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LETTER

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Are we eating the world's megafauna to extinction?

William J. Ripple[1] | Christopher Wolf[1] | Thomas M. Newsome[1,2] | Matthew G. Betts[1] | Gerardo Ceballos[3] | Franck Courchamp[4] | Matt W. Hayward[5] | Blaire Van Valkenburgh[6] | Arian D. Wallach[7] | Boris Worm[8]

[1]Department of Forest Ecosystems and Society, Forest Biodiversity Research Network, Oregon State University, Corvallis, Oregon

[2]School of Life and Environmental Science, The University of Sydney, Sydney, New South Wales, Australia

[3]Instituto de Ecologia, Universidad Nacional Autonoma de Mexico, C.U., Ciudad de Mexico, Mexico

[4]Ecologie, Systématique, and Evolution, Univ Paris-Sud, CNRS, AgroParisTech, Université Paris-Saclay, Orsay, France

[5]School of Environmental and Life Sciences, The University of Newcastle, Callaghan, New South Wales, Australia

[6]Department of Ecology and Evolutionary Biology, University of California, Los Angeles, California

[7]Centre for Compassionate Conservation, Faculty of Science, University of Technology Sydney, Broadway, New South Wales, Australia

[8]Department of Biology, Dalhousie University, Halifax, Nova Scotia, Canada

Correspondence
William J. Ripple, Department of Forest Ecosystems and Society, Oregon State University, Corvallis, OR 97331.
Email: bill.ripple@oregonstate.edu

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Abstract

Many of the world's vertebrates have experienced large population and geographic range declines due to anthropogenic threats that put them at risk of extinction. The largest vertebrates, defined as megafauna, are especially vulnerable. We analyzed how human activities are impacting the conservation status of megafauna within six classes: mammals, ray-finned fish, cartilaginous fish, amphibians, birds, and reptiles. We identified a total of 362 extant megafauna species. We found that 70% of megafauna species with sufficient information are decreasing and 59% are threatened with extinction. Surprisingly, direct harvesting of megafauna for human consumption of meat or body parts is the largest individual threat to each of the classes examined, and a threat for 98% (159/162) of threatened species with threat data available. Therefore, minimizing the direct killing of the world's largest vertebrates is a priority conservation strategy that might save many of these iconic species and the functions and services they provide.

KEYWORDS

conservation, endangerment, exploitation, global, vertebrates

1 | INTRODUCTION

Maintaining biodiversity is crucial to ecosystem structure and function, but it is compromised by population declines and geographic range losses that have left roughly one fifth of the world's vertebrate species threatened with extinction (Ceballos et al., 2015; Dirzo et al., 2014; Hoffmann et al., 2010; McCauley et al., 2015). The main causes of vertebrate biodiversity declines are overexploitation and habitat loss associated with an increasing human population and per capita resource use (Hoffmann et al., 2010; Maxwell, Fuller, Brooks, & Watson, 2016; Ripple et al. 2017a). The effects of these and other drivers such as habitat fragmentation, pollution, pathogens, the introduction of nonnative species, and, notably, global climate change provide mounting evidence that humans are poised to cause a sixth mass extinction event (Barnosky et al., 2011). The ongoing biodiversity crisis has prompted researchers to explore how species' life history traits relate to their threat status (Dirzo et al., 2014). Although it is known that the largest species of terrestrial mammals are at a high risk of extinction (Ripple et al., 2015, 2016; Smith, Smith, Lyons, & Payne, 2018), especially from anthropogenic sources, threats to megafauna across all major classes of vertebrates taken together have not been fully considered (Ripple et al., 2017b).

Here, we construct a list of species that qualify as megafauna based on new criteria of body size thresholds for six classes of vertebrates. Specifically, we defined megafauna as vertebrate species that are unusually large compared with other species in the same class. This approach builds on published definitions of megafauna that are based mostly on terrestrial mammals from the Pleistocene (Supporting Information Table S1; Martin & Klein, 1989). In doing so, the megafauna concept becomes context dependent and not fixed on one specific minimum body size or mass for all taxa (Hansen & Galetti, 2009). Motivated by previously published thresholds, which mostly ranged between 40 and 100 kg (Supporting Information Table S1), we define mass thresholds for megafauna separately for each class. Thus, we considered megafauna to be all species ≥100 kg for mammals, ray-finned fish, and cartilaginous fish, and all species ≥40 kg for amphibians, birds, and reptiles, because they have smaller body sizes, on average, compared with large mammals and fish.

These new megafauna mass thresholds extend the number and diversity of species included as megafauna, thereby allowing for a broader analysis of the status and ecological effects of the world's largest vertebrates. Under this framework, we herein provide an analysis of the status, trends, and key threats to megafauna, and report on the ecological consequences of their decline. We end by outlining priority conservation strategies to help ensure the survival of the Earth's remaining megafauna in marine, freshwater, and terrestrial ecosystems. By considering megafauna across classes, our analysis highlights similarities for the threats faced by species that differ geographically, taxonomically, and in their habitats.

2 | METHODS

We obtained body mass data from the Amniote database for mammals, reptiles, and birds (Myhrvold et al., 2015), and acquired body lengths from FishBase for ray-finned and cartilaginous fish (Froese & Pauly, 2000) and AmphibiaWeb for amphibians (AmphibiaWeb, 2016). Using the 1,735 fish species with known maximum lengths and masses in FishBase, we modeled the relationship between length and mass (both log transformed) with a generalized additive model, which allows for nonlinearity. We used this model to predict masses for all species in FishBase with known maximum lengths and unknown masses. For amphibians, we used the allometric equations given in Pough (1980) to predict masses from total and snout-to-vent lengths given in AmphibiaWeb species accounts. After determining body masses, we restricted our analysis to only those species that met our megafauna criteria (≥100 kg for mammals and fish and ≥40 kg for birds, amphibians, and reptiles).

We merged the body mass data with information on species-level extinction risk from the IUCN Red List (ver. 2018.1) using species' scientific names and taxonomic synonyms. Species not found in the IUCN Red List, because they have yet to be assessed, were listed separately but excluded from further analysis. We also excluded extinct (EX), extinct in the wild (EW), and data-deficient (DD) species from most of the analysis, focusing only on those classified as critically endangered (CR), endangered (EN), vulnerable (VU), near threatened (NT), or least concern (LC). We did, however, calculate the percentages of megafauna and all vertebrates that have gone extinct since 1500 CE (the timeframe used in the IUCN Red List). Lastly, we grouped the species by class for the following classes: ray-finned fish (Actinopterygii), cartilaginous fish (Chondrichthyes), birds, mammals, reptiles, and amphibians. Other minor fish classes contained no species with masses ≥100 kg and thus were only included in the results for all vertebrates together. We determined the percentages of species threatened and decreasing for both species classified as megafauna and for all vertebrates with available data. We also estimated the percentages of megafauna species by class that are threatened within various ecosystem types as defined by the IUCN Red List (Marine, Freshwater, and Terrestrial).

The threats faced by species were assessed using coded information from the IUCN Red List threats classification scheme (IUCN, 2018). Only threatened species with coded threat information available were included in this portion of the analysis. To separate threats related to livestock/aquaculture and crops, and those related to harvesting and logging, we split two of the top-level threats categories. Specifically, we split the "Agriculture & aquaculture" category (2) into agricultural "cropping" (composed of categories 2.1: "Annual & perennial nontimber crops" and 2.2: "Wood & pulp plantations") and "livestock/aquaculture (categories 2.3: "Livestock farming & ranching" and 2.4: "Marine & freshwater aquaculture") and the "Biological resource use" category (5) into "harvesting" (5.1: "Hunting & collecting terrestrial animals" and 5.4: "Fishing & harvesting aquatic resources") and "logging" (5.2: "Gathering terrestrial plants" and 5.3: "Logging & wood harvesting"). Finally, we manually recorded the reasons for harvesting of each megafauna species based on information in the IUCN Red List fact sheets and Arkive (2018).

3 | RESULTS

A total of 362 extant species qualified as megafauna based on our taxonomy-based size thresholds (Supporting Information Tables S2–S4). We excluded 77 species (38 mammals, 16 ray-finned fish, 6 reptiles, and 17 cartilaginous fish) from subsequent analyses (unless otherwise noted) because they were either extinct in the wild (EW; two species), extinct (EX; seven species), data deficient (DD; 48 species), or not listed in the IUCN Red List (20 species) (Supporting Information Table S3). Close to half of the remaining 292 megafauna species were mammals ($n = 140$), followed by cartilaginous fish ($n = 58$), ray-finned fish ($n = 56$), reptiles ($n = 33$), birds ($n = 4$), and an amphibian ($n = 1$) (Supporting Information Table S2).

Megafauna species are more threatened and have a relatively higher percentage of decreasing populations than all vertebrates together. Of the 39,493 (non-DD/EW/EX) vertebrate species in the IUCN Red List, 21% are catalogued as threatened and 46% have decreasing populations (Figure 1, Supporting Information Table S4). In contrast, of the 292 megafauna species, 70% have decreasing populations and 59% are threatened (Figure 1). Generally, freshwater ecosystems contain the highest proportion of threatened megafauna, while marine systems contain a lower proportion of threatened megafauna (Supporting Information Figure S1).

Notably, the top-ranked threat within each megafauna class was direct harvesting by humans, although there were typically multiple co-occurring threats, mostly related to habitat degradation (Figure 2). Meat consumption was the most common motive for harvesting megafauna for all classes except reptiles where harvesting eggs was ranked on top (Figure 3). Other leading reasons for harvesting megafauna included medicinal use, unintended bycatch in fisheries and trapping, live trade, and various other uses of body parts such as skins and fins (Figure 3). Over half (64%) of the threatened megafauna were listed by the Convention on International Trade in Endangered Species (CITES) because of threats involving global trade in these species (Supporting Information Table S5). Since 1500 CE, 2% of assessed megafauna species have gone extinct compared to 0.8% of all assessed vertebrates (Supporting Information Table S4). Interestingly, within each of the six vertebrate classes, some of the largest individual species were threatened with extinction (Figure 4, Supporting Information Table S2).

4 | DISCUSSION

Our results suggest that we are in the process of eating the world's megafauna to extinction. Megafauna are heavily exploited for human consumption (Figure 3) and are, on average, 2.75 times more likely to be threatened by extinction than other vertebrate species that have been assessed by the IUCN (and are not DD, EW, or EX) (Supporting Information Table S4). This means that seven out of 10 of our largest and most iconic fauna will experience further population declines in the near future, and three out of five could go extinct. Declines of the largest vertebrate species will jeopardize ecosystem services to humans and generate cascading evolutionary and ecological effects on other species and processes (Estes et al., 2011; Estes, Heithaus, McCauley, Rasher, & Worm, 2016; Ripple et al., 2017b).

The Pleistocene extinctions reinforce our findings regarding the elevated extinction risk of extant megafauna. Since the late Pleistocene, humans have emerged as a "super-predator" (Darimont, Fox, Bryan, & Reimchen, 2015), specializing in killing prey larger than their individual body mass, similar to gray wolves (*Canis lupus*) and orcas (*Orcinus orca*). In the wake of growing human populations, their increased geographic range, and improved tool use, many large terrestrial mammals went extinct during the late Pleistocene (Sandom, Faurby, Sandel, & Svenning, 2014). The strong extinction bias toward species of large size is highly unusual and unmatched over the prior 65 million years (Smith et al., 2018). Humans, commonly using projectile weapons, differ from other predators of large prey, such as lions (*Panthera leo*) and wolves, in their ability to cause death at a distance (Worm, 2015). Attacking from a safe distance enables the tackling of very large, dangerous prey with much less risk to the predator, compared with the physical combat required for all non-human predators on land and sea. In addition, the limitation of predator numbers through natural prey availability does not hold for humans, whose global population grows disproportionately to its sustainability because of our ability to produce food.

The impact of the human appetite for large prey was first felt on land with the extinction of the Pleistocene megafauna in terrestrial systems, and more recently extended to marine and freshwater ecosystems as humans enhanced their fishing skills with sophisticated technology (Jackson et al., 2001). Historically, human hunters have preferentially targeted large prey items as a way of signaling their fitness – a pattern that may be continuing today in the form of trophy hunting (Darimont, Codding, & Hawkes, 2017). Following this habitual (or possibly hard-wired) pattern of humans focusing on the largest size classes in our prey spectrum, direct harvesting for meat or egg consumption is still a dominant threat for all megafauna classes (Figures 2 and 3). The current trend is consistent with optimal foraging theory, which predicts that predators attempt to gain the most benefit (e.g., large vulnerable prey) at the least cost (Stephens & Krebs, 1986). But in today's world, the reasons for continuing such a practice are unclear, because the vast majority of human food is produced by agriculture and aquaculture, and most "wild" meat likely comes from smaller bodied species, which are more plentiful. Despite this

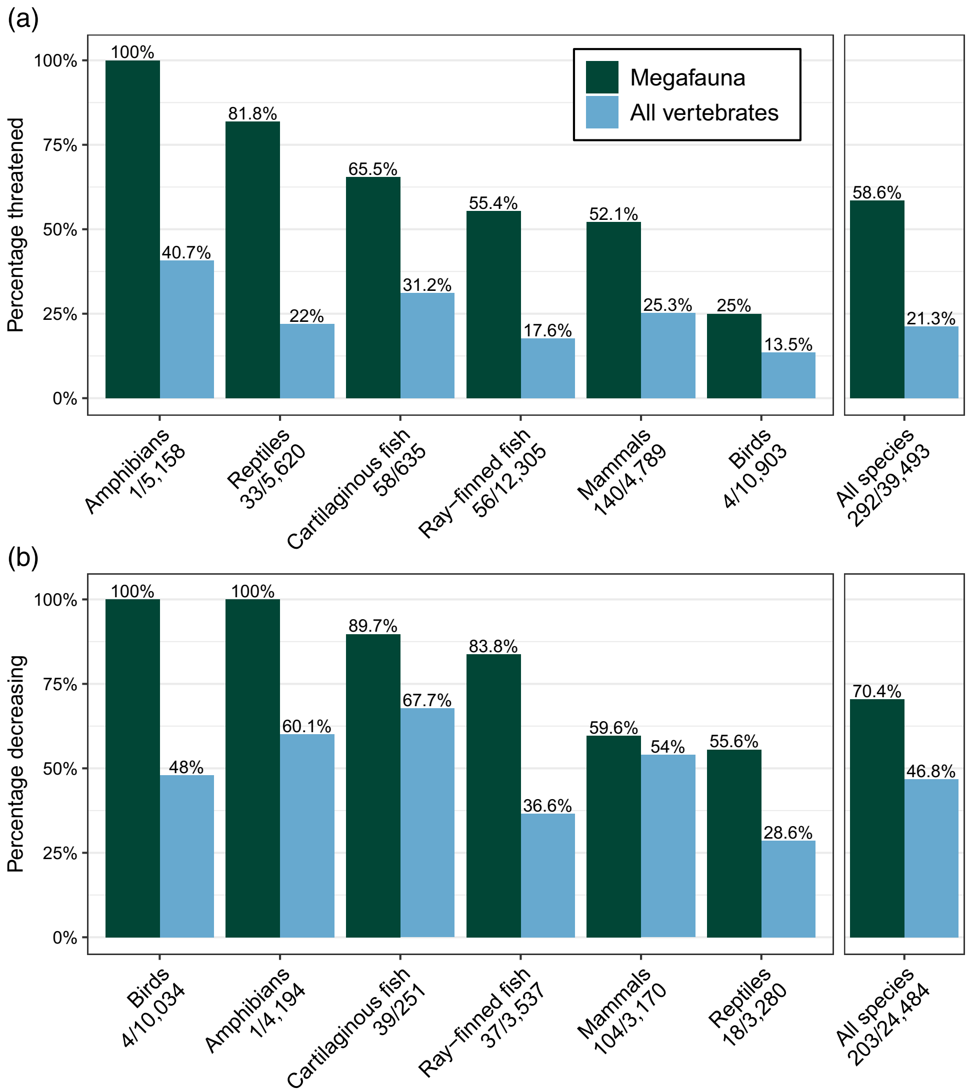

FIGURE 1 Megafauna extinction risk and trends. Shown are percentages of species classified as (a) threatened (IUCN Red List Category Vulnerable, Endangered, or Critically Endangered) and (b) with decreasing population trend. Data are separated by megafauna (dark green) versus all vertebrate species (blue) in each class, and for all vertebrates combined (IUCN, 2018). Numbers of megafauna species in each class followed by numbers of all IUCN-assessed species in each class are indicated at the bottom of each panel. Only species with IUCN Red List category and population trend data are counted for panels (a) and (b), respectively. Megafauna are defined here as species with ≥100 kg body mass for mammals, ray-finned fish, and cartilaginous fish, and ≥40 kg for amphibians, birds, and reptiles

pattern, humanity's predatory behavior can cause declines in megafauna because a given rate of exploitation will reduce populations of large animals more quickly, because on average, they tend to be less abundant and productive, than smaller species. Although consideration should be given to the fact that megafauna can be an important food source for some people in developing countries, bushmeat hunting for food and medicinal products may harvest millions of tonnes of animal biomass per year in the southern hemisphere (Cawthorn & Hoffman, 2015), and worldwide, threatens over 300 terrestrial mammal species with extinction, some of which are large size (Ripple et al., 2016). In certain cases, if people no longer eat wild meat for subsistence, they may need to obtain sufficient nutrients from agricultural sources that could result in other impacts to habitats. The surge in demand for Asian traditional medicinal products also exert heavy tolls on the largest species, which are often the most appealing, for various reasons (Ellis, 2013).

There is good reason to raise further awareness of the declining status of large vertebrates. Nine megafauna species went extinct or became extinct in the wild between the 1760s and 2012, and in each case this was due to excessive hunting or a combination of hunting and habitat degradation (Supporting Information Table S6). The reasons for hunting these species to extinction were for the acquisition of meat for consumption or for body parts such as skins, horns, organs, and antlers

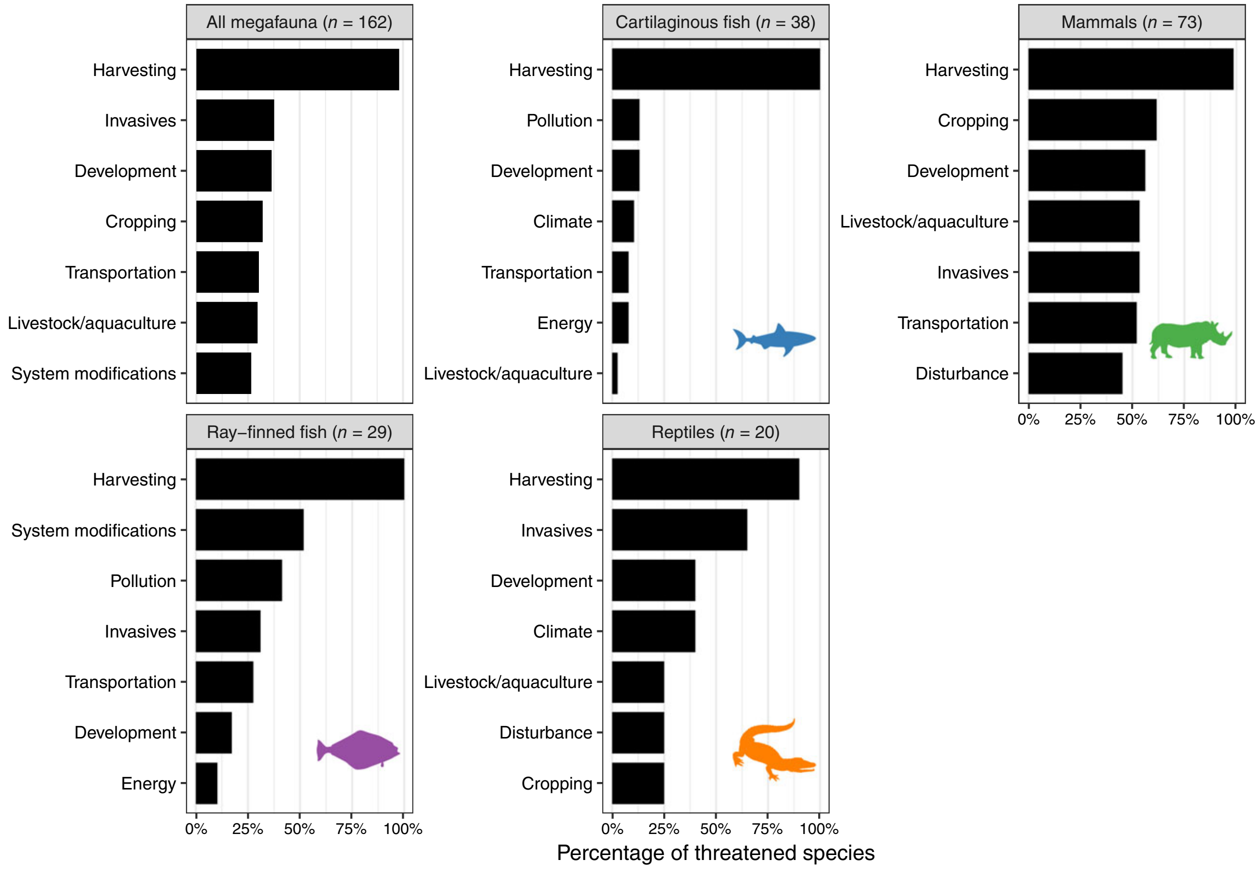

FIGURE 2 Current threats to megafauna. Shown are percentages of threatened megafauna species in each class facing different types of threats. We used the top-level coded threat data on species Red List fact sheet pages, grouping threats 5.1/5.4 together as "Harvesting," 5.2/5.3 as "Logging," 2.1/2.2 as "Cropping," and 2.3/2.4 as "Livestock/aquaculture." Only threatened species with coded threat information available (145/155) were used for this plot. Only the seven most common threats for each group are shown. No panel is shown for the single threatened amphibian species, the Chinese giant salamander. It was threatened by harvesting, system modifications, pollution, logging, energy, and cropping. Similarly, no panel is shown for the single threatened bird species, the Somali Ostrich, which was threatened by harvesting, livestock, and cropping

for traditional medicine or trophies (Supporting Information Table S6). Persecution is a major cause of mortality for many of the large carnivores in terrestrial systems (Ripple et al., 2014). Due to their slow life history traits, involving delayed reproduction and few offspring, megafauna are extremely vulnerable to fishing, trapping, and hunting pressures (Johnson, 2002). In addition to intentional harvesting, much of this mortality is due to bycatch in snares and traps in terrestrial systems or gillnets, trawls, and longlines in aquatic systems. Many of the megafauna species are simultaneously affected by various types of habitat degradation (Figure 2). When taken together, these threats to habitats can have major negative cumulative effects on vertebrate species (Betts et al., 2017; Shackelford, Standish, Ripple, & Starzomski, 2018). Consistent with our results, overexploitation and habitat loss (mainly from agriculture) are considered major twin threats to biodiversity in general (Maxwell et al., 2016).

The world's terrestrial mammalian megafauna are more prone to elevated extinction risk than all terrestrial mammal species considered as a group (59% vs. 21% threatened, Supporting Information Table S4). Megafaunal mammals in marine systems are faring relatively better, with only nine of 33 species (27%) currently assessed as threatened, although 28 more species are data deficient (Supporting Information Tables S2–S4). Indeed, many of the largest marine mammals are in the process of recovering after the global cessation of industrial whaling in 1986 (Magera, Flemming, Kaschner, Christensen, & Lotze, 2013). This bold action required global cooperation and enforcement and has been successful in halting and reversing extinction threats for most of the great whales, with some notable exceptions such as the North Atlantic right whale (*Eubalaena glacialis*) (Taylor & Walker, 2017). Efforts to rebuild depleted fish populations worldwide have been more limited, but with some regional successes (Neubauer, Jensen, Hutchings, & Baum, 2013; Worm et al., 2009). The situation appears particularly dire for cartilaginous fish; sharks, skates, and rays include the highest proportion (9%) of species ≥100 kg of any of the classes examined here, and are more threatened, on average than any other marine group (Figure 1; Dulvy et al., 2014; Worm et al., 2013). The

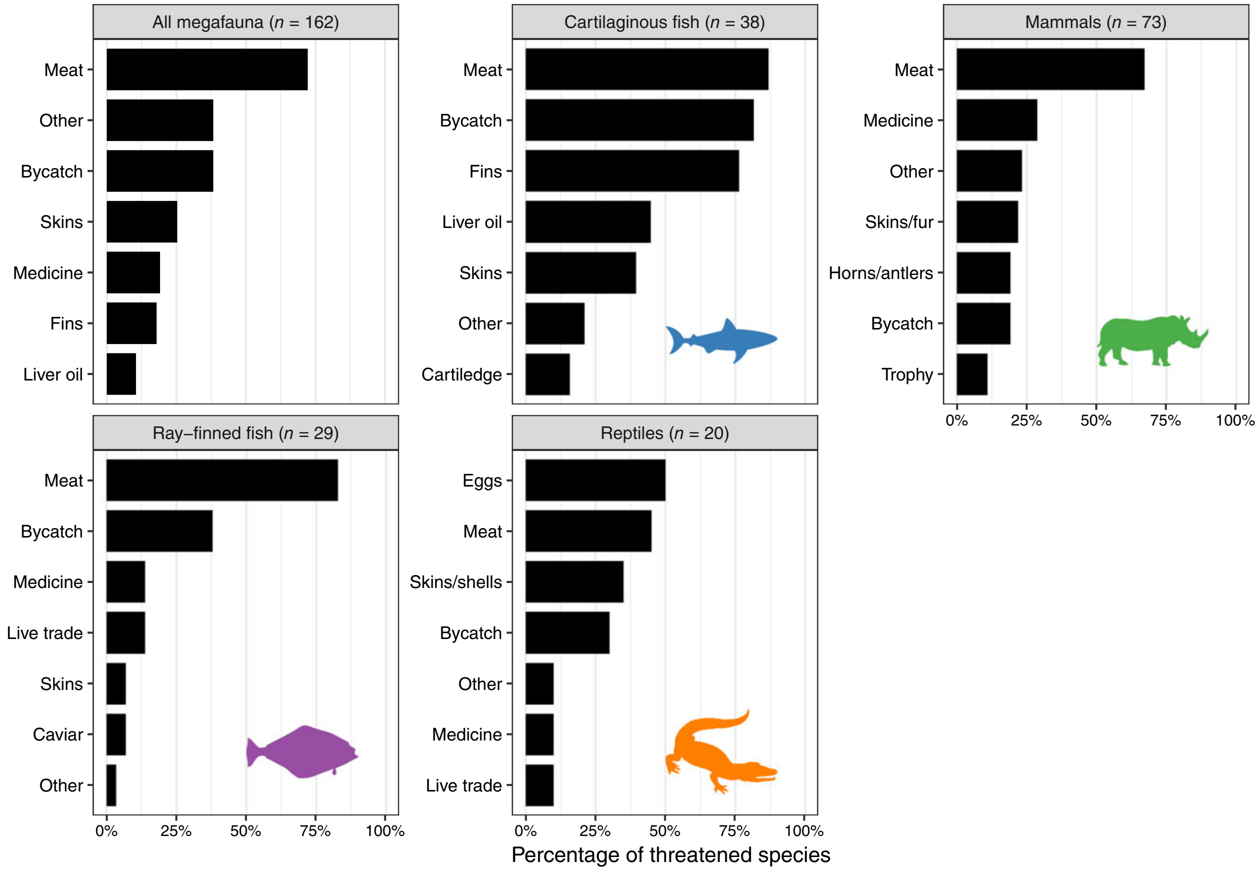

FIGURE 3 Reasons for harvesting threatened megafauna. Numbers of threatened megafauna species are shown in the panel titles. Reasons for harvesting were determined using species Red List fact sheet pages as well as Arkive.org species accounts (Arkive, 2018). Only the six most common reasons for each group are shown (other reasons are grouped under "Other"). No panel is shown for the single threatened amphibian species, the Chinese giant salamander. It is hunted for meat and live trade. Similarly, no panel is shown for the single threatened bird species, the Somali Ostrich, which is hunted for meat, eggs, skins, and feathers

large ray-finned fish are highly threatened in both marine and freshwater systems (Supporting Information Table S2).

The single threatened megafauna bird species, the Somali ostrich (*Struthio molybdophanes*) (Figure 4), is killed for its meat, feathers, and leather. Egg collection is also a major concern. Other threats include logging, livestock, and cropping. Of the amphibians, only one species ≥40 kg exists, the Chinese Giant Salamander (*Andrias davidianus*) (Figure 4), and it is critically endangered. This salamander, which can grow to 1.8 m long, is considered a living fossil and is one of only three living species in a family that dates back 170 million years (Chen et al., 2018). However, it is considered a delicacy in Asia, and consequently is threatened by hunting. Other threats include development, pollution, and cropping. Since the 1980s, 14 nature reserves have been created to conserve the Chinese Giant Salamander (Arkive, 2018), but population numbers are still declining (Supporting Information Table S1), and its imminent extinction in the wild has now been predicted (Turvey et al., 2018). We also identified 33 (assessed non-DD/EW/EX) reptile megafauna species, of which 27 (82%) are threatened (Figure 1). Even with this extraordinary level of threat, reptiles have often been less prominent in global conservation efforts. This is at least partially due to the paucity of available information on their extinction risk and threats reflecting a lack of attention (Böhm et al., 2013). All of the 20 threatened reptile species with coded threat data are at risk due to harvesting (Figure 2). The top reasons for harvesting reptiles include egg collection and meat acquisition (Figure 3). An additional seven reptile megafauna are listed as threatened but lack coded threat data, a situation that should be remedied by the IUCN as soon as possible (Tingley, Meiri, & Chapple, 2016).

The ecosystem impacts that the loss of megafauna may entail are likely out of proportion to their dwindling numbers and small collective biomass. The ongoing loss of megafauna alters the structure and function of their ecosystems, often in ways that are surprising and disruptive (Estes et al., 2011, 2016). Known examples include impacts on seed dispersal, nutrient cycling, fire, and small animals when large terrestrial herbivores decline (Ripple et al., 2015), or the destabilization of fish communities that experienced a loss of sharks and other large predators (Britten et al., 2014). Interestingly, these

FIGURE 4 Largest megafauna species in each major vertebrate group. All of the species shown are threatened with extinction and are threatened by human harvesters seeking their meat, body parts, or eggs. Whale shark (*Rhincodon typus*; upper left) by Christian Jensen (CC BY 2.0), leatherback (*Dermochelys coriacea*; top right) by U.S. Fish and Wildlife Service Southeast Region (CC BY 2.0), Beluga (*Huso huso*; middle left) by Jeff Whitlock (CC BY-NC-SA 3.0), African Elephant (*Loxodonta Africana*; middle right) by Jude (CC BY 2.0), Chinese Giant Salamander (*Andrias davidianus*; bottom left) by James Joel (CC BY-ND 2.0), and Somali Ostrich (*Struthio molybdophanes*; bottom right) by Julian Mason (CC BY 2.0). Whale shark (EN) flesh is highly valued in some Asian markets and the demand for shark-fin soup threatens this species. Leatherbacks (VU) are threatened by fisheries bycatch as well as human consumption of eggs and meat. Belugas (CR) are threatened by overfishing for meat and caviar, which will soon cause global extinction of the remaining natural wild populations. Elephant (VU) poaching is critically elevated due to an increased demand for ivory. The Chinese Giant Salamander (CR) is threatened by hunting, as its flesh is considered a delicacy in Asia. Somali ostriches (VU) are shot for food, leather, and feathers. The largest marine mammal, the blue whale (*Balaenoptera musculus*), is not shown

effects are transmitted both through consumptive and nonconsumptive mechanisms, whereas the presence of megafauna predators fundamentally alters the behavior and distribution of prey species even in the absence of direct predation events (Heithaus, Frid, Wirsing, & Worm, 2008). Megafauna are also of critical importance for conservation because the largest species are often flagship species, umbrella species, keystone, and engineer species or highly charismatic species (Courchamp et al., 2018; Ripple et al., 2015).

Preserving the remaining megafauna is likely going to be a difficult and complex task, as megafauna are represented by a diversity of taxa using assorted (terrestrial, freshwater, marine) habitats, and scattered across jurisdictions around the world. Based on the research presented here, we argue that any successful conservation strategy must consider minimizing the direct killing of megafauna as a priority solution, because it appears to be a major driver of extinction threat. Given the low abundances of most threatened megafauna (abundance is one of the IUCN's criteria for listing species as threatened), the impacts of such a strategy on food supply would likely be minimal, but economic values, cultural practices, and social norms might complicate the picture. We believe creating an informed public is an important first step as educational campaigns can reduce demand for highly valuable megafauna species. For example, shark fin commerce has declined following effective media campaigns involving Chinese celebrities (Dell'Apa, Smith, & Kaneshiro-Pineiro, 2014). For charismatic megafauna species threatened by human harvesting, additional well-organized pleas by celebrities might be very effective, but this is not enough on its own. Where possible, it is also essential to use legal means to lower the harvesting of the concerned species, as these can be more effective than campaigns based on ethical and moral grounds. Legal tools limiting collection and trade would help raise awareness and implicate major economic actors responsible for the overexploitation of many of these species. Ensuring that scientifically established harvesting quotas or bans are established and respected is a key step toward maintaining robust megafauna populations.

In order to achieve effective megafauna conservation, a large group of nations needs to take coordinated action soon. Wealthier countries must stop exacerbating the problem by inflating demand and prices for meat, medicinal, and ornamental products from megafauna. For example, governments could sponsor public awareness campaigns or fund organizations that provide information about the plights of specific megafauna species, ecosystem services of megafauna, as well as health concerns and the lack of proven benefits for some types of wildlife-based medicinal products (Still, 2003; Weiss & Tschirhart, 1994).

The success of the International Whaling Commission suggests that a multinational initiative for saving the full diversity of vertebrate megafauna has merit. New international agreements should include conventions to share the financial burden of responsibility among nations, especially the developed ones. This might help to facilitate accomplishments under existing conventions that are already trying to preserve biodiversity such as CITES, the Convention on Biological Diversity, and for marine areas, the United Nations Convention on the Law of the Sea. At the local scale, it is important that nations that harbor megafauna within their jurisdictions, limit through harvesting laws and informational campaigns, the exploitation of megafauna while at the same time, protect critical habitat.

In conclusion, our heightened abilities as hunters must be matched by a sober ability to consider, critique, and adjust our behaviors to avoid consuming the last of the Earth's megafauna (Darimont et al., 2015; Worm, 2015). As direct mortality is a dominant threat to megafauna and live megafauna entails larger economic benefits (e.g., ecotourism and ecosystem services) than dead megafauna, it appears that conservation dollars may be best spent on addressing direct mortality threats head-on, wherever possible.

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ORCID

Matthew G. Betts https://orcid.org/0000-0002-7100-2551
Matt W. Hayward https://orcid.org/0000-0002-5574-1653

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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Supplemental Information

Are We Eating the World's Megafauna to Extinction?

William J. Ripple, Christopher Wolf, Thomas M. Newsome, Matthew G. Betts, Gerardo Ceballos, Franck Courchamp, Matt W. Hayward, Blaire Van Valkenburgh, Arian D. Wallach, Boris Worm

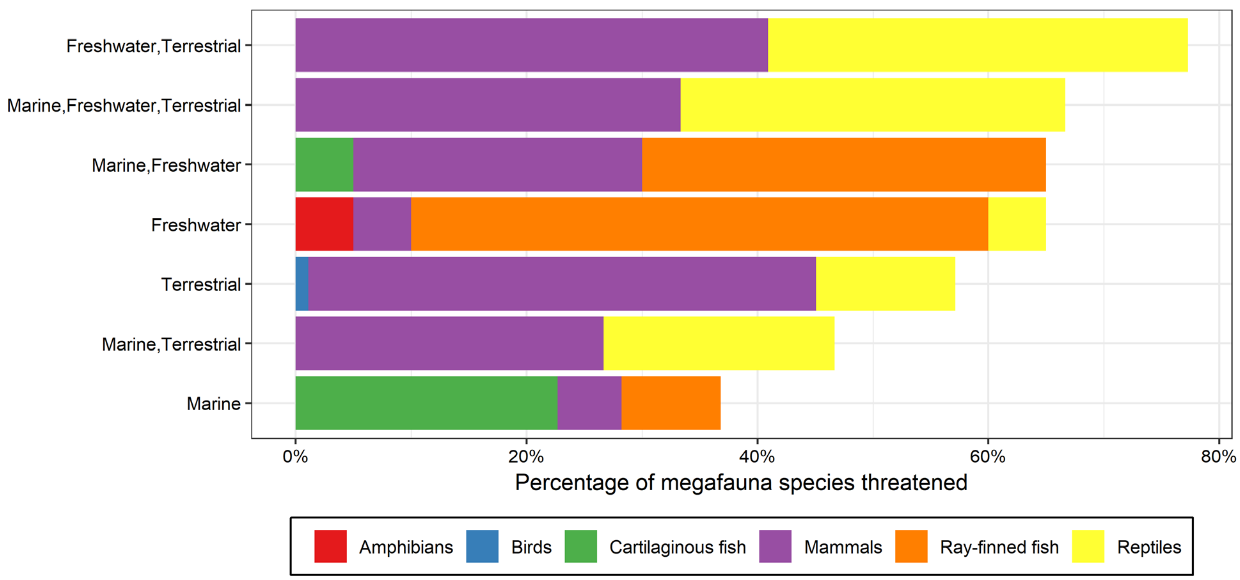

Figure S1. Percentages of megafauna species that are threatened and belonging to each class. Results are grouped by ecosystem type. Total bar lengths indicate the percentages of all megafauna species threatened within each ecosystem type. Species may belong to more than one ecosystem type. For example, species that use both freshwater and terrestrial ecosystems are counted in the "Freshwater,Terrestrial" category.

Table S1 Megafauna definitions

Based on Google Scholar and Web of Science search of "megafauna" and "kg". Search included abstract and full text. Google Scholar returns were sorted by relevance and the first 100 returns inspected (very few relevant hits were returned thereafter). For Web of Science a "Topic" search was completed and all returns inspected (total = 38). Papers were included if they stated a body mass cut-off for megafauna in the study design or simply stated the body mass cut-off for megafauna in the text.

Class	Body mass threshold (kg)	Epoch	System	Source
Mammals	1,000	11,000 B.P / Pleistocene	Terrestrial	Owen-Smith (1989) http://onlinelibrary.wiley.com/doi/10.1111/j.1523-1739.1989.tb00246.x/full
Mammals	44	Quaternary	Terrestrial	P. S. Martin, R. G. Klein, (1995) Quaternary Extinctions: A Prehistoric Revolution (Univ. of Arizona Press, Tucson, 1995).
Mammals	1,000	Recent	Terrestrial	R. N. Owen-Smith (1988) Megaherbivores: The Influence of Very Large Body Size on Ecology (Cambridge Univ. Press, New York, 1988).
Mammals	44	Pleistocene	Terrestrial	Stuart, A. J. (1991) http://onlinelibrary.wiley.com/doi/10.1111/j.1469-185X.1991.tb01149.x/abstract
Mammals	100	Pleistocene	Terrestrial	Martin, P. S. & Steadman, D. W. (1999) Prehistoric extinctions on islands and continents. In Extinctions in near time: causes, contexts and consequences (ed. R. D. E. MacPhee), pp. 17 56. New York: Kluwer/Plenum.
Mammals	250-1000	Pleistocene	Terrestrial	Choquenot and Bowman (1998) http://onlinelibrary.wiley.com/doi/10.1046/j.1466-822X.1998.00285.x/full
Mammals, reptiles, birds	45-100	Late Quaternary	Terrestrial	Roberts et al. (2001) http://science.sciencemag.org/content/292/5523/1888
Not specified	40	Late Quaternary	Terrestrial	Western (2001) http://www.pnas.org/content/105/34/12150.short
Mammals	44	Pleistocene	Terrestrial	Koch and Barnosky (2006) http://www.jstor.org/stable/30033832?seq=1#page_scan_tab_contents

Mammals	44	Late Quaternary	Terrestrial	Martin, P. (1984)*:* Prehistoric overkill*: The global model. In* Martin, P. S. & Klein, R. G. *(eds.):* Quaternary Extinctions: A Prehistoric Revolution*,* 354–403*. University of Arizona Press, Tucson.*
Mammals	50	Late Quaternary	Terrestrial	Webb (2008) http://onlinelibrary.wiley.com/doi/10.1111/j.1502-3885.2008.00026.x/full
Mammals	50	Late Quaternary	Terrestrial	Webb (2008) http://onlinelibrary.wiley.com/doi/10.1111/j.1502-3885.2008.00044.x/full
Mammals	1000	Pleistocene	Terrestrial	Guimarães et al. (2008) http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0001745
Mammals	10	Holocene	Terrestrial	Crowley (2010) http://www.sciencedirect.com/science/article/pii/S0277379110002246
Mammals	45	Recent	Terrestrial	Epps et al (2011) http://onlinelibrary.wiley.com/doi/10.1111/j.1472-4642.2011.00773.x/full
Mammals, reptiles, birds	10	Pleistocene	Terrestrial	Wroe et al. (2013) http://www.pnas.org/content/110/22/8777.short
Marine	100	Recent	Marine	McClenachan et al (2011) http://onlinelibrary.wiley.com/doi/10.1111/j.1755-263X.2011.00206.x/full
Mammals	1000 (megaherbivores)	Extant and lost	Terrestrial	Malhi et al http://www.pnas.org/content/113/4/838.short
Mammals	100 (megacarnivores)	Extant and lost	Terrestrial	Malhi et al http://www.pnas.org/content/113/4/838.short
Mammals	45 (large herbivores)	Extant and lost	Terrestrial	Malhi et al http://www.pnas.org/content/113/4/838.short
Mammals	21.5 (large carnivores)	Extant and lost	Terrestrial	Malhi et al http://www.pnas.org/content/113/4/838.short
Mammals, reptiles	44	Late Pleistocene	Terrestrial	Barnosky et al (2004) http://science.sciencemag.org/content/306/5693/70

Mammals, reptiles, fish	10	Extant	Terrestrial, Marine	McClenachan et al (2016) http://www.cell.com/current-biology/references/S0960-9822(16)30484-5
Mammals	44	Late Quaternary	Terrestrial	Villavicencio et al. (2015) http://onlinelibrary.wiley.com/doi/10.1111/ecog.01606/abstract
Mammals	1000 (megaherbivores)	Pleistocene and Early Holocene	Terrestrial	Doughty et al (2015) http://onlinelibrary.wiley.com/doi/10.1111/ecog.01593/abstract
Mammals	1000	Pleistocene	Terrestrial	Smith et al. (2015) http://onlinelibrary.wiley.com/doi/10.1111/ecog.01779/abstract
Mammals	800 (megaherbivores)	Pleistocene	Terrestrial	Van Valkenburg et al (2016) http://www.pnas.org/content/113/4/862.abstract
Mammals	44	Late Pleistocene and early Holocene	Terrestrial	Doughty et al (2015) http://www.pnas.org/content/113/4/868.abstract
Mammals	10	Late Quaternary	Terrestrial	Sandom et al (2014) http://rspb.royalsocietypublishing.org/content/281/1787/20133254
Mammals	44	Late Pleistocene	Terrestrial	Yule et al. (2014) http://www.jstor.org/stable/10.1086/676045?seq=1#page_scan_tab_contents
Mammals	44	Middle Pleistocene	Terrestrial	Corlett (2013) http://www.sciencedirect.com/science/article/pii/S0006320712004806
Mammals	44	Last Interglacial	Terrestrial	Stuart and Lister (2012) http://www.sciencedirect.com/science/article/pii/S0277379112002326
Mammals	Large (> 44); megamammals (> 1000)	Late Pleistocene	Terrestrial	Dantas et al. (2011) http://www.sbpbrasil.org/revista/edicoes/14_3/artigo_10.pdf
Mammals	45	Extant	Terrestrial	Epps et al (2011) http://onlinelibrary.wiley.com/doi/10.1111/j.1472-4642.2011.00773.x/abstract
Mammals	Very large (> 150); large (10-150)	Pleistocene and early Holocene	Terrestrial	Crowley (2010) http://www.sciencedirect.com/science/article/pii/S0277379110002246

Mammals	44	Quaternary	Terrestrial	Barnosky (2008) http://www.pnas.org/content/105/Supplement_1/11543.abstract
Mammals	44	Late Pleistocene	Terrestrial	Roberts et al (2016) http://www.pnas.org/content/111/16/5848.full.pdf
Mammals	1	Late Pleistocene	Terrestrial	Louys and Meijaard (2010) http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2699.2010.02297.x/full
Mammals	750	Extant	Terrestrial	Castley et al. (2012) http://onlinelibrary.wiley.com/doi/10.1111/j.1745-5871.2012.00767.x/full
Mammals	40 and 44	Late Quaternary	Terrestrial	Wroe et al (2008) http://www.tandfonline.com/doi/abs/10.1080/03115510408619286
Mammals, fish, reptiles	30	Extant	Freshwater	Carizo et al. 2017 https://academic.oup.com/bioscience/article/67/10/919/4201669

Table S2. Megafauna scientific and common names, current IUCN categories (LC – Least Concern, NT – Near Threatened, VU – Vulnerable, EN – Endangered, CR- Critically Endangered), population trends (U – unknown, D – decreasing, I – increasing, S – stable), ecosystem types (F – freshwater, M – marine, T – terrestrial), and masses. For birds, amphibians, and mammals, genuine status changes are listed in parentheses after IUCN categories (no change data were available for the other classes). For example, "(3)" means a species has been uplisted by three categories). The category changes correspond to the period 1980-2004 for amphibians and 1996-2008 for mammals. Masses or lengths were obtained from the Amniote database for mammals, reptiles, and birds (Myhrvold et al. 2015), using Fishbase for ray-finned and cartilaginous fish (Froese & Pauly 2000), and using AmphibiaWeb for amphibians (AmphibiaWeb 2016). For fish, we used a generalized additive model predicting mass using maximum length fit on the Fishbase data to predict masses for fish with unknown masses. For amphibians, we used the allometric equations given in Pough (1980) to predict masses from total and snout-to-vent lengths given in AmphibiaWeb species accounts.

Scientific Name	Common Name	Category	Trend	Systems	Mass (kg)
Amphibians (1)					
Andrias davidianus	Chinese Giant Salamander	CR(3)	D	F	65.5
Birds (4)					
Struthio camelus	Common Ostrich	LC	D	T	109.2
Struthio molybdophanes	Somali Ostrich	VU	D	T	109.2
Casuarius unappendiculatus	Northern Cassowary	LC	D	T	47.3
Casuarius casuarius	Southern Cassowary	LC	D	T	44
Cartilaginous fish (58)					
Rhincodon typus	Whale Shark	EN	D	M	34000
Cetorhinus maximus	Basking Shark	VU	D	M	4000
Pristis pristis	Largetooth Sawfish	CR	D	F,M	1054.2
Pristis zijsron	Green Sawfish	CR	D	M	988.9
Galeocerdo cuvier	Tiger Shark	NT	U	M	807.4
Somniosus microcephalus	Greenland Shark	NT	U	M	775
Mitsukurina owstoni	Goblin Shark	LC	S	M	668
Hexanchus griseus	Bluntnose Sixgill Shark	NT	U	M	590
Megachasma pelagios	Megamouth Shark	LC	U	M	510.9
Isurus oxyrinchus	Shortfin Mako	VU	D	M	505.8
Carcharodon carcharias	Great White Shark	VU	U	M	494
Mobula mobular	Giant Devil Ray	EN	D	M	451.3
Sphyrna mokarran	Great Hammerhead	EN	D	M	449.5
Sphyrna zygaena	Smooth Hammerhead	VU	D	M	400
Alopias superciliosus	Bigeye Thresher Shark	VU	D	M	363.8
Anoxypristis cuspidata	Narrow Sawfish	EN	D	M	358.2
Mobula tarapacana	Sicklefin Devil Ray	VU	D	M	350
Pristis pectinata	Smalltooth Sawfish	CR	D	M	350
Alopias vulpinus	Common Thresher Shark	VU	D	M	348
Carcharhinus obscurus	Dusky Shark	VU	D	M	346.5

Carcharhinus falciformis	Silky Shark	VU	D	M	346
Carcharhinus leucas	Bull Shark	NT	U	F,M	316.5
Carcharhinus brachyurus	Copper Shark	NT	U	F,M	304.6
Bathytoshia brevicaudata	Short-tail Stingray	LC	S	M	292.1
Odontaspis ferox	Smalltooth Sand Tiger	VU	D	M	289
Isurus paucus	Longfin Mako	VU	D	M	272.1
Himantura undulata	Bleeker's Variegated Whipray	VU	D	M	261.7
Echinorhinus cookei	Prickly Shark	NT	U	M	247.1
Aetobatus narinari	Spotted Eagle Ray	NT	D	M	230
Lamna nasus	Porbeagle	VU	D	M	230
Rhynchobatus djiddensis	Whitespotted Wedgefish	VU	D	M	227
Negaprion acutidens	Sharptooth Lemon Shark	VU	D	M	219.3
Prionace glauca	Blue Shark	NT	U	M	205.9
Eucrossorhinus dasypogon	Tasselled Wobbegong	LC	U	M	200.8
Aetobatus ocellatus	Spotted Eagle Ray	VU	D	M	200
Stegostoma fasciatum	Zebra Shark	EN	D	M	185.6
Negaprion brevirostris	Lemon Shark	NT	U	F,M	183.7
Alopias pelagicus	Pelagic Thresher	VU	D	M	177
Lamna ditropis	Salmon Shark	LC	S	M	175
Carcharhinus longimanus	Oceanic Whitetip Shark	VU	D	M	167.4
Carcharhinus albimarginatus	Silvertip Shark	VU	D	M	162.2
Carcharias taurus	Sand Tiger Shark	VU	U	M	158.8
Bathytoshia centroura	Roughtail Stingray	LC	U	M	155
Sphyrna lewini	Scalloped Hammerhead	EN	U	M	152.4
Taeniurops meyeni	Blotched Fantail Ray	VU	D	M	150
Nebrius ferrugineus	Tawny Nurse Shark	VU	D	M	145.9
Orectolobus maculatus	Spotted Wobbegong	LC	U	M	145.9
Mobula japanica	Spinetail Devil Ray	NT	U	M	135.1
Rhina ancylostoma	Bowmouth Guitarfish	VU	D	M	135
Glaucostegus thouin	Clubnose Guitarfish	VU	U	M	124.7
Rhynchobatus australiae	Bottlenose Wedgefish	VU	D	M	124.7
Rhynchobatus luebberti	African Wedgefish	EN	D	M	124.7
Carcharhinus limbatus	Blacktip Shark	NT	U	M	122.8
Himantura uarnak	Reticulate Whipray	VU	D	M	120
Carcharhinus plumbeus	Sandbar Shark	VU	D	M	117.9
Orectolobus halei	Banded Wobbegong	LC	S	M	114.8
Orectolobus ornatus	Ornate Wobbegong	LC	U	M	114.8
Glaucostegus granulatus	Sharpnose Guitarfish	VU	D	M	105.4
Marine mammals (33)					
Balaenoptera musculus	Blue Whale	EN(-1)	I	M	149000
Balaena mysticetus	Bowhead Whale	LC	I	M	80000
Balaenoptera physalus	Fin Whale	EN	U	M	38800

Megaptera novaeangliae	Humpback Whale	LC(-2)	I	M	30000
Eschrichtius robustus	Gray Whale	LC	S	M	27300
Eubalaena australis	Southern Right Whale	LC	U	M	23000
Eubalaena glacialis	North Atlantic Right Whale	EN	D	M	23000
Eubalaena japonica	North Pacific Right Whale	EN	U	M	23000
Balaenoptera borealis	Sei Whale	EN	U	M	20000
Balaenoptera edeni	Bryde's Whale	LC	U	M	20000
Balaenoptera acutorostrata	(Common) Minke Whale	LC	S	M	7500
Balaenoptera bonaerensis	Antarctic Minke Whale	NT	U	M	7500
Physeter macrocephalus	Sperm Whale	VU	U	M	7200
Hyperoodon planifrons	Southern Bottlenose Whale	LC	U	M	5440
Ziphius cavirostris	Cuvier's Beaked Whale	LC	U	M	2950
Delphinapterus leucas	Beluga Whale	LC	U	M	1380
Monodon monoceros	Narwhal	LC	U	M	938.1
Grampus griseus	Risso's Dolphin	LC	U	M	425
Dugong dugon	Dugong	VU	D	M	360
Sousa plumbea	Indian Ocean Humpback Dolphin	EN	D	M	280
Tursiops truncatus	Common Bottlenose Dolphin	LC	U	M	230
Peponocephala electra	Melon-headed Whale	LC	U	M	206
Orcaella heinsohni	Australian Snubfin Dolphin	VU	D	M	190
Lagenorhynchus acutus	Atlantic White-sided Dolphin	LC	U	M	186.5
Lagenorhynchus albirostris	White-beaked Dolphin	LC	U	M	183.3
Lagenodelphis hosei	Fraser's Dolphin	LC	U	M	164
Pagophilus groenlandicus	Harp Seal	LC	I	M	141.1
Stenella coeruleoalba	Striped Dolphin	LC	U	M	123
Steno bredanensis	Rough-toothed Dolphin	LC	U	M	118.2
Lissodelphis borealis	Northern Right Whale Dolphin	LC	U	M	113
Stenella attenuata	Pantropical Spotted Dolphin	LC	U	M	112.5
Phocoenoides dalli	Dall's Porpoise	LC	U	M	106
Lagenorhynchus obliquidens	Pacific White-sided Dolphin	LC	U	M	103
Ray-finned fish (56)					
Huso huso	Beluga	CR	D	F,M	3200
Mola mola	Ocean Sunfish	VU	D	M	2300
Masturus lanceolatus	Sharptail Mola	LC	U	M	2000
Huso dauricus	Kaluga	CR	D	F,M	1000
Acipenser transmontanus	White Sturgeon	LC	S	F,M	816
Thunnus thynnus	Atlantic Bluefin Tuna	EN	D	M	684
Xiphias gladius	Swordfish	LC	D	M	650
Makaira nigricans	Blue Marlin	VU	D	M	636
Acipenser sinensis	Chinese Sturgeon	CR	D	F,M	600
Regalecus russelii		LC	U	M	492
Epinephelus itajara	Atlantic Goliath Grouper	CR	U	M	455

Thunnus orientalis	Pacific Bluefin Tuna	VU	D	M	450
Kajikia audax	Striped Marlin	NT	D	M	440
Acipenser sturio	Atlantic Sturgeon	CR	D	F,M	400
Epinephelus lanceolatus	Giant Grouper	VU	D	M	400
Pangasianodon gigas	Mekong Giant Catfish	CR	D	F	350
Hippoglossus hippoglossus	Atlantic Halibut	EN	U	M	320
Silurus glanis	Wels Catfish	LC	U	F	306
Catlocarpio siamensis	Giant Carp	CR	D	F	300
Pangasius sanitwongsei	Giant Pangasius	CR	D	F	300
Psephurus gladius	Chinese Paddlefish	CR	U	F,M	300
Regalecus glesne	Oarfish	LC	U	M	272
Lampris guttatus	Opah	LC	U	M	270
Thunnus maccoyii	Southern Bluefin Tuna	CR	D	M	260
Stereolepis gigas	Giant Sea Bass	CR	U	M	255.6
Acipenser oxyrinchus	Gulf Sturgeon	NT	I	F,M	251.5
Acipenser baerii	Siberian Sturgeon	EN	D	F	210
Thunnus obesus	Bigeye Tuna	VU	D	M	210
Lates niloticus	Nile Perch	LC	U	F	200
Thunnus albacares	Yellowfin Tuna	NT	D	M	200
Hyporthodus nigritus	Warsaw Grouper	CR	U	M	198.1
Cheilinus undulatus	Humphead Wrasse	EN	D	M	191
Acipenser schrenckii	Amur Sturgeon	CR	D	F	190
Megalops atlanticus	Tarpon	VU	D	M	161
Acipenser medirostris	Green Sturgeon	NT	S	F,M	159
Epinephelus malabaricus	Malabar Grouper	NT	D	M	150
Luvarus imperialis	Louvar	LC	U	M	150
Luciobarbus esocinus	Pike Barbel	VU	D	F	140
Chrysichthys cranchii	Kokuni	LC	U	F	135
Gymnosarda unicolor	Dogtooth Tuna	LC	U	M	131
Scaphirhynchus albus	Pallid Sturgeon	EN	D	F	130
Acipenser fulvescens	Lake Sturgeon	LC	I	F	125
Pangasius pangasius		LC	D	F	124.7
Trachipterus trachypterus	Mediterranean Dealfish	LC	U	M	124.7
Acipenser gueldenstaedtii	Russian Sturgeon	CR	D	F,M	115
Maccullochella peelii	Murray River Cod	CR	U	F	113.5
Conger conger	Conger Eel	LC	I	M	110
Epinephelus tukula	Potato Grouper	LC	U	M	110
Hyporthodus mystacinus	Misty Grouper	LC	S	M	107
Hucho taimen	Siberian Taimen	VU	D	F	105
Argyrosomus regius	Meagre	LC	U	M	103
Istiophorus platypterus	Sailfish	LC	U	M	100.2
Bahaba taipingensis	Chinese Bahaba	CR	D	M	100

Lates angustifrons	Tanganyika Lates	EN	D	F	100
Mycteroperca bonaci	Black Grouper	NT	D	M	100
Totoaba macdonaldi	Totoaba	CR	D	F,M	100
Reptiles (33)					
Dermochelys coriacea	Leatherback	VU	D	M,T	420
Morelia amethistina	Amethystine Python	LC	S	T	246
Crocodylus porosus	Salt-water Crocodile	LC	U	F,M,T	200
Chelonoidis becki	Wolf Volcano Giant Tortoise	VU	U	T	175
Chelonoidis chathamensis	San Cristóbal Giant Tortoise	EN	I	T	175
Chelonoidis darwini	Santiago Giant Tortoise	CR	I	T	175
Chelonoidis duncanensis	Pinzón Giant Tortoise	VU	I	T	175
Chelonoidis hoodensis	Española Giant Tortoise	CR	I	T	175
Chelonoidis phantasticus	Fernandina Giant Tortoise	CR	U	T	175
Chelonoidis porteri	Western Santa Cruz Giant Tortoise	CR	I	T	175
Chelonoidis vandenburghi	Volcán Alcedo Giant Tortoise	VU	U	T	175
Chelonoidis vicina	Cerro Azul Giant Tortoise	EN	U	T	175
Chelonia mydas	Green Turtle	EN	D	M,T	160
Gavialis gangeticus	Gharial	CR	D	F,T	153
Tomistoma schlegelii	False Gharial	VU	D	F,T	119
Geochelone gigantea	Aldabra Giant Tortoise	VU	U	T	117.2
Caretta caretta	Loggerhead Turtle	VU	D	M,T	109.2
Chitra indica	Indian Narrow-headed Softshell Turtle	EN	U	F	108
Crocodylus intermedius	Orinoco Crocodile	CR	D	F,T	107.9
Lepidochelys olivacea	Olive Ridley	VU	D	M,T	102
Crocodylus niloticus	Nile Crocodile	LC	U	F,T	94.2
Melanosuchus niger	Black Caiman	NT	U	F,T	82
Macrochelys temminckii	Alligator Snapping Turtle	VU	U	F,T	78.9
Crocodylus acutus	American Crocodile	VU	I	F,M,T	76.7
Eretmochelys imbricata	Hawksbill Turtle	CR	D	M,T	67
Alligator mississippiensis	American Alligator	LC	U	F,T	62
Crocodylus rhombifer	Cuban Crocodile	CR	U	F,T	57.5
Varanus salvadorii	Crocodile Monitor	LC	U	T	51.5
Mecistops cataphractus	Slender-snouted Crocodile	CR	D	F,T	50.5
Lepidochelys kempii	Kemp's Ridley	CR	U	M,T	50
Crocodylus palustris	Mugger	VU	S	F,T	42.7
Crocodylus siamensis	Siamese Crocodile	CR	D	F,T	42.5
Varanus komodoensis	Komodo Dragon	VU	U	T	41.1
Terrestrial mammals (107)					
Loxodonta africana	African Elephant	VU	I	T	4500
Elephas maximus	Asian Elephant	EN	D	T	3220
Hippopotamus amphibius	Hippopotamus	VU	S	F,M,T	2640
Ceratotherium simum	White Rhinoceros	NT	I	T	2230

Rhinoceros sondaicus	Javan Rhinoceros	CR	U	T	1750
Rhinoceros unicornis	Indian Rhinoceros	VU(-1)	I	F,T	1600
Mirounga leonina	Southern Elephant Seal	LC	S	M,T	1400
Dicerorhinus sumatrensis	Sumatran Rhinoceros	CR	D	T	1260
Diceros bicornis	Black Rhinoceros	CR	I	T	995.9
Mirounga angustirostris	Northern Elephant Seal	LC	I	M,T	914.5
Odobenus rosmarus	Walrus	VU	U	M,T	846.5
Bubalus arnee	Wild Water Buffalo	EN	D	F,T	827.3
Bos gaurus	Gaur	VU	D	T	812.6
Giraffa camelopardalis	Giraffe	VU	D	T	800
Bos sauveli	Kouprey	CR	D	T	795.7
Bos javanicus	Banteng	EN	D	T	683.3
Syncerus caffer	African Buffalo	LC	D	T	646.3
Bison bison	American Bison	NT	S	T	624.6
Bison bonasus	European Bison	VU(-1)	I	T	624.6
Bos mutus	Wild Yak	VU	D	T	583.5
Trichechus senegalensis	African Manatee	VU	U	F,M	477
Camelus ferus	Bactrian Camel	CR(1)	D	T	475
Tragelaphus oryx	Common Eland	LC	S	T	426.9
Leptonychotes weddellii	Weddell Seal	LC	U	M,T	410.8
Trichechus manatus	American Manatee	VU	D	F,M	387.5
Equus grevyi	Grevy's Zebra	EN	S	T	384
Eumetopias jubatus	Steller Sea Lion	NT	I	M,T	382.5
Hydrurga leptonyx	Leopard Seal	LC	U	M,T	375.7
Ursus maritimus	Polar Bear	VU(2)	U	M,T	371.7
Alces alces	Moose	LC	I	T	351
Ovibos moschatus	Muskox	LC	S	T	312.5
Equus quagga	Plains Zebra	NT	D	T	300
Tapirus bairdii	Baird's Tapir	EN	D	F,T	300
Tapirus indicus	Malay Tapir	EN(1)	D	F,T	296.2
Equus zebra	Mountain Zebra	VU	U	T	296
Budorcas taxicolor	Takin	VU	D	T	294.5
Trichechus inunguis	South American Manatee	VU	D	F	294
Monachus monachus	Mediterranean Monk Seal	EN	I	M,T	284.9
Erignathus barbatus	Bearded Seal	LC	U	M,T	283.3
Sousa chinensis	Indo-Pacific Humpback Dolphin	VU	D	F,M	280
Phocarctos hookeri	New Zealand Sea Lion	EN(1)	D	M,T	273.5
Tragelaphus eurycerus	Bongo	NT	D	T	271
Equus kiang	Kiang	LC	S	T	262.5
Equus ferus	Przewalski's Horse	EN(-1)	I	T	250
Cystophora cristata	Hooded Seal	VU	U	M,T	245.4
Bubalus mindorensis	Tamaraw	CR(1)	D	T	243.9

Ursus arctos	Brown Bear	LC	S	T	240.5
Lobodon carcinophaga	Crabeater Seal	LC	U	M,T	238.3
Hippotragus equinus	Roan Antelope	LC	D	T	233.5
Equus hemionus	Asiatic Wild Ass	NT(2)	S	T	230
Okapia johnstoni	Okapi	EN	D	T	230
Hippotragus niger	Sable Antelope	LC	S	T	225
Tapirus terrestris	Lowland Tapir	VU(1)	D	F,T	225
Tragelaphus buxtoni	Mountain Nyala	EN	D	T	216.5
Choeropsis liberiensis	Pygmy Hippopotamus	EN	D	F,T	215
Tragelaphus strepsiceros	Greater Kudu	LC	S	T	206.1
Bubalus depressicornis	Lowland Anoa	EN	D	T	206
Hylochoerus meinertzhageni	Forest Hog	LC	D	T	200.3
Ommatophoca rossii	Ross Seal	LC	U	M,T	198
Neomonachus schauinslandi	Hawaiian Monk Seal	EN(1)	D	M,T	197.8
Halichoerus grypus	Grey Seal	LC	I	M,T	197.6
Otaria byronia	South American Sea Lion	LC	S	M,T	193.7
Orcaella brevirostris	Irrawaddy Dolphin	EN	D	F,M	190
Neophoca cinerea	Australian Sea Lion	EN(1)	D	M,T	189.3
Connochaetes taurinus	Common Wildebeest	LC	S	T	180.5
Boselaphus tragocamelus	Nilgai	LC	S	T	180
Rusa unicolor	Sambar	VU	D	T	177.5
Kobus ellipsiprymnus	Waterbuck	LC	D	T	175.3
Equus africanus	African Wild Ass	CR	D	T	171.2
Rucervus duvaucelii	Barasingha	VU	D	F,T	171.2
Bubalus quarlesi	Mountain Anoa	EN	D	T	165.9
Cervus canadensis	Wapiti	LC	I	T	160.2
Cervus elaphus	Red Deer	LC	I	T	160.2
Cervus hanglu	Tarim Red Deer	LC	I	T	160.2
Ovis ammon	Argali	NT	D	T	160
Alcelaphus buselaphus	Hartebeest	LC	D	T	159
Zalophus californianus	Californian Sea Lion	LC	I	M,T	158.6
Zalophus wollebaeki	Galápagos Sea Lion	EN(1)	D	M,T	158.6
Panthera leo	Lion	VU	D	T	149.1
Tapirus pinchaque	Mountain Tapir	EN	D	F,T	148.9
Gorilla beringei	Eastern Gorilla	CR	D	T	139.8
Cervus albirostris	White-lipped Deer	VU	U	T	135
Sus scrofa	Wild Boar	LC	U	T	135
Ursus americanus	American Black Bear	LC	I	T	132.4
Connochaetes gnou	Black Wildebeest	LC	I	T	132.2
Panthera tigris	Tiger	EN	D	T	128.8
Arctocephalus pusillus	Afro-Australian Fur Seal	LC	I	M,T	127.6
Gorilla gorilla	Western Gorilla	CR(1)	D	T	126.2

Oryx leucoryx	Arabian Oryx	VU	S	T	121.3
Beatragus hunteri	Hirola	CR	D	T	119
Damaliscus lunatus	Topi/tsessebe	LC	D	T	119
Ailuropoda melanoleuca	Giant Panda	VU	I	T	117.5
Ovis orientalis	Mouflon	VU	D	T	110
Tremarctos ornatus	Spectacled Bear	VU	D	T	109.2
Oryx beisa	Beisa Oryx	NT	D	T	103.8
Sus ahoenobarbus	Palawan Bearded Pig	NT	D	T	102.8
Sus barbatus	Bearded Pig	VU(1)	D	T	102.8
Sus cebifrons	Visayan Warty Pig	CR	D	T	102.8
Sus oliveri	Oliver's Warty Pig	VU	D	T	102.8
Sus philippensis	Philippine Warty Pig	VU	D	T	102.8
Blastocerus dichotomus	Marsh Deer	VU	D	F,T	102.5
Rangifer tarandus	Reindeer/caribou	VU	D	T	101.2
Arctocephalus townsendi	Guadalupe Fur Seal	LC	I	M,T	101.1
Tragelaphus angasii	Nyala	LC	S	T	100.7
Melursus ursinus	Sloth Bear	VU	D	T	100
Sousa teuszii	Atlantic Humpback Dolphin	CR	D	F,M	100
Ursus thibetanus	Asiatic Black Bear	VU	D	T	100

Table S3. Megafauna scientific and common names for the 77 megafauna species that are Data Deficient (DD), Extinct in the Wild (category EW), Extinct (category EX) or not assessed (no category). The table shows scientific name, common name, IUCN Red List category ('Category'), population trend ('Trend'; U – unknown, D – decreasing, I – increasing, S – stable), ecosystem types ('Systems'; F – freshwater, M – marine, T – terrestrial), and mass. 'Category,' 'Trend,' and 'Systems' data are unavailable for species that have not been assessed. Masses were obtained from the Amniote database for mammals, reptiles, and birds (Myhrvold et al. 2015), using Fishbase for ray-finned and cartilaginous fish (Froese & Pauly 2000), and using AmphibiaWeb for amphibians (AmphibiaWeb 2016). For fish, we used a generalized additive model predicting mass using maximum length fit on the Fishbase data to predict masses for fish with unknown masses. For amphibians, we used the allometric equations given in Pough (1980) to predict masses from total and snout-to-vent lengths given in AmphibiaWeb species accounts.

Scientific Name	Common Name	Category	Trend	Systems	Mass (kg)
		Bony fish (16)			
Istiompax indica	Black Marlin	DD	U	M	750
Hippoglossus stenolepis	Pacific halibut				363
Strophidon sathete	Slender giant moray				247.1
Arapaima gigas	Arapaima	DD	U	F	200
Brachyplatystoma filamentosum	Kumakuma				200
Makaira mazara	Indo-Pacific blue marlin				170
Eleutheronema tetradactylum	Fourfinger threadfin				145
Atractosteus spatula	Alligator gar				137
Scomberomorus sinensis	Chinese Seerfish	DD	U	F,M	131
Mola ramsayi	Southern sunfish				124.7
Gymnothorax favagineus	Laced moray				124.7
Agrostichthys parkeri	Streamer fish				124.7
Trachipterus arcticus	Dealfish				124.7
Polyprion americanus	Wreckfish	DD	U	M	100
Pseudoplatystoma corruscans	Spotted sorubim				100
Polyprion oxygeneios	Hapuku wreckfish				100
		Cartilaginous fish (17)			
Somniosus pacificus	Pacific Sleeper Shark	DD	U	M	308
Somniosus antarcticus	Southern Sleeper Shark	DD	U	M	304.8
Apristurus gibbosus	Humpback Catshark	DD	U	M	230.2
Dasyatis thetidis	Thorntail Stingray				214
Potamotrygon brachyura	Giant Freshwater Stingray	DD	U	F	208
Carcharias tricuspidatus	Indian sand tiger				206
Odontaspis noronhai	Bigeye Sand Tiger	DD	U	M	202.1
Bathyraja hesperafricana	West African Skate	DD	U	M	171
Carcharhinus altimus	Bignose Shark	DD	U	M	167.8
Megatrygon microps	Smalleye Stingray	DD	U	M	145.9
Hypanus rudis	Smalltooth Stingray	DD	U	M	145.9
Hypanus americanus	Southern Stingray	DD	U	M	135.6

Echinorhinus brucus	Bramble Shark	DD	U	M	135.1
Aetomylaeus bovinus	Bullray	DD	U	M	116
Ginglymostoma cirratum	Nurse Shark	DD	U	M	109.6
Notorynchus cepedianus	Broadnose Sevengill Shark	DD	U	M	107
Carcharhinus amboinensis	Pigeye Shark	DD	U	M	105.4
Exclusively marine mammals (29)					
Berardius bairdii	Baird's Beaked Whale	DD	U	M	11400
Berardius arnuxii	Arnoux's Beaked Whale	DD	U	M	7000
Hydrodamalis gigas	Steller's Sea Cow	EX	U	M	6700
Mesoplodon europaeus	Gervais' Beaked Whale	DD	U	M	5600
Tasmacetus shepherdi	Shepherd's Beaked Whale	DD	U	M	5600
Hyperoodon ampullatus	North Atlantic Bottlenose Whale	DD	U	M	5350
Orcinus orca	Killer Whale	DD	U	M	4300
Caperea marginata	Pygmy Right Whale	DD	U	M	4000
Mesoplodon grayi	Gray's Beaked Whale	DD	U	M	2900
Mesoplodon bidens	Sowerby's Beaked Whale	DD	U	M	2350
Indopacetus pacificus	Indo-pacific Beaked Whale	DD	U	M	2150
Mesoplodon mirus	True's Beaked Whale	DD	U	M	2100
Mesoplodon bowdoini	Andrew's Beaked Whale	DD	U	M	1930
Mesoplodon stejnegeri	Stejneger's Beaked Whale	DD	U	M	1930
Mesoplodon carlhubbsi	Hubbs' Beaked Whale	DD	U	M	1500
Mesoplodon ginkgodens	Ginkgo-toothed Beaked Whale	DD	U	M	1500
Mesoplodon layardii	Strap-toothed Whale	DD	U	M	1500
Pseudorca crassidens	False Killer Whale	DD	U	M	1360
Mesoplodon densirostris	Blainville's Beaked Whale	DD	U	M	1070
Globicephala melas	Long-finned Pilot Whale	DD	U	M	1060
Mesoplodon peruvianus	Pygmy Beaked Whale	DD	U	M	1060
Mesoplodon hectori	Hector's Beaked Whale	DD	U	M	900
Globicephala macrorhynchus	Short-finned Pilot Whale	DD	U	M	726
Kogia breviceps	Pygmy Sperm Whale	DD	U	M	424.6
Kogia sima	Dwarf Sperm Whale	DD	U	M	186.6
Lagenorhynchus australis	Peale's Dolphin	DD	U	M	180
Feresa attenuata	Pygmy Killer Whale	DD	U	M	151.5
Tursiops aduncus	Indo-Pacific Bottlenose Dolphin	DD	U	M	141.2
Lissodelphis peronii	Southern Right Whale Dolphin	DD	U	M	100
Reptiles (6)					
Chelonoidis abingdonii	Pinta Giant Tortoise	EX	U	T	175
Chelonoidis niger	Floreana Giant Tortoise	EX	U	T	175
Eunectes murinus	Anaconda, Green Anaconda				97.5
Natator depressus	Flatback	DD	U	M,T	74.4
Python natalensis	Southern African Python				73
Python sebae	African Rock Python				73

Terrestrial mammals (9)					
Bos taurus	Aurochs				618.6
Camelus dromedarius	One-humped Camel				434
Hippotragus leucophaeus	Bluebuck	EX	U	T	225
Neomonachus tropicalis	Caribbean Monk Seal	EX	U	M,T	197.8
Oryx dammah	Scimitar-horned Oryx	EW	U	T	177.5
Elaphurus davidianus	Père David's Deer	EW	U	F,T	166
Alcelaphus lichtensteinii	Lichtenstein's Hartebeest				160.8
Zalophus japonicus	Japanese Sea Lion	EX	U	M,T	158.6
Rucervus schomburgki	Schomburgk's Deer	EX	U	F,T	107.6

Table S4. Summary of megafauna and all vertebrate species showing ‘Species’ (total number of species), ‘Not assessed’ (number of species not in the IUCN Red list), ‘DD’ (number of Data Deficient species), ‘EW’ (number of Extinct in the Wild species), ‘EX’ (number of extinct species), ‘Assessed non-DD/EW/EX’ (number of assessed species that are not DD, EW, or EX), ‘Threatened’ (number of species that are threatened, i.e., Vulnerable, Endangered, or Critically Endangered), ‘% Threatened’ (percentage of assessed and non-DD/EW/EX species that are threatened), ‘% Harvested’ (percentage of threatened species with coded threat information that are facing threats 5.1 (Hunting & collecting terrestrial animals) or 5.4 (Fishing & harvesting aquatic resources) according to the Red List), ‘% Decreasing’ (percentage of species with known population trend that have a decreasing population trend), ‘% EX’ (percentage of assessed species that are Extinct), ‘%DD’ (percentage of assessed species that are Data Deficient). Marine mammals are exclusively marine and terrestrial/freshwater mammals are those that use terrestrial and/or freshwater ecosystems.

		Species	Not assessed[1]	DD	EW	EX	Assessed non-DD/EW/EX	Threatened	% Threatened	% Harvested	% Decreasing	% EX	% DD
Megafauna	Amphibians	1	0	0	0	0	1	1	100.0%	100.0%	100.0%	0.0%	0.0%
	Birds	4	0	0	0	0	4	1	25.0%	100.0%	100.0%	0.0%	0.0%
	Cartilaginous fish	75	2	15	0	0	58	38	65.5%	100.0%	89.7%	0.0%	20.5%
	Marine mammals	62	0	28	0	1	33	9	27.3%	100.0%[2]	40.0%	1.6%	45.2%
	Ray-finned fish	72	12	4	0	0	56	31	55.4%	100.0%	83.8%	0.0%	6.7%
	Reptiles	39	3	1	0	2	33	27	81.8%	90.0%	55.6%	5.6%	2.8%
	Terrestrial mammals	116	3	0	2	4	107	64	59.8%	98.4%	61.7%	3.5%	0.0%
	All classes	**369**	**20**	**48**	**2**	**7**	**292**	**171**	**58.6%**	**98.1%**	**70.4%**	**2.0%**	**13.8%**
All vertebrates	Amphibians			1490	2	32	5158	2100	40.7%	8.4%	59.7%	0.5%	22.3%
	Birds			58	5	156	10903	1469	13.5%	41.4%	48.0%	1.4%	0.5%
	Cartilaginous fish			455	0	0	635	198	31.2%	100.0%	67.9%	0.0%	41.7%
	Marine mammals			40	0	1	43	14	32.6%	100.0%	60.0%	1.2%	47.6%
	Ray-finned fish			2825	6	63	12305	2169	17.6%	35.2%	35.2%	0.4%	18.6%
	Reptiles			1018	3	28	5620	1236	22.0%	24.1%	28.3%	0.4%	15.3%
	Terrestrial mammals			765	2	80	4746	1196	25.2%	50.8%	53.3%	1.4%	13.7%
	All classes			**6684**	**18**	**361**	**39493**	**8400**	**21.3%**	**31.9%**	**46.4%**	**0.8%**	**14.4%**

[1] Some species may be counted as “Not assessed” due to differences in taxonomic classification systems (despite matching by synonyms when possible).

[2] Commercial harvesting of these marine mammals has ceased and most of the current harvesting is due to incidental capture known as bycatch.

Table S5. CITES listing data for the threatened megafauna. The first six columns show the number of species listed under each appendix (or appendices). Category "I/II" is for species listed under both appendix I and appendix II. "NC" indicates species that are only partly listed under an appendix. "Listed" is the total number of threatened species listed (at least partly) under any appendix. "Total" is the total number of threatened megafauna. "% Listed" is the percentage of species that are (at least partly) listed under any appendix or appendices. Appendix I is for the most endangered of the CITES listed species, while appendix II is for species that may become threatened with extinction if trade is not controlled. Appendix III is for species where cooperation between countries is required. For more details, see https://cites.org/eng/app/index.php.

	I	I/II	I/NC	II	II/NC	III	Listed	Total	% Listed
All megafauna	71	4	1	30	1	3	110	171	64.3%
Amphibians	1	0	0	0	0	0	1	1	100.0%
Birds	0	0	1	0	0	0	1	1	100.0%
Cartilaginous fish	4	0	0	14	0	0	18	38	47.4%
Mammals	43	3	0	5	1	2	54	73	74.0%
Ray-finned fish	3	0	0	9	0	0	12	31	38.7%
Reptiles	20	1	0	2	0	1	24	27	88.9%

Table S6. Megafauna species that have gone extinct since the year 1500 according to the IUCN Red List. "EX" and "EW" represent extinct and extinct in the wild categories respectively, "year" represents the date of the species extinction, "yes" and "no" denote the reason(s) the species went extinct: habitat degradation and/or hunting.

Scientific Name	Common Name	Category/year	Habitat/Hunted	Reason for Hunting
Hydrodamalis gigas	Steller's Sea Cow	EX/1768	yes/yes	meat
Chelonoidis abingdonii	Pinta Giant Tortoise	EX/2012	yes/yes	meat
Hippotragus leucophaeus	Bluebuck	EX/1800	yes/yes	meat
Neomonachus tropicalis	Caribbean Monk Seal	EX/1952	no/yes	skins/oil
Oryx dammah	Scimitar-horned Oryx	EW/2000	yes/yes	meat/hides/horns
Elaphurus davidianus	Père David's Deer	EW/1865	yes/yes	meat
Zalophus japonicus	Japanese Sea Lion	EX/1950s	no/yes	skins/organs/oil
Rucervus schomburgki	Schomburgk's Deer	EX/1938	yes/yes	meat/antlers/medicine
Chelonoidis niger	Floreana Giant Tortoise	EX/1850	yes/yes	meat