Mammals facing global change

According to the Union Internationale pour la Conservation de la Nature (IUCN, 2017), nearly a quarter of the mammalian species known in the 20th century (i.e., 1219 species out of 5487), are threatened with extinction or have recently become extinct. Or, more precisely, more than a quarter (26.2%) of the 4651 mammal species whose conservation status could be assessed, because sufficient biogeographic and demographic studies have been made, are threatened or recently extinct.

1. Threatened species

Figure 1. Black rhino in the savanna (Massai Mara, Kenya). Heavily hunted in the 20th century, then poached for its horn even today, the Black Rhino (Diceros bicornis) is a critically endangered species. [Source: © Jacques Joyard]

These threatened or recently extinct species, however, are not a random sample of mammals. They are **more numerous** among the large, late-breeding and low fecondity (**so-called *'K'*** species), specialists of natural or semi-natural habitats, little anthropized. For example, all recorded species of moshidae (musk deer), hippopotamus and sirenians are threatened with extinction, or have recently become extinct, as are a large majority of perissodactyls (13 out of 16 species of equids, rhinoceroses and tapirs), cervids (26 out of 45 species) and bears (6 out of 8 species). One of the most affected orders is our own, the primates, which includes monkeys and apes, humans, lemurs and tarsiers: among the species sufficiently studied, all the great apes (common chimpanzees and bonobos, gorillas and orangutans), all the gibbons and siamangs (16 species), and almost all the lemurs and indris (28 species out of 32) are threatened, particularly by the disappearance of their forest habitat.

On the other hand, less than 20% of the known and studied species of bats (183 out of 946 species studied) and rodents (about 400 out of 1900 species studied), or 12% of opossums (9 out of 78 species studied), which are generally small species, are considered as threatened with extinction or recently extinct.

2. Weaknesses of large mammals

The greater vulnerability of large specialist mammals may be explained on the one hand by the massive reduction, fragmentation

and transformation of their **habitats**, in the face of which a **generalist** strategy (or eurytopia) is an obvious **asset**.

On the other hand, large mammals are **more vulnerable** because:

- warm-blooded species (**homeotherms**) with high metabolism and energy requirements, their **spatial requirements** increase with their size and trophic level (from herbivores to carnivores); as a result, in their fragmented or degraded habitats (by agriculture, urbanization, climate change...), large mammal populations are often close to or below the viability threshold [1];
- the viability of small populations of large mammals is further reduced by their **low intrinsic growth rate**, due to the late maturity and low fecundity of females [2];
- at the population level, hunting not only reduces local numbers (due to low female fecundity) but also the intensity of exchange between regional populations (in fragmented habitats), which reduces the viability of **metapopulations**.

Figure 2. Deforestation for agriculture, Mexico. Habitat fragmentation of large forest-dependent mammals can drive local remnant populations into a (demogenetic) extinction vortex. [Source: Jami Dwyer, Public domain, via Wikimedia Commons]

- low intrinsic population growth rates (related to low fecundity and late female reproduction) **reduce the resilience** of local populations of large mammals to episodes of high mortality or morbidity (related to a harsh winter, a long period of drought, high predation, a disease outbreak, or other critical regional event), and thus the viability of regional and global populations, or metapopulations [3].

3. Extinction bias in the Late Quaternary

The **vulnerability of large mammals** to human activities and other major environmental changes has been highlighted since the 2000s [4]. Dirzo and his colleagues [5] estimated the median weight of mammal species that became extinct during the **Late Pleistocene**, between -120,000 and -10,000 years ago, at 182 kg. These include mammoths, woolly rhinoceroses, bears, lions and other large cave carnivores, for Europe and North America, all species doubly threatened at the end of the last ice age, by humans (predation, competition) and by global warming. But also of all the marsupial species exceeding 45 kg that populated Australia before its colonization by humans, some 50,000 years ago, and that disappeared less than 10,000 years later, probably victims of hunting and bushfires, without any significant change in climate.

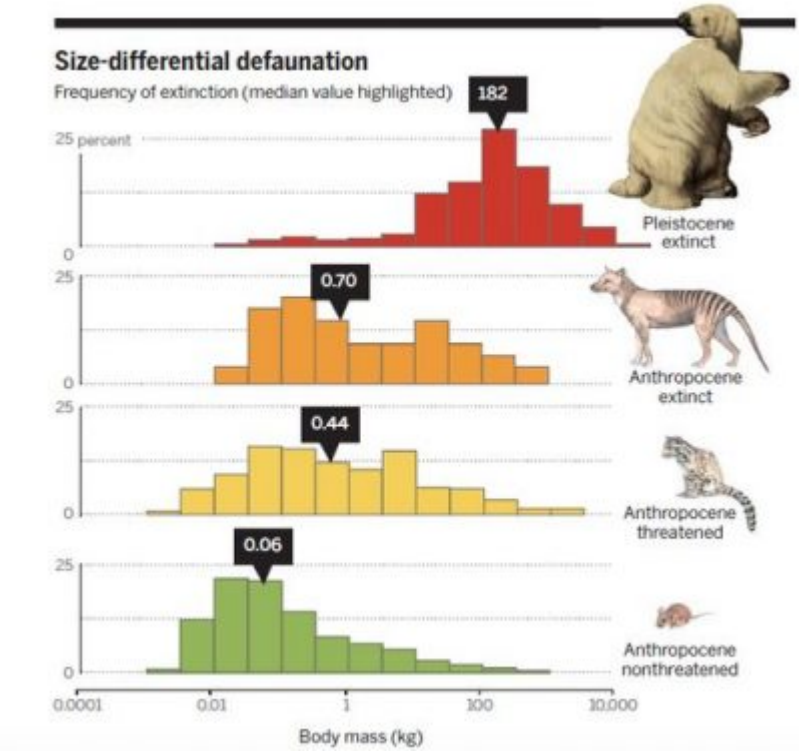

Figure 3. Diagram showing the extinction bias of mammals according to their size, in the Pleistocene (1st row), then since 500 years ago (2nd to 5th row). [Source: Dirzo et al, Science 345, 2014 - DOI: 10.1126/science.1251817]

A recent paper [6] confirms that the large mammal extinction bias observed in the **Late Quaternary**, from -125,000 years ago to the present, is characteristic of this brief geological period relative to the entire 65 million years covered by the Cenozoic Era (i.e. Tertiary + Quaternary), i.e., since the last major extinction crisis, marking the end of the Mesozoic (or Secondary) Era (See **Mass extinctions in geological time**). Since regional climates and global climate varied widely during the Cenozoic, especially during the late Miocene and Quaternary glacial cycles, with no extinction bias (towards large species) until the Middle Paleolithic and before the first waves of human migration out of Africa 125,000 years ago, it seems more than likely that humans **are responsible for this bias**. According to this study, our species *Homo sapiens* is no longer the only one involved: armed with spears and stakes with fire-hardened tips, the Neanderthals *Homo neandertalensis* and perhaps the denisovans (*Homo denisova*) also seem to be involved in the disappearance of the large mammals of Eurasia.

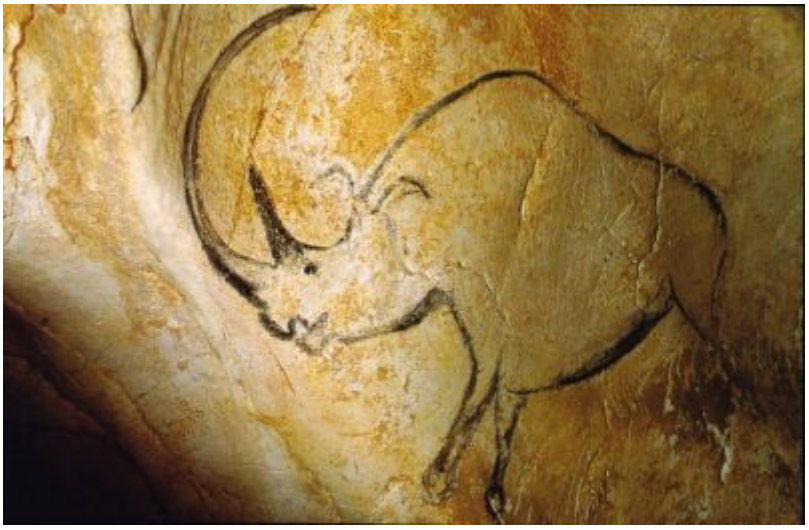

Figure 4. Woolly Rhinoceros immortalized by an Aurignacian artist, about 35,000 years ago, in the Chauvet Cave. [Source: Chauvet Cave, Public domain, via Wikimedia Commons]

After the extinction of large mammals in the Late Pleistocene, first in Eurasia and probably in Africa (from 120,000 years ago, by *H. sapiens* and *H. neandertalensis* for Eurasia), then around 45,000 years ago in Australia, then around 13,000 years ago in the

two Americas, Holocene and contemporary humans took over, necessarily targeting smaller terrestrial species... as well as large marine mammals [7]. For terrestrial mammals, Dirzo *et al* [5] estimate the median weight of recently threatened or extinct species at 500 grams... and that of non-threatened wild species at 60 grams! This last result is easier to understand if we remember that **70%** of current **mammal** species are **small** rodents, bats and insectivores (eulipotyphla).

4. Resource hoarding and forcing of ecological networks

Exploring more specifically the impacts of **agriculture and livestock farming** on wildlife in the relatively recent past, Smil [8] estimates that the **biomass** of **wild** mammals was halved during the 20th century, falling from **10 million tonnes of Carbon (MtC)** in 1900 to **5 MtC** in 2000. Large species in particular have been affected.

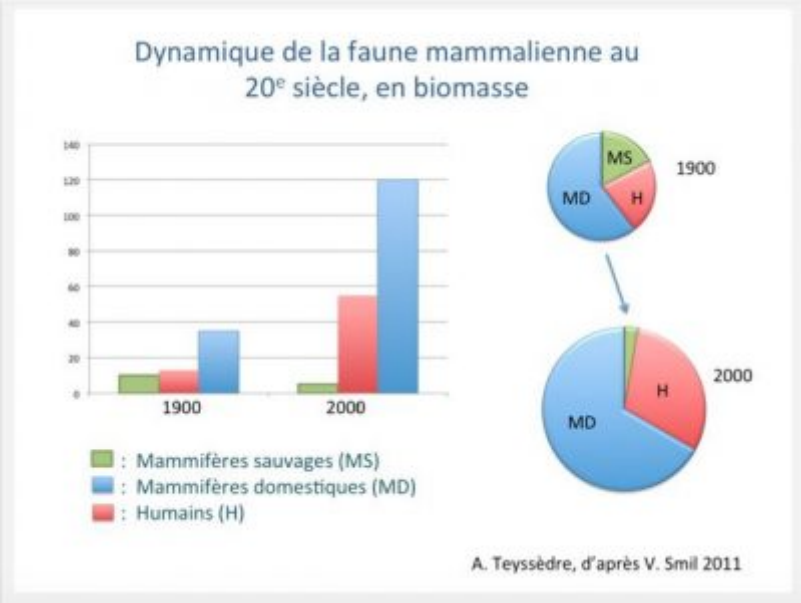

Figure 5. Biomass variation of mammal communities in the 20th century. On the left, biomasses of wild, domestic and human mammals in millions of tons of carbon equivalent (MtC). On the right, the same data as a proportion of the total mammalian biomass. If the total biomass of mammals has tripled in a century, it is to the benefit of humans and at the expense of wild species, in terms of both biomass (-50%) and number of species. Today, less than 0.3% of mammalian species, ours and a dozen domestic species, alone account for 97% of the mammalian biomass. [Source: Diagram by A. Teyssèdre based on estimates by V. Smil, 2011]

From 1900 to 2000, while the biomass of wild mammals dropped from 10 to 5 MtC, that of **humans** increased from 13 to **55 MtC** and that of **domestic** mammals from 35 to **120 MtC** - including 80 MtC for domestic cattle alone! The demographic expansion of our species, through the expansion and intensification of agriculture, implies the appropriation by humans of an increasing fraction of the primary productivity (plant biomass) of ecosystems [9], which is the basis of food webs and, more broadly, ecological webs, and thus their diversion to the benefit of humans and a minority of associated domestic and commensal species. This **diversion of ecological networks** not only deprives many animal and plant species of their habitats and food (organic and mineral), but also **disorganizes** and **weakens** the entire concerned **ecosystems**. The disappearance of large wild mammals is a symptom of this dynamic crisis.

Notes and References

Cover image. Common hippopotamus *(Hippopotamus amphibius)*. Source: © Jacques Joyard

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