Why Species Become Threatened or Endangered:

A Mammalogist's Perspective

Prepared by the Conservation of Land Mammals Committee of the

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WHY SPECIES BECOME THREATENED OR ENDANGERED:

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Why do species become threatened or endangered? This question is often asked by individuals seeking to understand the causes of the wave of extinctions that is sweeping the Earth. This brochure is designed to answer this question from the perspective of a mammalogist, a scientist who studies mammals.

THE PROCESS OF EXTINCTION

A species is considered to be endangered when its numbers are reduced to such an extent that it is likely to become extinct in the near future. A threatened species is one whose numbers have been reduced to such an extent that any further decline in numbers will warrant its designation as an endangered species. A species becomes extinct when it no longer exists in the wild or in captivity. An important first step in understanding why species become threatened or endangered is, therefore, to understand the process of extinction. Biologists know that extinction is a natural phenomenon or process that has been occurring since the earliest forms of life evolved. It is estimated that more than 99.9% of all species of plants and animals that have ever existed are now extinct. Under natural conditions, extinction of a species or group of species provides opportunities for other species to take over the niche(s) or ecological role(s) of species that become extinct. In this way, extinction of the dinosaurs provided numerous opportunities for mammals, which had been minor players on the evolutionary stage throughout the Age of Reptiles. In the absence of dinosaurs, mammals were able to prosper and evolved to fill many of the ecological niches formerly occupied by dinosaurs. What is of concern today is not the process of extinction, but rather the increasing rate at which extinctions are occurring, and especially the role that humans are playing in this increase.

The term extinction has two principal usages. Extinction may refer to the disappearance of a species from its entire range (global extinction), or it may refer to the loss of a species from a portion of its geographic range (regional or local extinction; also referred to as

extirpation). For example, the Irish elk, a large deer with huge antlers that were 3 meters (10 ft.) across, became globally extinct at the end of the last glacial age. At the same time, wild horses became regionally extinct in North America, but survived in Europe and Asia.

BIOLOGICAL DIVERSITY

The term biological diversity or biodiversity often is used in discussions of the impact of the increasing rate of extinctions. For example, what effects will the current wave of extinctions have on the Earth's biodiversity? Scientists define biodiversity as the total number of species and biological communities in a region, plus the ecological roles played by individual species (e.g., producers, herbivores, carnivores, parasites), and the amount of genetic variation in each species or population. When a species becomes extinct, its loss not only reduces the biodiversity of its community but may affect other species as well. For example, in the tropics many species of trees depend upon bats for pollination to insure successful reproduction. In regions where these bats have been greatly reduced in numbers or eliminated, trees may not be able to reproduce successfully, and thus they may become locally or globally extinct because they will not leave any offspring.

The maintenance of biodiversity is vital to the welfare and future of humans. Many of our medicines such as quinine, morphine, digitalis, atropine, taxol, and codeine were initially discovered in natural populations of plants. We do not know how many pharmaceutical products may lie undiscovered in the forests of the tropics, which are rapidly being cut and burned. We must not forget that all of our domesticated plants and animals are descended from wild ancestors. Today, wild-growing relatives of domesticated species may possess valuable genetic information, which could prove useful in providing disease resistance. We continue to depend on natural populations of fish, shellfish, and trees for food, wood, rubber, and other products.

In addition to contributing materially to human welfare, biodiversity contributes immeasurably to the quality of life on earth. Humans evolved as part of the natural world, and we share a common evolutionary history with all other living organisms. Professor E. 0.

Wilson of Harvard University coined the word "biophilia" to express our kinship with nature. We must remember that every time a species becomes extinct, the quality of our lives and that of our descendants is diminished.

THE CHARACTERISTICS OF THREATENED/ENDANGERED SPECIES

One way to answer the question of why species become threatened or endangered is to ask another question: Do threatened, endangered, or extinct species possess certain characteristics that are not shared with species that are considered to be secure (i.e., not threatened or endangered)? If we examine a list of threatened or endangered species, we will find that many species on that list share certain characteristics. Some of these include large size, specialized diet, specialized habitat requirements, small population size, limited geographic distribution, and economic or commercial value. A closer examination of each of these characteristics will aid our understanding of why species that possess several of these characteristics often are candidates not only for threatened or endangered status but also for possible extinction.

Large Size.--Large mammals, by virtue of their size alone, require larger areas in which to obtain the necessities of life (e.g., food, mates, and cover) than do smaller mammals. For example, a small woodlot that can support a population of white-footed mice cannot support a population of white-tailed deer. A local population of deer may require hundreds or thousands of acres, which will include a variety of forested and nonforested habitats. Large herbivorous mammals like caribou, bighorn sheep, and elephants need very large sanctuaries, such as national parks, to survive. The same is true for predators of such species, which tend to roam over even larger areas or home ranges. Individual home ranges of the mountain lion can exceed 116 square miles, and those of a female grizzly and cubs can be up to 80 square miles. Not only do large mammals need large areas to live, but also their total numbers are much smaller than those of small mammals.

Dietary Specialist.--Mammals that have specialized dietary needs such as carnivores (meat-eaters) and frugivores (fruit-eaters) need to forage over much larger

areas than dietary generalists such as herbivores (plant-eaters) and omnivores (animals that eat a variety of plant and animals foods) to obtain sufficient food to survive. This is particularly true of carnivores, which are less abundant than the species on which they prey. It is not surprising, therefore, that lists of threatened and endangered mammals often include many carnivores. One such carnivore is the black-footed ferret, which preys almost exclusively on prairie dogs. The black-footed ferret has declined in numbers to the brink of extinction principally as a consequence of successful, large-scale eradication programs for prairie dogs, which were viewed by farmers and ranchers as serious pests and threats to livestock and farm machinery.

Low Reproductive Output.--Species of mammals have evolved reproductive strategies that in part reflect their probability of dying. For example, many small rodents, which face a vast array of natural enemies, have the ability to produce several large litters each year. In contrast, large hoofed mammals, which are much longer-lived and have fewer natural enemies, typically produce only one offspring each year. Thus, there is a balance between the probability of dying and the number of young a female must produce to help insure the survival of the species. When man alters the natural balance between births and deaths by increasing mortality, populations decline. Large species, which often are subject to human-induced mortality, have a very limited ability to rapidly increase in numbers because of their naturally low birth rates. As a consequence, it often takes a long time for populations of these species to recover, even after they are provided with protection. Examples of this include many species of marine mammals whose populations have been very slow to increase following protection from commercial exploitation.

Bats are an important exception to the general rule that small mammals typically have high reproductive output. Many species are characterized by small litter sizes (usually one young) and only one litter/year. The low reproductive output of bats is an indication that they are long-lived compared to similar-sized terrestrial (non-flying) mammals. This is particularly true of bats that hibernate. For example, the little brown myotis, which weighs less than the combined weight of two nickels, may live 30 years, or 10 times longer

than similar-sized terrestrial small mammals. Because of their low reproductive output, bat populations are not able to recover rapidly when they suffer high mortality, which often occurs when humans disturb or kill bats while they are in hibernation and thus are virtually helpless.

Habitat Specialist.--Species of mammals often become threatened if the specialized habitats they occupy are small in size and widely separated in space. Under such conditions, these species exist in small, isolated populations, which can be affected by local catastrophic events. Agood example is cave-dwelling bats. Caves generally are limited in distribution and extent. In addition, they vary internally in terms of temperature, humidity, and seasonal fluctuations of these characteristics. As a consequence, conditions in a particular cave may not be suitable for a bat species that has very specific requirements for roosting and/or hibernating. While roosting in caves, and especially when hibernating, bats also are subject to mortality from human disturbance. Hibernating bats are essentially helpless and thus are easily killed. Even during hibernation, bats are sensitive to their surroundings and will expend stored energy to arouse from hibernation when disturbed. Repeated arousals caused by frequent disturbances can so deplete energy reserves of hibernating bats that they cannot survive the winter and will die. Additionally, while congregated in caves, bats may be subject to mass mortality from chance (stochastic) environmental events. A classic example of this is the presumed total loss of a population of 300,000 Indiana bats, a federally endangered species, when the cave in which they were hibernating flooded.

Small Population Size.--Species with small populations have a greater probability of extinction than those with large populations. As a species declines in numbers and is limited in distribution to a few isolated populations, the probability that individual populations will become extinct increases. We usually think of this in terms of declining populations of large carnivores and hoofed mammals; however, some species appear to be naturally rare and may never have occurred in large numbers. These include species that are confined in distribution to isolated mountaintops.

An important aspect of a species becoming rare is that the genetic diversity or variability within that

species tends to decrease as its populations decline. The genetic variability of a population is a measure of its potential to adapt to environmental changes. As such, genetic variability within a species can be thought of as an evolutionary insurance policy. If populations are reduced to extremely low numbers (10-500 individuals), they may experience what is known as a "genetic bottleneck," in which the total genetic diversity of the population is drastically reduced. Even if the population increases to its former size, the genetic information carried in that population is no greater than it was at its lowest point. This has serious consequences for the ability of such a population to adapt to a changing environment or to novel factors in its environment such as a new disease.

An example of a species with greatly reduced genetic diversity is the cheetah. Once widespread in the Old World, the cheetah is presently restricted to populations in eastern and southern Africa. Apparently, cheetahs have experienced one or more genetic bottlenecks when populations were reduced much below what they are today. As a consequence, all cheetahs are almost genetically identical. Both wild and captive cheetahs exhibit a high degree of male sterility and high infant mortality. These conditions are attributed to the high degree of genetic similarity among individuals, and what amounts to a high degree of inbreeding (mating between closely related individuals).

Limited Geographic Distribution.--Mammals with limited geographic distributions risk becoming extinct whenever their habitat is altered or destroyed. A good example of this is the four federally endangered subspecies (races) of oldfield mice that are restricted in distribution to small islands off the coast of Florida. Populations of these mice have been reduced greatly as the sand dune habitats where they live have been destroyed by humans for construction of vacation homes and other recreational purposes. Another example is the numerous threatened or endangered species of primates that exist in the remnant forests of the island of Madagascar.

Economic or Commercial Value.--Mammals that have commercial value because of their fur, meat, oil, or other products, or that have some other economic importance (e.g., predators on or competitors with livestock), often are subjected to higher mortality rates than

mammals not possessing these characteristics. In North America, furbearers such as the beaver, marten, fisher, and lynx were so greatly reduced in numbers byoverharvesting that they became regionally extinct. Unregulated commercial harvesting of marine mammals such as whales, sea otters, and seals caused populations of these species to decline to the point that many were classified as threatened or endangered. Efforts to eradicate predators of livestock have resulted in the regional extinction of the mountain lion and gray wolf in much of the eastern United States and in many parts of the American West. Laws protecting or regulating the harvest of commercially valuable mammals have resulted in the recovery of many species faced with extinction and in the reestablishment of species in portions of their ranges where they had previously been extirpated.

EFFECTS OF ENVIRONMENTAL FACTORS

In addition to characteristics that serve as predictors of which species likely will become threatened or endangered, other factors in the environment also influence the probability of extinction. Today, these environmental factors usually represent negative impacts that humans have on the environment. Included among these factors are disturbance or destruction of habitats, exploitation, pollution, and introduction of exotic species.

Loss or Disturbance of Habitats.--The global population of humans is increasing at an alarming rate, and as it increases, so does our ability to alter natural environments. The negative effects of humans on habitats where mammals live is seen almost daily as forests are cut, and as grasslands, deserts, and other open lands are converted to housing developments, industrial parks, or shopping malls. The expanding human population uses space for housing and recreation, to produce food and fiber, to harvest various wood products, and to manufacture a myriad of commercial goods. Although the impacts of these activities are not entirely avoidable, they can be reduced by using methods that minimize long-term damage to the environment and, thus, to the species occurring there.

Human Exploitation.--The role of human exploitation in the endangerment or extinction of mammals and other species during historical times is a matter of

record. The list of mammals that have become extinct regionally or globally includes many species that were hunted or trapped by humans. We might ask if this pattern is strictly a modern phenomenon or did humans also play a role in the extinction of mammals in prehistoric times? That humans were associated with and hunted large mammals that are now extinct is clear from prehistoric artwork and artifacts at archaeological sites. It is less clear if humans played a role in the massive wave of extinctions of large mammals that occurred at the end of the Pleistocene glacial epoch approximately 10,000 years ago. Dr. Paul S. Martin of the University of Arizona has proposed the "Pleistocene Overkill Hypothesis" to explain the extinction of many species of large herbivorous mammals (e.g., mammoths, mastodons, and ground sloths) and their predators (e.g., sabertooths, American lions, and dire wolves) at the end of the Pleistocene. Martin contends that the end of the Pleistocene coincided with the arrival of the first humans in North America. Ancient hunters represented a new and efficient predator to which many large mammals in North America had never been exposed, and to which they were not adapted. It is noteworthy that 33 genera (different types) of large mammals disappeared from North America at the end of the last or Wisconsinan glaciation, whereas no genera of small mammals were lost. Martin hypothesized that many of the large Pleistocene mammals were naive and did not fear this newly arrived predator from Asia. Among large mammals in North America at the end of the Pleistocene, those that had crossed into the New World from Eurasia such as moose, muskox, caribou, and wapiti survived. In contrast, native New World species such as ground sloths, peccaries (pig-like mammals), horses, and the American mastodon, became extinct. Perhaps the survival of many immigrant mammals from the Old World was a consequence of their having coevolved for a longer period of time with man as a predator, in contrast to native New World mammals, which had not.

Another hypothesis to explain the extinction of many large mammals in North America at the end of the Pleistocene epoch focuses on the rapid climatic and corresponding major changes in habitat that occurred at that time. Reduction of habitat may have served to reduce populations of many species of large mammals. Species whose numbers were already declining because of climatic and habitat changes may have been further

reduced in numbers when subjected to a new source of mortality in the form of recently arrived human hunters.

Pollution.--Mammals may be affected directly or indirectly by environmental pollutants. For example, mammals that die after drinking water from ponds contaminated by cyanide, which is used to extract gold from low-grade ore in the western United States, provide an example of pollutants directly affecting mammals. More often though, mammals are affected indirectly through the influence that pollutants have on their food resources. Pollution may reduce or eliminate key food items or may bioaccumulate to toxic levels in food items. As evidenced by high levels of insecticides in their tissues, some bats have been adversely affected by pesticides used to control their prey species.

Water pollution has adversely affected semi-aquatic mammals such as the river otter and water shrew, either by direct toxicity or indirectly by reducing their food resources. Marine mammals including sea otters, seals, and whales also have been adversely affected by pollutants. This is particularly the case in estuaries and shallow coastal waters where pollutants are present in higher concentrations than in the open ocean.

Introduction of Exotics.--Exotics are species that are not native to a particular area. Humans have a long history of both deliberately and accidently introducing exotic species. The long history of negative impacts that introduced exotics have had on native species and habitats dictates that extreme caution should be exercised before any exotic species is introduced. There are many examples of negative impacts that exotics have had on native species. Exotics may contribute to the decline and extinction of native species in several ways. They may carry diseases to which native organisms have not evolved defenses. For example, canine distemper, a disease of the domestic dog, recently has been contracted by lions in southern Africa, resulting in numerous deaths. Exotics may also outcompete native species for habitat, food, and nest sites, or may become predators on native species. The feeding activities of exotic herbivores may deplete food resources and otherwise disturb habitats to the extent that native species can no longer survive. A classic example is the negative impact that introduced European rabbits had on vegetation in Australia, which, in turn, negatively impacted

small native marsupial (pouched) herbivores. Introduced hoofed mammals such as goats, sheep, horses, and pigs have had major negative impacts on the vegetation and native species of many islands and in the western United States. In Great Britain, competition from the introduced North American gray squirrel has resulted in a substantial decrease in the population and distribution of the native Eurasian red squirrel.

CONSERVATION STRATEGIES

Nature Reserves. --The most effective strategy for preventing extinction of species is to protect and preserve their habitats., Land to protect threatened or endangered species often is purchased by governments and private organizations; such areas include nature reserves, national parks, state parks, and designated wilderness areas. Only about 3.2% of Earth's land surface is currently included in 4,500 protected areas worldwide. This low percentage decreases to only 1.6%, if the largest park, in Greenland, is excluded.

Well-planned and well-managed protected areas can benefit large numbers of species. Unfortunately, too few protected areas or reserves exist, and those currently in existence do not include sufficient area to conserve the world's biological diversity. Because these areas are so critical, their design and management must be based on sound biological knowledge, so that these valuable sites can effectively conserve biological diversity.

Captive Breeding.--Some species in danger of extinction in the wild have been brought into captivity where efforts have been made to breed them in order to increase their numbers. Offspring from these captive colonies may be used to reestablish populations of these species in the wild. Captive breeding programs are very costly, and even when they succeed in producing offspring, they may ultimately fail if suitable habitat no longer exists for reestablishing populations or if survival of released animals is low. Additionally, many endangered species like the giant panda are difficult to maintain and breed in captivity.

Reestablishment/Reintroductions.--Populations of some endangered species can be reestablished in the wild. Reintroduction programs involve the release of individuals within the historic range of a species. For

example, gray wolves recently were released in Yellowstone National Park and in Idaho. Animals used in reintroductions may come either from captive-breeding programs or from populations in localities where the species is not endangered.

Laws and Regulations.--Species and biological diversity are protected by laws at state, national, and international levels. States regulate hunting and fishing, establish state parks and natural areas, and may regulate land use and pollution. National governments attempt to protect biodiversity through the establishment of national parks and nature reserves, regulation of imports and exports of animals and animal parts (e.g., ivory), and through legislation that controls pollution. The U.S. Endangered Species Act of 1973 stands as the most effective law ever enacted to protect plant and animal species.

International Agreements.--Because ranges of many species extend across national borders and because of international trade in biological products, international agreements are also needed to protect biodiversity. The benefits of maintaining biodiversity are of international significance, and many threats to biodiversity are international in scope and thus require the cooperation among nations. Two important international agreements that have served to protect threatened or endangered mammals are the Convention on the International Trade in Endangered Species (CITES), which controls international trade in endangered species and their parts (e.g., ivory, rhino horns, and skins), and the International Whaling Commission (IWC), which regulates the commercial harvesting of whales.

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