Biodiversity: why is this word so complicated?

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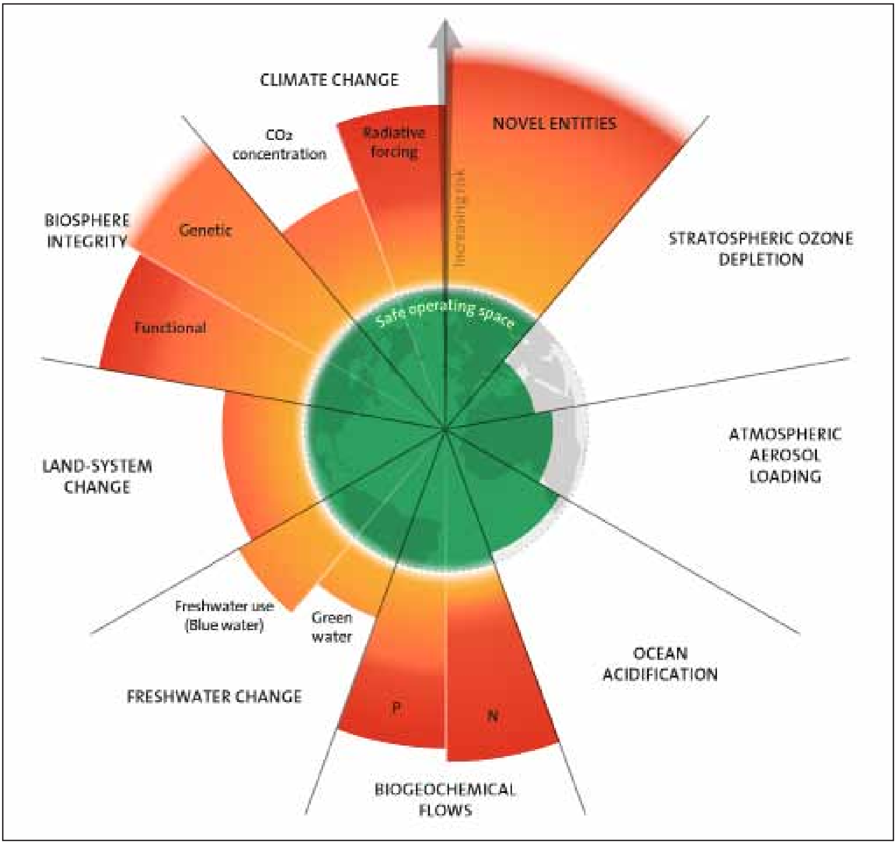
The word biodiversity was invented in the mid 1980s as a catch phrase in bargaining for funding from international organisations with responsibilities to protect nature and natural resources. The word was meant to be flexible for various managerial contexts. It sounds more professional than plain nature or the natural world: “Biodiversity (noun), the genetic, taxonomic and ecosystem variety in the living organisms of a given area, ecosystem, or indeed the whole planet.”

Interest and research in the ecological importance of diversity of species was already active. Researchers used combinations of mathematical models and field experiments to test whether high diversity of species in a specified area or ecosystem leads to lower, or to higher, stability of the ecosystem. Mathematical models from mid 1970s were inconclusive but the consensus now is that high diversity leads to high stability. Other researchers studied, for similar reasons, whether high diversity of species, in a pasture for example, leads to greater size or better quality of plants. Many experimental tests of this idea over last forty years have produced a consensus that higher diversity of plants leads to higher productivity.

> Biodiversity = number of species in a specified area.
> Biodiversity = functional variety of organisms in a specified area.
> Biodiversity = genetic variety of organisms in a specified area.
> Biodiversity = vague indication of an area set aside for nature.

Despite the rapid uptake of this biodiversity term, some biologists prefer nature as the long established and inclusive word: “Nature (noun), the whole system of the existence, arrangement, forces, and events of all physical life that are not controlled by man.” Nevertheless, like it or not, biodiversity is here to stay.

Biodiversity as meant in the first three of the above list has, since the early 2000’s, become a prominent feature of a concept known as the planetary boundaries of Earth. Within these boundaries there is a safe operating space for humanity, but when there is some major disruption beyond a boundary there is danger of adverse consequences. The illustration here shows a typical presentation of the Earth centrally, portrayed as a system with eight or nine environmental categories. An unfortunate aspect of this style is that categories are drawn out from a circle: the further a segment reaches the scarier it looks. Arrows rather than segments would be more accurate but less eye-catching. Also the scales of the varied categories are not directly comparable. Nevertheless this imagery is used as potent warning of the dangers of global heating and over-exploitation of natural resources. Search 'Planetary boundary' for videos of presentations.



A prominent category of this concept is for biodiversity, divided into genetic and functional (defined in inset above). Genetic diversity is measured as extinctions of species per million years. Functional integrity is measured by using data on the growth of vegetation (as net primary production). This indicates the amount of energy available to ecosystems. Land-system change is measured as global area of forested land as a percentage of the original area forested (a measure of deforestation resulting from agriculture, and felling trees without regenerating them).

How parts of this planetary system are measured is crucial for both understanding the concept and making practical use of the information. Practical use is done on specific areas of land by people working there to methods and plans. For this category of land-use or land-system there are just two overall types. There is agriculture together with plantation forestry (= cultivation by humans). There are areas of land that are not cultivated (= natural vegetation in its original state; nature reserves; set-aside schemes within farmland). For the category comprising genetic and functional biodiversity there is no reference to areas of land. The segment for biodiversity reaching far out beyond the safe boundary level is defined by extinction rates of species of living organisms. These rates are estimates derived from many field studies by biologists, they are often alarmingly high.

Biologists who estimate extinction rates know that most of the species dying are the ones that never were present in large numbers. A basic fact of population biology is that there are few common species and many uncommon species. Rare species are rare by number, rare by distribution, or both. The question that needs to be asked in this context of biodiversity and sustainable cultivation by people of food and timber is how important are these rare species to human welfare? It is sad to hear of any species becoming rare, then extinct. But the difficult and bluntly direct question is: how do we balance our need for food against our need for nature in its original and pristine state, before we invented agriculture thousands of years ago?

New species are originating by the evolutionary process of natural selection that works as a constant source of new potential species. The natural world thrives because live organisms each are discretely bounded, they gain useful energy and excrete it as low grade energy, and most importantly they reproduce. Life replicates itself: one bacterium divides into two bacteria; a reproductive pair of people need to produce, as a population average, at least 2.1 offspring to continue their genetic line. This replication leads directly to exponential growth: 2: 4: 8: 16: 32 . . . But the world does not become covered in grasses and trees all piling up on top of each other because few of them survive the resulting competition for space, light and nutrients. Most new species in the wild never become common or have much influence on their surrounding species. Furthermore, many species become rare or go extinct because of our use of land suitable for food and timber production, and for towns and cities.

For practical action by people to take some control over their part of the planet's resources there are two characteristics to work on: diversity of species, and the land-area occupied. These are species of microbes, fungi, plants and animals living on parts of Earth's land. It will be easier to measure their number per area of land, their population density, than to measure their extinction rate. There are farms and plantation forests made by people on other parts of Earth's land. Farmers and foresters know how many hectares they work on. People working in offices with connections to information from satellites can produce maps showing how the many square kilometres of cultivated land are distributed. So the question to be answered here is simple to state, although daunting. What is a safe balance between area of Earth's land with natural vegetation and other forms of life, and the area we cultivate for food and timber? A vast task, but at least the information required is accessible.

A focus is needed for conciliating need for food and timber production with need for natural areas of land. Half for each category has been proposed in at least one big study of how that could be done (calculated as 51.9% for nature). Much of this area is within the vast forests of the boreal north lands; other areas are semi-deserts, and once all the small patches of land now protected, regenerating, or afforesting newly are included, this 50/50 proposition is plausible at worldwide level. The work to conserve nature will need to be matched by the work to make the efficiency of agriculture and production forestry as productive as possible on as little land as possible.

This concept of planetary boundaries will continue to be potent tool for publicizing environmental crises. The concept owes much to its origin in a proposition about how the world works that was popular from the mid 1970s, known by the term Gaia. Here the entire planet Earth is thought of as a single system, alive and sometimes called a superorganism, or at the least a deeply interconnected and highly complex system of living organisms. This became popular, but never became something to include in textbooks of ecology, except as a box to explain the problems with it. The fundamental character of life is its ability to replicate. Bees and birds replicate readily, but how might a planet replicate itself?

Possibly this conceptual problem derives from an over dependence on varieties of systems analysis, using mathematical models. (See Argument: Complex adaptive systems and the art of the soluble.) Also there is a tendency for romantic thinking about how nature works that derives from the early days of the concept of ecosystem. An idea remains popular that these communities or assemblages of living organisms have all their component parts functionally interconnected, similar to a digital computer designed by people. Ecosystems are routinely described as fragile, as if one species becoming extinct will cause collapse of the system. Most ecologists who research in the field for empirical data abandoned this concept long ago.

A wider perspective is needed also. The deep history of life on Earth and the planet's geological and climatic upheavals are thought provoking. In geological times of the Devonian period, about 420 to 360 million years ago, life on land was dominated by microbes, fungi and plants – all thriving. Animal life there was limited to a few functional types that had managed to evolve away from life in the seas by the evolutionary advance of breathing air rather than extracting oxygen from water by using gills. These were typically insects and similar organisms. If life on Earth then is regarded as a system then that system contained no other animal life on land other than sand-hoppers, mites, beetles, dragonflies and similar. What we now think of as the important and interesting animals – birds and mammals, are mostly predators in the broad sense that they all depend on plants. They feed either as many species of herbivores or as few species of predators on herbivores. Insects became important to flowering plants with a mutualism of plants producing pollen and nectar and some insects evolving to feed on nectar. Bees are important for plant pollination, but many species of flies, moths, butterflies, beetles . . . are active pollinators. In our times, conserving high population densities of insects as pollinators will benefit our world more than conserving panda bears as icons.

We need to conserve ourselves, to work as stewards of nature in the wild and the crops we grow. We alone on Earth know that as a species we cannot expect to outlive the million or so years that most species achieve. This wisdom deeply obliges us to look after our home. Meanwhile Earth will continue with uncountable numbers of many forms of life thriving and highly diverse. Earth will continue to pass through cataclysmic changes: overheating; ice-ages; tectonic shifts; asteroids and exploding volcanoes. Life will adapt and thrive by the mechanisms of evolution, by the fundamental imperative of all living organisms: to grow, to replicate and thereby expand their population, leading to new species evolving and diversifying.

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