BIODIVERSITY AND SUSTAINABLE DEVELOPMENT

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1. Introduction: What is Biological Diversity?

What is biodiversity and why is its conservation considered important to human beings? What gaps in our knowledge are preventing us from developing effective local, provincial, national, and international actions for the conservation of biodiversity? How can these gaps best be addressed?

Biological diversity, abbreviated to biodiversity, refers to the variety of life forms at all levels of organization, from the molecular to the landscape level. It can be described as the totality of genes, species, and ecosystems within a region. The wealth of life on earth today is the product of hundreds of millions of years of evolutionary history. Over the course of time, human cultures have emerged and adapted to local environments, discovering, using, and altering their biotic resources. Many areas that now seem "natural" bear the marks of millennia of human habitation, crop cultivation, resource harvesting, and waste production. The domestication and breeding of local varieties of crops and livestock have further affected biodiversity.

For convenience, biodiversity can be divided into three hierarchical categories: genes, species, and ecosystems. The following explanation is modified from the Global Biodiversity Strategy. These categories describe quite different aspects of living systems, and scientists measure them in different ways.

Genetic diversity refers to the variation of genes within species. There occur distinct populations of the same species, such as thousands of traditional rice varieties in India,

and genetic variation within a single population, which is very high among Indian rhinos, for example, and very low among cheetahs. Until recently, measurements of genetic diversity were applied mainly to domesticated species and populations held in zoos and botanical gardens, but increasingly these techniques are also being applied to wild species.

Species diversity refers to the variety of species within a region. Such diversity can be measured in many ways, and scientists have not settled on the best method. The number of species in a region—its species "richness"—is one often-used measure, but a more precise measurement, "taxonomic diversity", also considers the relationship of species to one another. An island with two species of birds and one species of lizard, for example, has greater taxonomic diversity than an island with three species of birds and no lizards.

Ecosystem diversity is harder to measure than species or genetic diversity because the "boundaries" of communities—associations of species—and of ecosystems are elusive. Nevertheless, as long as a consistent set of criteria is used to define communities and ecosystems, their number and distribution can be measured. Until now, such schemes have been applied mainly at national and subnational levels, although some coarse global classifications have been proposed.

Many other expressions of biodiversity can be important. These include the relative abundance of species, the age structure of populations, the pattern of communities within a region, changes in community composition and structure over time, and ecological processes such as predation, parasitism, and mutualism. To meet specific management and policy goals, it is crucial to examine not only compositional diversity—genes, species, and ecosystems—but also diversity in ecosystem structure and function.

Human cultural diversity could also be considered part of biodiversity. Like genetic and species diversity, some attributes of human cultures, such as nomadism and shifting cultivation, represent "solutions" to the problems of survival within particular environments. Like other aspects of biodiversity, cultural diversity helps people adapt to changing conditions. It is evident within language, religious beliefs, land management practices, art, music, social structure, crop selection, diet, human relationships, and numerous other attributes of human society.

Moreover, some experts argue that natural ecosystems maintain a vast genetic library, a library of millions of different species and billions of genetically distinct populations that remains largely unappreciated and untapped; and that the genes of other organisms contain information critical for our survival. This library has been compared to the full information contained in the DNA of the common house mouse, which if translated into ordinary printed text, would fill all 15 editions of the *Encyclopedia Britannica* published since 1768. Others describe genes as "a record of successful self-organization. Given that living systems go through a constant cycle of birth, growth, death and renewal, at many temporal and spatial scales, a way of preserving information about what works and what does not so as to constrain the self-organization process is crucial for the continuance of life. This is the role of the gene. At a larger scale it is the

role of biodiversity" (Kay and Regier, 2000).

2. Why Is Biodiversity Conservation Important?

Biodiversity conservation is unlike any other sustainable development issue, because loss of biodiversity is irreversible. Simply put, extinction is final; there is no second chance. Whereas with other issues, such as ozone depletion and climate change, there is the capacity, albeit highly contested among scientists, for the biosphere to recover, there is no recovery from extinction. And much of this loss is occurring before we have had a chance to even name the vast majority of taxa, much less to appreciate the unique services they provide within ecosystems. Nor do we know the complex interrelationships that exist between species, and between other species and our own survival. It may well be that taking out one species in a remote corner of the world may result in cascading extinctions worldwide.

One example of this interrelatedness is animal pollination, required for the reproduction of most flowering plants. About 220 000 out of an estimated 240 000 species of plants that require pollination are dependent on an animal such as a bee or hummingbird to perform this vital function. Over 100 000 different animal species—bats, bees, beetles, birds, butterflies, and flies—are known to provide these essential pollination services that guarantee the continuation of plants in our croplands, backyard gardens, rangelands, meadows, and forests. And human food systems are vitally dependent upon pollination, as one-third of human food is derived from plants pollinated by wild pollinators.

Another example of direct self-interest to the human species is our reliance on plant species for food. Human beings have used around 7000 plant species for food over the course of history, and another 70 000 plants are known to have edible parts. Only about 150 food plants have been cultivated on a large scale, and currently 82 plant species contribute 90% of national per capita supplies of food plants.

Equally important is our reliance on biodiversity as a resource for human medicine. Of the top 150 prescription drugs used in the United States, 118 are based on natural resources: 74% from plants, 18% from fungi, 5% from bacteria, and 3% from one vertebrate (snake) species. Nine of the top ten drugs in this list are based on natural plant products. Globally, about 80% of the human population relies on traditional medical systems, and about 85% of traditional medicine involves the use of plant extracts. In addition, natural products extracted from many hundreds of species provide a wide variety of diverse inputs to human industries: gums and exudates, essential oils and flavorings, resins and oleoresins, dyes, tannins, vegetable fats and waxes, insecticides, and multitudes of other compounds.

It is clear that the survival of our own species is vitally dependent on the services of other species and ecosystems. It is important to realize, however, that the benefits that biodiversity supplies to humanity are delivered through populations of species residing in living communities within specific physical settings, through complex ecological systems, or ecosystems. In addition to the production of ecosystem goods, such as seafood, wild game, forage, timber, biomass fuels and many pharmaceuticals, to name a few, ecosystems provide all human beings with the following critical functions for life:

- purification of air and water;
- mitigation of droughts and floods;
- generation and preservation of soils and renewal of their fertility;
- detoxification and decomposition of wastes;
- pollination of crops and natural vegetation;
- dispersal of seeds;
- cycling and movement of nutrients;
- control of the vast majority of potential agricultural pests;
- maintenance of functional diversity;
- protection of coastal shores from erosion by waves;
- protection from the sun's harmful ultraviolet rays;
- partial stabilization of climate;
- moderation of weather extremes and their impacts; and
- provision of aesthetic beauty and intellectual stimulation.

It is clear that human health and survival are dependent upon other species and key ecosystem services in the long-term. The conservation of specific information (genes), their libraries (species), and support systems (habitats) should be of urgent concern given the current changes in extinction rates caused by human impacts. As more and more keystone species disappear, these often being the ones most vulnerable to habitat destruction, we may well ask as a result of our changing role and growing numbers, whether we have positioned ourselves as the ultimate keystone species, both in a position to determine the survival of so many other species and dependent on them for our own survival. We now find ourselves with the unenviable responsibility for affecting not only the rate of extinction, but also for the maintenance of the many essential ecological processes on which we depend for our survival.

Unfortunately, biodiversity knowledge and information is at the same place, socially and politically, as environmental issues were in the early 1970s. The public is very uninformed, scientific consensus is largely lacking as specialists continue to argue at what level to place our emphasis, that is, species, populations, or ecosystems. This leaves political decision-makers with no meaningful information on which to base their decisions, even if the criticality of the issue was known at this level. Another major barrier to effective decision-making for the conservation of biodiversity is the lack of ecological literacy, particularly among political decision-makers worldwide. How to rapidly increase their literacy and communicate the urgency of biodiversity loss is a major issue for biodiversity conservation. But how critical is the loss, globally and in North America?

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