI does not reflect ongoing population changes that are occurring too slowly to trigger change to different categories of threat. Other indicators based on vertebrate population sizes showed declines of 30% between 1970 and 2007 (1, 2, 22).

Global patterns of increase in overall extinction risk are most marked in Southeast Asia (Fig. 4 and figs. SSA and S6). It is known that the planting of perennial export crops like oil palm, commercial hardwood timber operations, agricultural conversion to rice paddies, and unsustainable hunting have been detrimental to species in the region (23), but here we show the accelerating rate at which these forces are driving change. In California, Central America, the tropical Andean regions of South America, and Australia, patterns have been driven mainly by the “enigmatic” deteriorations among amphibians (24), increasingly linked to the infectious disease chytridiomycosis, caused by the presumed invasive fungal pathogen *Batrachochytrium dendrobatidis* (25). Almost 40 amphibians have deteriorated in status by three or more IUCN Red List categories between 1980 and 2004 (Table 1).

Although chytridiomycosis has been perhaps the most virulent threat affecting vertebrates to emerge in recent years, it is not the only novel cause of rapid declines. The toxic effects of the veterinary drug diclofenac on Asian vultures is not the only novel cause of rapid declines. The toxic effects of the veterinary drug diclofenac on Asian vultures has resulted in extinction (23% of species). No mammals are listed as Extinct for the period 1996–2008, although the possible extinction of the Yangtze River Dolphin *Lipotes vexillifer* would be the first megafauna vertebrate species extinction since the Caribbean Monk Seal in the 1950s (30).

**Estimates of conservation success.** These results support previous findings that the state of biodiversity continues to decline, despite increasing trends in responses such as protected areas coverage and adoption of national legislation (1, 2). Next, we asked whether conservation efforts have made any measurable contribution to reducing declines or improving the status of biodiversity.

The Red List Index trends reported here are derived from 928 cases of recategorization on the IUCN Red List (Table 1 and Table S6), but not all of these refer to deteriorations. In seven percent of cases (68/928), species underwent an improvement in status, all but four due to conservation action (e.g., Asian Crested Ibis *Nipponia nippon*, changed from Critically Endangered in 1994 to Endangered in 2000 owing to protection of nesting trees, control of agrochemicals in ricefields, and prohibition of firearms; the four exceptions were improvements resulting from natural processes, such as unassisted habitat regeneration; tables S7 and S8). Nearly all of these improvements involved mammals and birds, where the history of conservation extends back farther and where the bulk of species-focused conservation funding and attention is directed (31). Only four amphibian species underwent improvements, because the amphibian extinction crisis is such a new phenomenon and a plan for action has only recently been developed (32).

To estimate the impact of conservation successes, we compared the observed changes in the RLI with the RLI trends expected if all 64 species that underwent an improvement in status due to conservation action had not done so (16). Our explicit assumption is that, in the absence of conservation, these species would have remained unchanged in their original category, although we note that this approach is conservative because it is likely that some would have deteriorated [in the sense of (6)]. The resulting difference between the two RLIs can be attributed to conservation. We show that the index would have declined by an additional 18% for both birds and mammals in the absence of conservation (Fig. 3, B and C, and table S4). There was little difference for amphibians (+1.4%; Fig. 3D) given the paucity of species improvements. For birds, conservation action reduced the decline in the RLI from 0.58% to 0.49%, equivalent to preventing 39 species each moving one Red List category closer to extinction between 1988 and 2008. For mammals, conservation action reduced the RLI decline from 0.94% to 0.8%, equivalent to preventing 29 species moving one category closer to extinction between 1996 and 2008.
These results grossly underestimate the impact of conservation, because they do not account for species that either i) would have deteriorated further in the absence of conservation actions, or ii) improved numerically though not enough to change Red List status. As an example among the former, Black Stilt Himantopus novaezelandiae would have gone extinct were it not for reintroduction and predator control efforts and its Critically Endangered listing has thus remained unchanged (6). Among the latter, conservation efforts improved the total population numbers of 33 Critically Endangered birds during 1994-2004, but not sufficiently for any species to be moved to a lower category of threat (33). As many as 9% of mammals, birds, and amphibians classified as Threatened or in the category Near Threatened have stable or increasing populations (15) largely due to conservation efforts, but it will take time for these successes to translate into improvements in status. Conservation efforts have also helped avoid the deterioration in status of Least Concern species. Finally, conservation actions have benefited many other Threatened species besides birds, mammals and amphibians, but this cannot yet be quantified through the RLIs for groups that have been assessed only once (e.g., Salmon Shark Lamna ditropis have improved due to a 1992 UN moratorium on large-scale pelagic driftnet fisheries).

**Confronting threats.** Species recovery is complex and case-specific, but always requires mitigating threats. We investigated the main drivers of increased extinction risk by identifying for each species that deteriorated in status the primary threat responsible for that change. To understand which drivers of increased extinction risk conservation efforts are being mitigated most successfully, we identified for each species that improved in status the primary threat offset by successful conservation (table S6).

We found that, for any single threat, regardless of the taxa involved, deteriorations outnumber improvements—conservation actions have not yet succeeded in offsetting any major driver of increased extinction risk (fig. S7). On a per-species basis, amphibians are in an especially dire situation, suffering the double-jeopardy of exceptionally high levels of threat coupled with low levels of conservation effort. Still, there are conservation successes among birds and mammals, and here we investigate the degree to which particular threats have been addressed.

Conservation actions have been relatively successful at offsetting the threat of invasive alien species for birds and mammals: for every five species that deteriorated in status due to this threat, two improved through its mitigation. These successes have resulted from the implementation of targeted control or eradication programs (e.g., introduced cats have been eradicated from 37 islands since the mid-1980s, (34) coupled with reintroduction initiatives (e.g., Seychelles Magpie-robin Copsychus sechellarum: population increased from 12-15 birds in 1965 to 150 in 2005) (fig. S8). Many of these improvements have occurred on small islands, but also in Australia owing, in part, to Red Fox Vulpes vulpes control (Fig. 4; SSB). However, among amphibians, only a single species, the Mallorcan Midwife Toad Alytes muletensis, improved in status due to mitigation of the threat posed by invasive alien species, compared with 208 species that deteriorated. This is because there is still a lack of understanding of the pathways by which chytridiomycosis is spread and may be controlled, and in situ conservation management options are only just beginning to be identified [e.g., (35)]. Meanwhile, the establishment of select, targeted captive populations with a vision to reintroducing species in the wild may offer valuable opportunities once impacts in their native habitat are brought under control (e.g., Kihansi Spray Toad Nectophrynoides asperginis, Extinct in the Wild due to dramatic alteration of its spray zone habitat).

For mammals and birds, the threats leading to habitat loss have been less effectively addressed relative to that of invasive alien species: for every ten species deteriorating due to agricultural expansion, less than one improved due to mitigation of this threat. Protected areas are an essential tool to safeguard biodiversity from habitat loss, but the protected areas network remains incomplete and non-strategic relative to Threatened species (17) and reserve management can be ineffective (36). Numerous Threatened species are restricted to single sites, many still unprotected (37), and these present key opportunities to slow rates of extinction. In the broader matrix of unprotected land, agri-environmental schemes could offer important biodiversity benefits provided that management policies are sufficient to enhance populations of Threatened species (38).

Hunting has been relatively poorly addressed in mammals (6 improvements cf. 62 deteriorations) when compared with birds (9 improvements cf. 31 deteriorations). In birds, successes have resulted mainly from targeted protection (e.g., Lear’s Macaw Anodorhynchus leari, changed from Critically Endangered to Endangered due to active protection of the Toca Velha/Serra Branca cliffs in Brazil), but also from enforcement of legislation (e.g., hunting bans) and harvest management measures. Many mammals subject to hunting occur at low densities, have large home ranges, and/or are large-bodied. Although active site-based protection has contributed to an improvement in the status of some of these species, site protection alone is often insufficient if not complemented by appropriate legislation, biological management, and effective enforcement (39). For example, a combination of the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) and enactment of the Vicuña Convention, which prohibited domestic exploitation and mandated the establishment of
protected areas, has helped improve the status of Vicuña *Vicugna vicugna* (Near Threatened to Least Concern).

The threat of fisheries has been mitigated relatively more effectively for marine mammals (4 deteriorations, 2 improvements) than for birds (10 deteriorations, zero improvements), reflecting both the time when drivers first emerged and the past influence of supranational conservation policy. Among historically exploited, long-lived mammals, for example, the Humpback Whale *Megaptera novaeangliae* (Vulnerable to Least Concern) has benefited from recent protection from commercial whaling (since 1955). Declines among slow-breeding seabirds (particularly albatrosses and petrels, fig. S9) are mainly a consequence of increasing incidental by-catch resulting from the growth of commercial fisheries, particularly long-line and trawling. Legislative tools, such as the recently enacted multi-lateral Agreement on the Conservation of Albatrosses and Petrels (40), may yet deliver dividends by coordinating international action to reduce fisheries mortality of these highly migratory species. Binding legislation and harvest management strategies also are urgently needed to address the disproportionate impact of fisheries on cartilaginous fishes (fig. S10).

We have no data on the relationship between expenditure on biodiversity and conservation success. A disproportionate percentage of annual conservation funding is spent in economically wealthy countries (41), where there are generally fewer Threatened species (Fig. 2 and fig. S4B) and the disparity between success and failure appears less evident (Fig. 4). Southeast Asia, by contrast, has the greatest imbalance between improving and deteriorating trends, emphasizing the need there for greater investment of resources and effort.

**Conclusions.** Our study confirms previous reports of continued biodiversity losses. We also find evidence of notable conservation successes illustrating that targeted, strategic conservation action can reduce the rate of loss compared with that anticipated without such efforts. Nonetheless, the current level of action is outweighed by the magnitude of threat, and conservation responses will need to be substantially scaled up to combat the extinction crisis. Even with recoveries, many species remain conservation-dependent, requiring sustained, long-term investment (42); for example, actions have been underway for 30 years for Golden Lion Tamarin *Leontopithecus rosalia*, 70 for Whooping Crane *Grus americana*, and 115 for White Rhinoceros *Ceratotherium simum*.

Halting biodiversity loss will require coordinated efforts to safeguard and effectively manage critical sites, complemented by broad-scale action to minimize further destruction, degradation and fragmentation of habitats (37, 39) and to promote sustainable use of productive lands and waters in a way that is supportive to biodiversity. Effective implementation and enforcement of appropriate legislation could deliver quick successes; for example, by-catch mitigation measures, shark-finning bans, and meaningful catch limits have considerable potential to reduce declines in marine species (19). The 2010 biodiversity target may not have been met, but conservation efforts have not been a failure. The challenge is to remedy the current shortfall in conservation action to halt attrition of global biodiversity.

**References and Notes**

5. UNEP, Report on the sixth meeting of the Conference of the Parties to the Convention on Biological Diversity (UNEP/CBD/COP/20/Part 2) Strategic Plan Decision VI/26 in CBD (UNEP, Nairobi, 2002).
16. See supporting material on Science Online.
43. We are indebted to the more than 3,000 species experts who devoted their knowledge, intellect and time to the compilation of vertebrate data on the IUCN Red List. Full acknowledgments are provided in the supporting online material.

**Supporting Online Material**
www.sciencemag.org/cgi/content/full/science.1194442/DC1
Materials and Methods
Figs. S1 to S10
Tables S1 to S9
References
Acknowledgments

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**Fig. 1.** The proportion of vertebrate species in different Red List categories compared with completely (or representatively) assessed invertebrate and plant taxa on the 2010 IUCN Red List (15). EW, Extinct in the Wild; CR, Critically Endangered; EN, Endangered; VU, Vulnerable; NT, Near Threatened; LC, Least Concern; DD, Data Deficient. Extinct species excluded. Taxa ordered according to the estimated percentage (shown by horizontal red lines and given in parentheses at top of bar) of extant species considered Threatened if Data Deficient species are Threatened in the same proportion as data sufficient species. Numbers above the bars represent numbers of extant species assessed in the group; asterisks indicate those groups in which estimates are derived from a randomized sampling approach.

**Fig. 2.** Global patterns of threat, for land (terrestrial and freshwater, in brown) and marine (in blue) vertebrates, based on the number of globally Threatened species in total.

**Fig. 3.** (A) Trends in the Red List Index (RLI) for the world’s birds, mammals, and amphibians. (B to D) Observed change in the RLI for each group (black) compared with RLI trends that would be expected if species that underwent an improvement in status due to conservation action had undergone no change (red). The difference is attributable to conservation. An RLI value of 1 equates to all species being Least Concern; an RLI value of 0 to all species being Extinct. Improvements in species conservation status lead to increases in the RLI, while deteriorations lead to declines. A downwards trend in the RLI value means that the net expected rate of species extinctions is increasing. Shading shows 95% confidence intervals. Note: RLI scales for (B), (C), and (D) vary.

**Fig. 4.** Global patterns of net change in overall extinction risk across birds, mammals and amphibians (for the periods plotted in Fig. 3) mapped as average number of genuine Red List category changes per cell per year. Purple shades correspond to net deterioration (i.e., net increase in extinction risk) in that cell, green to net improvement (i.e., decrease in extinction risk), and white to no change. The uniform pattern of improvement at sea is driven by improvements of migratory marine mammals with cosmopolitan distributions (e.g., Humpback Whale). Deteriorations (e.g., Nightingale Reed-warbler *Acrocephalus luscinius* in the Northern Mariana Islands) and improvements (e.g., Rarotonga Monarch *Pomarea dimidiata* in the Cook Islands) on islands are hard to discern; islands showing overall net improvements are shown in blue. Note that the intensity of improvements never matches the intensity of deteriorations.
Table 1. Net number of species qualifying for revised IUCN Red List categories between assessments owing to genuine improvement or deterioration in status, for birds (1988-2008); mammals (1996-2008); and amphibians (1980-2004). Category abbreviations as for Fig. 1; CR(PE/PEW), Critically Endangered (Possibly Extinct or Possibly Extinct in the Wild). CR excludes PE/PEW. Species undergoing an improvement (i.e., moving from a higher to a lower category of threat) indicated by “+”; species deteriorating in status (i.e., moving from a lower to a higher category of threat) indicated by “–”. Species changing categories for non-genuine reasons, such as improved knowledge or revised taxonomy, are excluded. In the case of birds, for which multiple assessments have been undertaken, values in parentheses correspond to the sum of all changes between consecutive assessments; the same species may therefore contribute to the table more than once [see (16)].

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