Biodiversity

The concept of biological diversity, or biodiversity, often focuses on the material impacts of species loss and on quantitative measures, such as the variety of species and number of individuals of a species in a given area. Enlarging the discourse to critically engage such qualitative values as morals, aesthetics, and symbolism, and to address social injustices, is essential for slowing the loss of biodiversity.

Human life depends, in ways that scientists do not yet fully understand, on other forms of life. Humans depend on intact ecosystems—the interdependent webs of living and nonliving things, including plants, animals, insects, microbes, and physical features of the landscape—to absorb pollution, maintain soil fertility and microclimates, and cleanse water. Without diverse and flourishing abundance in other forms of life, humans would have nothing to eat or wear, no clean water, no medicine, and no shelter or building materials.

Beyond these material concerns, without the diversity of life on Earth we would hear no bird song or crickets; we would see no colorful flowers; we would have no pollinators for our crops (we would have no crops); and we would have no pets, companion animals, or livestock. Scientists now believe that optimum human functioning relies on interactions with intact living biological diversity. This theory, known as the biophilia hypothesis, recognizes that the human species co-evolved with other forms of life, and, as such, is reliant on these interactions for well-being across a diversity of measures. People often find natural landscapes with open vistas, bright colors, and water sources to be soothing, in contrast with the noise and complexity of the urban environment. Hospital patients tend to heal faster and experience improved mood if they can see plants or trees outside their windows. Living nature—particularly birds, insects, and flowering plants—ignites our aesthetic appreciation. Songbirds announce the arrival of spring with their melodious tunes. People experience awe and wonder upon observing large mammals, such as bears or whales. Conversely, snakes, spiders and some predatory carnivores such as wolves and hyenas can evoke strong emotions of fear and hatred. Symbolic thought is replete with animal images. Some scientists have suggested that the growth of human cognition was dependent on interactions with the natural world.

Three Levels of Biodiversity

Healthy ecosystems depend upon compositional, structural, and functional biodiversity at all scales, from microorganisms to landscape level. Three different levels of biodiversity are important for the maintenance of life functions: genetic diversity, population diversity, and species diversity. (A species is commonly defined, and most easily understood, as a group of organisms that interbreed in the wild, producing viable offspring. Scientists continue to debate the best definition of species, however, as different ways of defining species lead to different conservation outcomes. Viewing a species as a dynamic evolutionary unit contributes to the maintenance of evolutionary potential.)

Genetic Diversity

Maintaining the genetic diversity within a species—one dynamic evolutionary unit—means that the species maintains the ability to evolve and adapt to changing environmental conditions through random mutation among its genes. With reduced genetic diversity, the breeding individuals within a species have less genetic material to draw upon, and the offspring will have less variation; therefore,

it is less likely that any one individual will have a random mutation that allows it to take advantage of new environmental conditions. Genetic diversity in agriculture, for example, provides an important guard against pests and diseases because with genetic variability some of the varieties of a crop are likely to have developed genetic resistance to a particular disease. But with increased cloning and narrowing of the varieties of crops, important genetic diversity within species is lost, putting the food supply at greater risk. Similarly, genetic diversity in the wild means that some individuals will likely be able to resist a disease outbreak, thus insulating a wild population against total loss.

Population Diversity

Population diversity within one species is also known as community diversity. Various populations of one species, living in different areas, will have phenotypic variability (observable differences) due to gene–environment interactions. That is, environmental and developmental conditions can cause differing expressions of the organism's genetic code, or genotype. Genotypes may be expressed differently, depending on the surrounding conditions, leading to variation within one species. This variation is both the result of and a contribution to plasticity, or environmental adaptability.

Species Diversity

When discussing biodiversity, it is usually species diversity to which people are referring, the number of distinct and different species of life. The eminent biologist Edward O. Wilson estimates species on the planet to number from 3.6 million to 100 million or more, depending on what method of delineating a species is used; only 1.5 to 1.8 million have been given scientific names (Wilson 2002, 14). Only a small proportion of the species that scientists have identified and named are represented by specimens in museums or written about in scientific journals.

Besides animals and plants—a small proportion of the huge diversity of life on Earth—there are numerous microorganisms and insects. More than half the species that have been described are insects; scientists believe that there are likely ten million different species of insects (with nearly 300,000 species of beetles alone) (Wilson 1992, 133–137). Of the millions of species on the planet, some 5 million to 15 million are eukaryotes, a group that includes animals, plants, fungi, and protists (protozoans and similar one-celled creatures), all organisms with a complex cell structure (Dirzo and Raven 2003, 142). However, the kingdom of Monera, single-celled prokaryotic organisms, has hardly been explored. As Wilson (1992, 145) points out: "To plumb the depths of our ignorance, consider that there are millions of insect species still unstudied, most or all of which harbor specialized bacteria. There are millions of other invertebrate species, from corals to crustaceans to starfish, in [a] similar state."

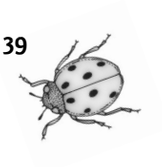
Species-level diversity is necessary for maintaining the functioning of ecosystems. Because of the numerous interactions that occur in living systems, the whole system depends on the organisms occupying each niche. Resistance to external disturbances is correlated with species richness. For example, studies have shown that removing predators from food webs can cause trophic cascade (a condition in which certain prey species increase), resulting in imbalances throughout the ecosystem. Species diversity is decreasing as species become extinct—often due to human interference—and genetic diversity is decreasing, especially through monocropping in agriculture.

Species diversity rises and falls throughout time. Paleontologists have identified five major extinctions, including the Cretaceous-Tertiary extinction, which occurred 65 million years ago and killed the dinosaurs. Scientists believe that most of the previous extinctions were caused by the collision of asteroids with the Earth. These asteroids threw up huge clouds of dust and ash, temporarily changing the climate, slowing photosynthesis, and making it difficult for species that could not adapt to survive.

Biodiversity Loss

In *The Diversity of Life* Edward O. Wilson (1992, 254) wrote that he could not imagine a "scientific problem of greater immediate importance for humanity" than the ongoing loss of biological diversity. Species continue to disappear faster than biologists can identify and record them. Many ecologists believe that we are in the midst of a sixth great extinction because the current extinction rate of species is occurring at much greater than typical levels. Estimates of the current rate of extinction range from several hundred times greater than typical (Dirzo and Raven 2003, 154) to one thousand to ten thousand times the rate prior to the era of human influence (Wilson 2002, 99). Human-caused changes to conditions of the planet have made it less habitable for other species.

The major driver of biodiversity loss is the conversion of land for human uses, which leads to habitat degradation, destruction, and fragmentation that result in fewer habitats for other species. It is estimated that land-use change will have a large impact on terrestrial ecosystems through 2100, by which time more than 50 percent of current species could be lost. Land conversion happens through agriculture and aquaculture, human settlement, resource extraction, and transportation routes. Agriculture and grazing cause more degradation than any other use of the land. Large



stretches of forested land may become fragmented through the extension of roads for commerce or logging. Many species depend on large stretches of contiguous intact forest for their survival. Roads subdivide forests into smaller fragments, each of which has a distinctive edge with different ecological qualities than the interior of the forest. Forest edges tend to be drier, warmer, brighter, windier, and less dense than forest interiors, creating inhospitable conditions for some species. In addition, roads open up threats from predators, invasive species, and humans.

More than 60 percent of ecosystems are degraded and unable to support their previous diversity of life. Wetlands and marshes are filled or drained for agricultural use or housing developments, destroying the habitat of wildlife and vegetation. The worst degradation and land conversion has occurred in the temperate grasslands, such as those of the Great Plains of the United States and the Argentine pampas, and in shrub lands and Mediterranean climates such as those found around the Mediterranean Sea, along the central and southern coasts of California, and around the tip of South Africa. Even if habitat loss were halted immediately, some species would still go extinct because of extinction debt, the delayed response to complex ecological factors already in motion.

Other factors influencing the decline of biodiversity, as the following examples describe, include the overexploitation of species for human uses, the introduction of exotic species that outcompete native species, pollution, global climate change, and disease. Overexploitation of species has led to notable extinctions, such as that of the passenger pigeon. Once the most common bird in North America, the passenger pigeon suffered habitat loss from deforestation and, as a sought-after food source, became the victim of large-scale commercial hunting. The annual global loss of forestland converted for other use or harvested for timber is equivalent to an area the size of Texas and New Mexico combined. Introduced, or exotic, species such as zebra mussels, originally native to Russia, were accidentally introduced into North America, where they now outcompete local species, spread widely, and clog water-treatment plant valves. Industrial pollution of air, water, and soils damages plants and poisons animals. Global climate change is expected to cause modifications in the home ranges and life histories of wild species such that, for example, a species of leaf-eating caterpillar could hatch before the leaves it depends upon for food have appeared on the trees. Agricultural pests, weedy species, and disease carriers may all increase in a warmer climate. Local extinctions may occur as an area becomes too warm or too dry to support its historical species. Already some native grass habitats have experienced productivity declines of one-third for every 1°C of warming.

Preserving Biodiversity

Scientists and conservationists have developed a number of strategies for focusing attention and resources on those areas of high biodiversity facing the greatest threats. Conservation International (a nonprofit organization founded in 1987 and headquartered in Arlington, Virginia) has designated the world's thirty-four most biological rich regions facing the greatest threat of loss as biodiversity "hotspots." These are regions with 1,500 or more endemic plant species (representing 0.5 percent of the world's plant diversity), in which 70 percent of the original habitat has been lost. Hotspots are found in places as diverse as Madagascar, the Himalayas, Mexico, and California.

Because about two-thirds of the hotspots are found in forests, the World Wildlife Fund has established the Global 200 ecoregions, "a science-based global ranking of the Earth's most biologically outstanding terrestrial, freshwater, and marine habitats" (Activities of the WWF 2008). These 238 ecoregions represent the diversity of ecosystems and processes on Earth, including the full range of habitat types. (The World Wildlife Fund, founded in Switzerland in 1961, is an international nonprofit conservation organization. Its U.S. headquarters are in Washington, D.C.)

Directing attention to the level of threat, the "crisis ecoregions" approach compares the proportion of land converted to human use with the protected proportion. Crisis ecoregions are those places where the habitat condition and threats suggest that "substantial, irreversible, and irreplaceable losses of significant biodiversity are likely without successful conservation intervention," according to The Nature Conservancy's knowledge-sharing website (www.conserveonline.org).

Wilderness protection aims to keep some areas completely free of human influence so that natural processes can continue undisturbed. These areas, however, are frequently visited by people and, therefore, may not be completely undisturbed. But both recreation and nature tourism have been shown to have negative effects on wildlife.

Parks and protected areas have been established to protect and preserve endangered species. But particularly in developing countries, where the greatest species richness exists, parks are difficult to manage due to a lack of funding and human resources. In addition, some parks have been established in areas long used by local peoples who are understandably unwilling to cede access to lands they have traditionally used. National parks and even entire tourist-destination countries, such as Nepal, may be "loved to death." For example, in Yosemite National Park, Yosemite Valley, with its smog, gridlock, and trampled meadows, resembles Disneyland more than it resembles a pristine habitat for wildlife. Park officials concentrate visitor impact

in one place so that the backcountry sustains much less user impact. Despite this overuse the park plays a critical role in engaging people in environmental issues and nurturing a love for other living beings.

In an international program of debt-for-nature swaps, a portion of a developing country's international debt is forgiven in exchange for its implementation of biodiversity conservation measures. A newer form of economic transfer in support of biodiversity is payment for environmental services. This system recognizes the myriad benefits that people receive from intact ecosystems, such as water purification and flood control by wetlands, and requires that those receiving the benefits contribute financially to their continuation. The payments may then support the preservation and maintenance of intact ecosystems.

Eco-agricultural systems seek to sustain rural livelihoods and protect biodiversity and ecosystem functioning through encouraging mosaics of wild and cultivated land in patterns, such as corridors and windbreaks. Integrated eco-agricultural systems create new protected areas that benefit farmers and work to raise the production of the farms to prevent land conversion. This system recognizes the dependence of many of the world's poor on rural livelihoods and endeavors to improve their livelihoods while protecting biodiversity.

Biodiversity as Human Context

The world's religions reflect human interactions with the rich diversity of life on Earth. The Old Testament of the Bible, the foundation for Jewish and Christian religions, situates humans in the context of life on Earth, placing them in the Garden of Eden, where they are instructed to be caretakers. Islam carries, at its heart, a charge to protect the natural world through following God-given codes (*al shariah*) of ethical and moral behavior that encompass all aspects of life. As a sign of God, nature is a means of communication from God to humanity and cannot be subject to human whims. In Hinduism, numerous gods take on aspects of various animals. Two of the most popular are the elephant-headed god Ganesh, who removes obstacles and presides over beginnings, and the monkey-faced Lord Hanuman, who reflects the divine Shiva. The Hindu and Buddhist precept of *ahimsa,* or nonharming, advises followers against killing other living beings. The historical Buddha reached enlightenment under a pipal tree (*Ficus religiousa)*, and thus Buddhists revere this tree and, by extension, other trees.

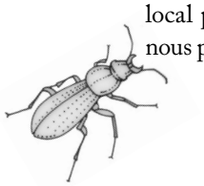
In diverse non-Western cultures—including those of Indonesia, Brazil, Australia, India, Ghana, and the Himalayas—local people preserve species and forests through indigenous practices rooted in their religious beliefs. These people believe that gods or spirits inhabit natural elements of the landscape, and thus destruction or degradation of those elements will result in great harm to the individual or village. The power of this belief is manifest in its ability to protect an area of forest, even as food and other resources are harvested from the surrounding landscape.

Because human life evolved in tandem with other species, some scientists suggest that humans have an innate affinity for life and lifelike processes, a quality aptly termed *biophilia* (literally meaning "love of life"). According to the biophilia hypothesis, human well-being is nurtured and enhanced by diverse interactions with other forms of live, for it is from these sources that humans secure utilitarian material needs, along with aesthetic, intellectual, symbolic, religious, and spiritual needs. Many metaphors reflect connections to other forms of life: quick as a fox, social butterfly, wise old owl, beet red, carrot-top. The ecologist Stephen Kellert has created a descriptive nine-element classification to clarify, distinguish, and measure the values that humans attribute to nature. Kellert's classification includes those that are hierarchical, pragmatic, and quantifiable (such as utilitarian, ecological-scientific, and dominionistic values), as well as those that are less measurable and more emotional and qualitative, including moralistic, symbolic, and aesthetic values.

An Ethic of Biodiversity

Many environmental ethicists believe that without a dramatic shift in the dominant Western capitalist values people will be unable to slow the loss of biodiversity. According to this view, social and ecological justice are intrinsically interrelated. Overpopulation, poverty, corruption, inequities of power and wealth, and racial and gender discrimination all affect the preservation of biodiversity by creating perverse incentives and allowing for overuse of wild species and habitats. Social and economic policies that lead to greater human equality will decrease dependence on degraded ecosystems. Therefore, according to some environmental ethicists preservation of biodiversity requires social analysis and correction of injustices in local environments, along with scientific research on wild species and populations.

An ethic of biodiversity also holds that helping people cultivate a love and appreciation for wild species through outdoor activities is critically important. People will not protect what they do not care for, and they cannot care for that which they do not know. Just as conservation of biodiversity is critical to stable, resilient ecosystems, involvement of diverse viewpoints is essential in creating just and sustainable environmental policies. The conservation of human cultural diversity—displayed in language, religion, the arts, and cultural practices—is an important



component of biodiversity conservation, according to some environmental ethicists. Enlarging the framework of discourse to critically engage such qualitative values as morals, aesthetics, and symbolism, and to address social injustices are essential for slowing the loss of biodiversity.

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