Biodiversity loss

Biodiversity loss, also called **loss of biodiversity**, a decrease in biodiversity within a species, an ecosystem, a given geographic area, or Earth as a whole. *Biodiversity*, or *biological diversity*, is a term that refers to the number of genes, species, individual organisms within a given species, and biological communities within a defined geographic area, ranging from the smallest ecosystem to the global biosphere. (A biological community is an interacting group of various species in a common location.) Likewise, *biodiversity loss* describes the decline in the number, genetic variability, and variety of species, and the biological communities in a given area. This loss in the variety of life can lead to a breakdown in the functioning of the ecosystem where decline has happened.

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deforestation in Australia
Riverside deforestation in Australia.
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The idea of biodiversity is most often associated with species richness (the count of species in an area), and thus biodiversity loss is often viewed as species loss from an ecosystem or even the entire biosphere (*see also* extinction). However, associating biodiversity loss with species loss alone overlooks other subtle phenomena that threaten long-term ecosystem health. Sudden population declines may upset social structures in some species, which may keep surviving males and females from finding mates, which may then produce further population declines. Declines in genetic diversity that accompany rapid

bleached coral seascape
A sea turtle swimming over a bleached coral seascape near Heron Island, February 2016.
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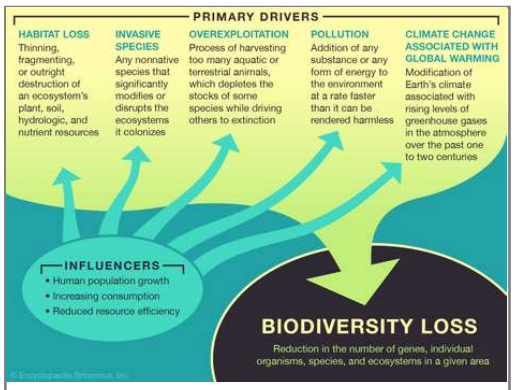

biodiversity loss
The primary drivers of biodiversity loss are influenced by the exponential growth of the human population, increased consumption as people strive for more affluent lifestyles, and reduced resource efficiency.
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falls in population may increase inbreeding (mating between closely related individuals), which could produce a further decline in genetic diversity.

Even though a species is not eliminated from the ecosystem or from the biosphere, its niche (the role the species play in the ecosystems it inhabits) diminishes as its numbers fall. If the niches filled by a single species or a group of species are critical to the proper functioning of the ecosystem, a sudden decline in numbers may produce significant changes in the ecosystem's structure. For example, clearing trees from a forest eliminates the shading, temperature and moisture regulation, animal habitat, and nutrient transport services they provide to the ecosystem.

Natural biodiversity loss

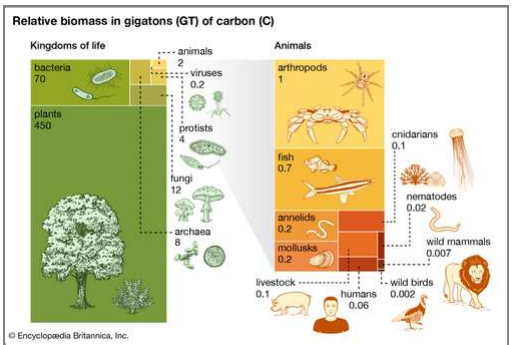
An area's biodiversity increases and decreases with natural cycles. Seasonal changes, such as the onset of spring, create opportunities for feeding and breeding, increasing biodiversity as the populations of many species rise. In contrast, the onset of winter temporarily decreases an area's biodiversity, as warm-adapted insects die and migrating animals leave. In addition, the seasonal rise and fall of plant and invertebrate populations (such as insects and plankton), which serve as food for other forms of life, also determine an area's biodiversity.

Biodiversity loss is typically associated with more permanent ecological changes in ecosystems, landscapes, and the global biosphere. Natural ecological disturbances, such as wildfire, floods, and volcanic eruptions, change ecosystems drastically by eliminating local populations of some species and transforming whole biological communities. Such disturbances are temporary, however, because natural disturbances are common and

ecosystems have adapted to their challenges (*see also* ecological succession).

Human-driven biodiversity loss

In contrast, biodiversity losses from disturbances caused by humans tend to be more severe and longer-lasting. Humans (*Homo sapiens*), their crops, and their food animals take up an increasing share of Earth's land area. Half of the world's habitable land (some 51 million square km [19.7 million square miles]) has been converted to agriculture, and some 77 percent of agricultural land (some 40 million square km [15.4 million square miles]) is used for grazing by cattle, sheep, goats, and other livestock. This massive conversion of forests, wetlands, grasslands, and other terrestrial ecosystems has produced a 60 percent decline (on average) in the number of vertebrates worldwide since 1970, with the greatest losses in vertebrate populations occurring in freshwater habitats (83 percent) and in South and Central America (89 percent). Between 1970 and 2014 the human population grew from about 3.7 billion to 7.3 billion people. By 2018 the biomass of humans and their livestock (0.16 gigaton) greatly outweighed the biomass of wild mammals (0.007 gigaton) and wild birds (0.002 gigaton). Researchers estimate that the current rate of species loss varies between 100 and 10,000 times the background extinction rate (which is roughly one to five species per year when the entire fossil record is considered). In addition, a 2019 report by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services noted that up to one million plant and animal species are facing extinction due to human activities.



biomass

Relative biomass on Earth. The planet's biomass is classified by kingdom of life and other major groupings, and the size of each group's relative footprint is displayed using

Forest clearing, wetland filling, stream channeling and rerouting, and road and building construction are often part of a systematic effort that produces a substantial change in the ecological trajectory of a landscape or a region. As human populations grow, the terrestrial and aquatic ecosystems they use may be transformed by the efforts of human beings to find and produce food, adapt the landscape to human settlement, and create opportunities for trading with

gigatons of carbon as the common measure.
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other communities for the purposes of building wealth. Biodiversity losses typically accompany these processes.

Researchers have identified five important drivers of biodiversity loss:

- Habitat loss and degradation—which is any thinning, fragmentation, or destruction of an existing natural habitat—reduces or eliminates the food resources and living space for most species. Species that cannot migrate are often wiped out.
- Invasive species—which are non-native species that significantly modify or disrupt the ecosystems they colonize—may outcompete native species for food and habitat, which triggers population declines in native species. Invasive species may arrive in new areas through natural migration or through human introduction.
- Overexploitation—which is the harvesting of game animals, fish, or other organisms beyond the capacity for surviving populations to replace their losses—results in some species being depleted to very low numbers and others being driven to extinction.
- Pollution—which is the addition of any substance or any form of energy to the environment at a rate faster than it can be dispersed, diluted, decomposed, recycled, or stored in some harmless form—contributes to biodiversity loss by creating health problems in exposed organisms. In some cases, exposure may occur in doses high enough to kill outright or create reproductive problems that threaten the species's survival.
- Climate change associated with global warming—which is the modification of Earth's climate caused by the burning of fossil fuels—is caused by industry and other human activities. Fossil fuel combustion produces greenhouse gases that enhance the atmospheric absorption of infrared radiation (heat energy) and trap the heat, influencing temperature and precipitation patterns.

Ecologists emphasize that habitat loss (typically from the conversion of forests, wetlands, grasslands, and other natural areas to urban and agricultural uses) and invasive species are the primary drivers of biodiversity loss, but they acknowledge that climate change could become a primary driver as the 21st century progresses. In an ecosystem, species tolerance

limits and nutrient cycling processes are adapted to existing temperature and precipitation patterns. Some species may not able to cope with environmental changes from global warming. These changes may also provide new opportunities for invasive species, which could further add to the stresses on species struggling to adapt to changing environmental conditions. All five drivers are strongly influenced by the continued growth of the human population and its consumption of natural resources.

Interactions between two or more of these drivers increase the pace of biodiversity loss. Fragmented ecosystems are generally not as resilient as contiguous ones, and areas clear-cut for farms, roads, and residences provide avenues for invasions by non-native species, which contribute to further declines in native species. Habitat loss combined with hunting pressure is hastening the decline of several well-known species, such as the Bornean orangutan (*Pongo pygmaeus*), which could become extinct by the middle of the 21st century. Hunters killed 2,000–3,000 Bornean orangutans every year between 1971 and 2011, and the clearing of large areas of tropical forest in Indonesia and Malaysia for oil palm (*Elaeis guineensis*) cultivation became an additional obstacle to the species' survival. Palm oil production increased 900 percent in Indonesia and Malaysia between 1980 and 2010, and, with large areas of Borneo's tropical forests cut, the Bornean orangutan and hundreds to thousands of other species have been deprived of habitat.

Ecological effects

The weight of biodiversity loss is most pronounced on species whose populations are decreasing. The loss of genes and individuals threatens the long-term survival of a species, as mates become scarce and risks from inbreeding rise when closely related survivors mate. The wholesale loss of populations also increases the risk that a particular species will become extinct.

Biodiversity is critical for maintaining ecosystem health. Declining biodiversity lowers an ecosystem's productivity (the amount of food energy that is converted into the biomass) and lowers the quality of the ecosystem's services (which often include maintaining the soil, purifying water that runs through it, and supplying food and shade, etc.).

Biodiversity loss also threatens the structure and proper functioning of the ecosystem. Although all ecosystems are able to adapt to the stresses associated with reductions in biodiversity to some degree, biodiversity loss reduces an ecosystem's complexity, as roles once played by multiple interacting species or multiple interacting individuals are played by fewer or none. As parts are lost, the ecosystem loses its ability to recover from a disturbance (*see* ecological resilience). Beyond a critical point of species removal or diminishment, the ecosystem can become destabilized and collapse. That is, it ceases to be what it was (e.g., a tropical forest, a temperate swamp, an Arctic meadow, etc.) and undergoes a rapid restructuring, becoming something else (e.g., cropland, a residential subdivision or other urban ecosystem, barren wasteland, etc.).

Reduced biodiversity also creates a kind of "ecosystem homogenization" across regions as well as throughout the biosphere. Specialist species (i.e., those adapted to narrow habitats, limited food resources, or other specific environmental conditions) are often the most vulnerable to dramatic population declines and extinction when conditions change. On the other hand, generalist species (those adapted to a wide variety of habitats, food resources, and environmental conditions) and species favoured by human beings (i.e., livestock, pets, crops, and ornamental plants) become the major players in ecosystems vacated by specialist species. As specialist species and unique species (as well as their interactions with other species) are lost across a broad area, each of the ecosystems in the area loses some amount of complexity and distinctiveness, as the structure of their food chains and nutrient-cycling processes become increasingly similar.

Economic and societal effects

Biodiversity loss affects economic systems and human society. Humans rely on various plants, animals, and other organisms for food, building materials, and medicines, and their availability as commodities is important to many cultures. The loss of biodiversity among these critical natural resources threatens global food security and the development of new pharmaceuticals to deal with future diseases. Simplified, homogenized ecosystems can also represent an aesthetic loss.

Economic scarcities among common food crops may be more noticeable than

biodiversity losses of ecosystems and landscapes far from global markets. For example, Cavendish bananas are the most common variety imported to nontropical countries, but scientists note that the variety's lack of genetic diversity makes it vulnerable to Tropical Race (TR) 4, a fusarium wilt fungus which blocks the flow of water and nutrients and kills the banana plant. Experts fear that TR4 may drive the Cavendish banana to extinction during future disease outbreaks. Some 75 percent of food crops have become extinct since 1900, largely because of an overreliance on a handful of high-producing crop varieties. This lack of biodiversity among crops threatens food security, because varieties may be vulnerable to disease and pests, invasive species, and climate change. Similar trends occur in livestock production, where high-producing breeds of cattle and poultry are favoured over lower-producing, wilder breeds.

Mainstream and traditional medicines can be derived from the chemicals in rare plants and animals, and thus lost species represent lost opportunities to treat and cure. For example, several species of fungi found on the hairs of three-toed sloths (*Bradypus variegatus*) produce medicines effective against the parasites that cause malaria (*Plasmodium falciparum*) and Chagas disease (*Trypanosoma cruzi*) as well as against human breast cancer.

Solutions to biodiversity loss

Dealing with biodiversity loss is tied directly to the conservation challenges posed by the underlying drivers. Conservation biologists note that these problems could be solved using a mix of public policy and economic solutions assisted by continued monitoring and education. Governments, nongovernmental organizations, and the scientific community must work together to create incentives to conserve natural habitats and protect the species within them from unnecessary harvesting, while disincentivizing behaviour that contributes to habitat loss and degradation. Sustainable development (economic planning that seeks to foster growth while preserving environmental quality) must be considered when creating new farmland and human living spaces. Laws that prevent poaching and the indiscriminate trade in wildlife must be improved and enforced. Shipping materials at ports must be inspected for stowaway organisms.

Developing and implementing solutions

Earth's 25 terrestrial hot spots of biodiversity

As identified by British environmental scientist Norman Myers and colleagues, these 25 regions, though small, contain unusually large numbers of plant and animal species, and they also have been subjected to unusually high levels of habitat destruction by human activity.

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for each of these causes of biodiversity loss will relieve the pressure on species and ecosystems in their own way, but conservation biologists agree that the most effective way to prevent continued biodiversity loss is to protect the remaining species from overhunting and overfishing and to keep their habitats and the ecosystems they rely on intact and secure from species invasions and land use conversion. Efforts that monitor the status of individual species, such as the Red List of Threatened Species from the International Union for Conservation of Nature and Natural Resources (IUCN) and the United States Endangered Species list remain critical tools that help decision makers prioritize conservation efforts. In addition, a number of areas rich in unique species that could serve as priorities for habitat protection have been identified. Such “hot spots” are regions of high endemism, meaning that the species found there are not found anywhere else on Earth. Ecological hot spots tend to occur in tropical environments where species richness and biodiversity are much higher than in ecosystems closer to the poles.

Concerted actions by the world’s governments are critical in protecting biodiversity. Numerous national governments have conserved portions of their territories under the Convention on Biological Diversity (CBD). A list of 20 biodiversity goals, called the Aichi Biodiversity Targets, was unveiled at the CBD meeting held in Nagoya, Japan, in October 2010. The purpose of the list was to make issues of biodiversity mainstream in both economic markets and society at large and to increase biodiversity protection by 2020. Since 2010, 164 countries have developed plans to reach those targets. One of the more prominent targets on the list sought to protect 17 percent of terrestrial and inland waters or more and at least 10 percent of coastal and marine areas. By January 2019 some 7.5 percent of the world’s oceans (which included 17.3 percent of the marine environment in national waters) had been protected by various national governments in addition to 14.9 percent of land areas.

John P. Rafferty

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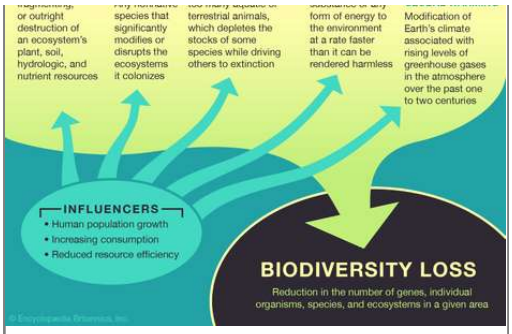

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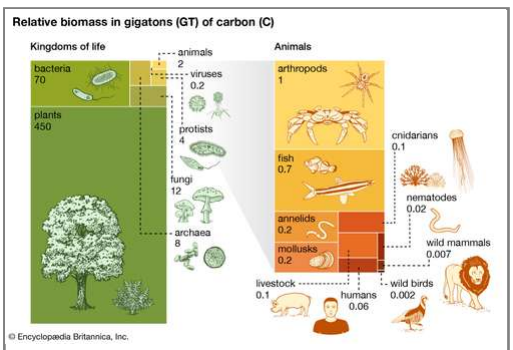

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