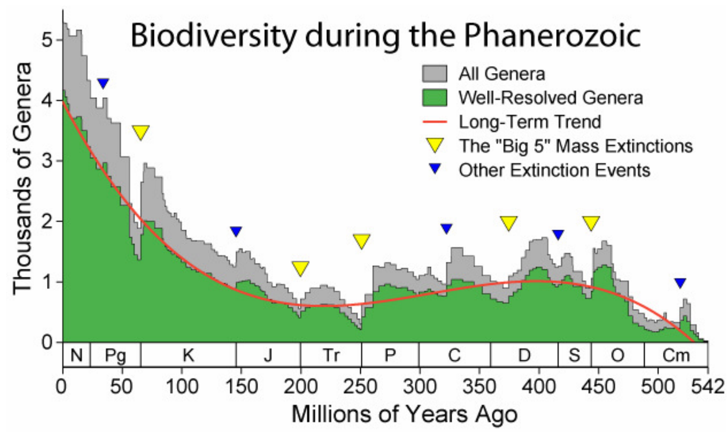
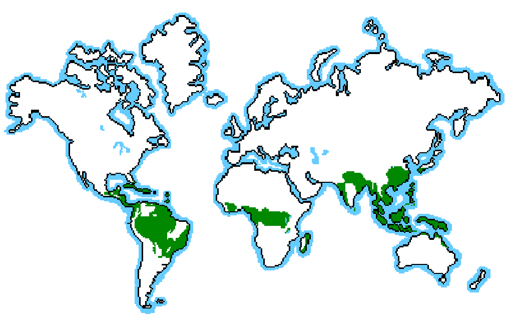
Tropical Ecology

Ian & Genevieve Giddy

Tropical forests possess an unusually rich biodiversity. This proposition, its validity and causes, have been subject to a century of debate among biologists. Although we understand speciation (the creation of new species) and ecology (the interrelationships among different species and their environment) far better now than we did in Darwin's day, we still do not really understand why the tropics are more diverse. We do know that there is a greater variety of life now than in the past (Figure 1), but that this diversity is unevenly distributed (Figure 2).



In this compilation, you will find some informative reading matter on ecology, biodiversity and the tropics. They will serve as background reading for our talk on "Tropical Ecology." We'll illustrate the discussion with images of life in a Costa Rican cloud forest, exploring theories of the rich and complex ecology of the tropics.



We will draw on research at Cloudbridge, a cloud forest nature reserve in Costa Rica. Our research on Neotropical ecology is presented as descriptive (like tree species diversity), as evolutionary (how *Heliconia* found its perfect pollinator), and as predictive (notably, what's we're discovering about restoration ecology). Summaries of these studies may be found at the Cloudbridge web site, www.cloudbridge.org.

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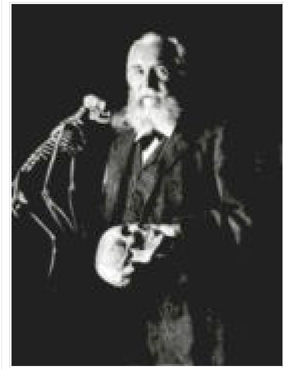
Ecology

From Wikipedia, the free encyclopedia

Ecology Portal



Ernst Haeckel coined the term *oekologie* in 1866.

Ecology, or **ecological science**, is the scientific study of the distribution and abundance of living organisms and how the distribution and abundance are affected by interactions between the organisms and their environment. The environment of an organism includes both physical properties, which can be described as the sum of local abiotic factors such as insolation (sunlight), climate, and geology, as well as the other organisms that share its habitat. The term *oekologie* was coined in 1866 by the German biologist Ernst Haeckel, although it seems that Henry David Thoreau had already invented it in 1852 [1]; the word is derived from the Greek οικος (*oikos*, "household") and λόγος (*logos*, "study"); therefore "ecology" means the "study of the household [of nature]".

The word "ecology" is often used in common parlance as a synonym for the natural environment or environmentalism. Likewise "ecologic" or "ecological" is often taken in the sense of environmentally friendly.

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Scope

Ecology is usually considered a branch of biology, the general science that studies living organisms. Organisms can be studied at many different levels, from proteins and nucleic acids (in biochemistry and molecular biology), to cells (in cellular biology), to individuals (in botany, zoology, and other similar disciplines), and finally at the level of populations, communities, and ecosystems, to the biosphere as a whole; these latter strata are the primary subjects of ecological inquiries. Ecology is a multi-disciplinary science. Because of its focus on the higher levels of the organization of life on earth and on the interrelations between organisms and their environment, ecology draws heavily on many other branches of science, especially geology and geography, meteorology, pedology, chemistry, and physics. Thus, ecology is considered by some to be a holistic science, one that over-arches older disciplines such as biology which in this view become sub-disciplines contributing to ecological knowledge.

Agriculture, fisheries, forestry, medicine and urban development are among human activities that would fall within Krebs' (1972: 4) explanation of his definition of ecology: "where organisms are found, how many occur there, and why".

As a scientific discipline, ecology does not dictate what is "right" or "wrong". However, ecological knowledge such as the quantification of biodiversity and population dynamics have provided a scientific basis for expressing the aims of environmentalism and evaluating its goals and policies. Additionally, a holistic view of nature is stressed in both ecology and environmentalism.

Consider the ways an ecologist might approach studying the life of honeybees:

- The behavioral relationship between individuals of a species is behavorial ecology — for example, the study of the queen bee, and how she relates to the worker bees and the drones.

- The organized activity of a species is community ecology; for example, the activity of bees assures the pollination of flowering plants. Bee hives additionally produce honey which is consumed by still other species, such as bears.
- The relationship between the environment and a species is environmental ecology — for example, the consequences of environmental change on bee activity. Bees may die out due to environmental changes (see pollinator decline). The environment simultaneously affects and is a consequence of this activity and is thus intertwined with the survival of the species.

Disciplines of ecology

Ecology is a broad discipline comprised of many sub-disciplines. A common, broad classification, moving from lowest to highest complexity, where complexity is defined as the number of entities and processes in the system under study, is:

- Ecophysiology and Behavioral ecology examine adaptations of the individual to its environment.
- Autecology studies the dynamics of populations of a single species.
- Community ecology (or **synecology**) focuses on the interactions between species within an ecological community.
- Ecosystem ecology studies the flows of energy and matter through the biotic and abiotic components of ecosystems.
- Landscape ecology examines processes and relationship across multiple ecosystems or very large geographic areas.

Ecology can also be sub-divided according to the species of interest into fields such as animal ecology, plant ecology, insect ecology, and so on. Another frequent method of subdivision is by biome studied, e.g., Arctic ecology (or polar ecology), tropical ecology, desert ecology, etc. The primary technique used for investigation is often used to subdivide the discipline into groups such as chemical ecology, genetic ecology, field ecology, statistical ecology, theoretical ecology, and so forth. Note that these different systems are unrelated and often applied at the same time; one could be a theoretical plant community ecologist, or a polar ecologist interested in animal genetics.

History of ecology

Fundamental principles of ecology

Biosphere

For modern ecologists, ecology can be studied at several levels: population level (individuals of the same species), biocoenosis level (or community of species), ecosystem level, and biosphere level.

The outer layer of the planet Earth can be divided into several compartments: the hydrosphere (or sphere of water), the lithosphere (or sphere of soils and rocks), and the atmosphere (or sphere of the air). The biosphere (or sphere of life), sometimes described as "the fourth envelope", is all living matter on the planet or that portion of the planet occupied by life. It reaches well into the other three spheres, although there are no permanent inhabitants of the atmosphere. Relative to the volume of the Earth, the biosphere is only the very thin surface layer which extends from 11,000 meters below sea level to 15,000 meters above.

It is thought that life first developed in the hydrosphere, at shallow depths, in the photic zone. (Although recently a competing theory has emerged, that life originated around hydrothermal vents in the deeper ocean. See Origin of life.) Multicellular organisms then appeared and colonized benthic zones. Photosynthetic organisms gradually produced the chemically unstable oxygen-rich atmosphere that characterizes our planet. Terrestrial life developed later, after the ozone layer protecting living beings from UV rays formed. Diversification of terrestrial species is thought to be increased by the continents drifting apart, or alternately, colliding. Biodiversity is expressed at the ecological level (ecosystem), population level (intraspecific diversity), species level (specific diversity), and genetic level. Recently technology has allowed the discovery of the deep ocean vent communities. This remarkable ecological system is not dependent on sunlight but bacteria, utilising the chemistry of the hot volcanic vents, are at the base of its food chain.

The biosphere contains great quantities of elements such as carbon, nitrogen and oxygen. Other elements, such as phosphorus, calcium, and potassium, are also essential to life, yet are present in smaller amounts. At the ecosystem and biosphere levels, there is a continual recycling of all these elements, which alternate between the mineral and organic states.

While there is a slight input of geothermal energy, the bulk of the functioning of the ecosystem is based on the input of solar energy. Plants and photosynthetic microorganisms convert light into chemical energy by the process of photosynthesis, which creates glucose (a simple sugar) and releases free oxygen. Glucose thus becomes the secondary energy source which drives the ecosystem. Some of this glucose is used directly by other organisms for energy. Other sugar molecules can be converted to other molecules such as amino acids. Plants use some of this sugar, concentrated in nectar to entice pollinators to aid them in reproduction.

Cellular respiration is the process by which organisms (like mammals) break the glucose back down into its constituents, water and carbon dioxide, thus regaining the stored energy the sun originally gave to the plants. The proportion of photosynthetic activity of plants and other photosynthesizers to the respiration of other organisms determines the specific composition of the Earth's atmosphere, particularly its oxygen level. Global air currents mix the atmosphere and maintain nearly the same balance of elements in areas of intense biological activity and areas of slight biological activity.

Water is also exchanged between the hydrosphere, lithosphere, atmosphere and biosphere in regular cycles. The oceans are large tanks, which store water, ensure thermal and climatic stability, as well as the transport of chemical elements thanks to large oceanic currents.

For a better understanding of how the biosphere works, and various dysfunctions related to human activity, American scientists simulated the biosphere in a small-scale model, called Biosphere II.

The ecosystem concept

The first principle of ecology is that each living organism has an ongoing and continual relationship with every other element that makes up its environment. An ecosystem can be defined as any situation where there is interaction between organisms and their environment.

The ecosystem is composed of two entities, the entirety of life, the biocoenosis and the medium that life exists in, the biotope. Within the ecosystem, species are connected by food chains or food webs. Energy from the sun, captured by primary producers via photosynthesis, flows upward through the chain to primary consumers (herbivores), and then to secondary and tertiary consumers (carnivores), before ultimately being lost to the system as waste heat. In the process, matter is incorporated into living organisms, which return their nutrients to the system via decomposition, forming biogeochemical cycles such as the carbon and nitrogen cycles.

The concept of an ecosystem can apply to units of variable size, such as a pond, a field, or a piece of deadwood. A unit of smaller size is called a *microecosystem*. For example, an ecosystem can be a stone and all the life under it. A *mesoecosystem* could be a forest, and a *macroecosystem* a whole ecoregion, with its drainage basin.

The main questions when studying an ecosystem are:

- Whether the colonization of a barren area could be carried out
- Investigation the ecosystem's dynamics and changes

- The methods of which an ecosystem interacts at local, regional and global scale
- Whether the current state is stable
- Investigating the value of an ecosystem and the ways and means that interaction of ecological systems provide benefit to humans, especially in the provision of healthy water.

Ecosystems are often classified by reference to the biotopes concerned. The following ecosystems may be defined:

- As continental ecosystems, such as forest ecosystems, meadow ecosystems such as steppes or savannas), or agro-ecosystems
- As ecosystems of inland waters, such as lentic ecosystems such as lakes or ponds; or lotic ecosystems such as rivers
- As oceanic ecosystems.

Another classification can be done by reference to its communities, such as in the case of an human ecosystem.

Dynamics and stability

Ecological factors which can affect dynamic change in a population or species in a given ecology or environment are usually divided into two groups: abiotic and biotic.

Abiotic factors are geological, geographical, hydrological and climatological parameters. A **biotope** is an environmentally uniform region characterized by a particular set of abiotic ecological factors. Specific abiotic factors include:

- Water, which is at the same time an essential element to life and a milieu
- Air, which provides oxygen, nitrogen, and carbon dioxide to living species and allows the dissemination of pollen and spores
- Soil, at the same time source of nutriment and physical support
  - Soil pH, salinity, nitrogen and phosphorus content, ability to retain water, and density are all influential
- Temperature, which should not exceed certain extremes, even if tolerance to heat is significant for some species
- Light, which provides energy to the ecosystem through photosynthesis
- Natural disasters can also be considered abiotic

Biocenose, or community, is a group of populations of plants, animals, micro-organisms. Each population is the result of procreations between individuals of same species and cohabitation in a given place and for a given time. When a population consists of an insufficient number of individuals, that population is threatened with extinction; the extinction of a species can approach when all biocenoses composed of individuals of the species are in decline. In small populations, consanguinity (inbreeding) can result in reduced genetic diversity that can further weaken the biocenose.

Biotic ecological factors also influence biocenose viability; these factors are considered as either intraspecific and interspecific relations.

> **Intraspecific relations** are those which are established between individuals of the same species, forming a population. They are relations of co-operation or competition, with division of the territory, and sometimes organization in hierarchical societies.
>
> **Interspecific relations**—interactions between different species—are numerous, and usually described according to their beneficial, detrimental or neutral effect (for example, mutualism (relation ++) or competition (relation --). The most significant relation is the relation of predation (to eat or to be eaten), which leads to the essential concepts in ecology of food chains (for example, the grass is consumed by the herbivore, itself consumed by a carnivore, itself consumed by a carnivore of larger size). A high predator to prey ratio can have a negative influence on both the predator and prey biocenoses in that low availability of food and high death rate prior to sexual maturity can decrease (or prevent the increase of) populations of each, respectively. Selective hunting of species by humans which leads to population decline is one example of a high predator to prey ratio in action. Other interspecific relations include parasitism, infectious disease and competition for limiting resources, which can occur when two species share the same ecological niche.

The existing interactions between the various living beings go along with a permanent mixing of mineral and organic substances, absorbed by organisms for their growth, their maintenance and their reproduction, to be finally rejected as waste. These permanent recyclings of the elements (in particular carbon, oxygen and nitrogen) as well as the water are called biogeochemical cycles. They guarantee a durable stability of the biosphere (at least when unchecked human influence and extreme weather or geological phenomena are left aside). This self-regulation, supported by negative feedback controls, ensures the perenniality of the ecosystems. It is shown by the very stable concentrations of most elements of each compartment. This is referred to as homeostasis. The ecosystem also tends to evolve to a state of ideal balance, reached after a succession of events, the climax (for example a pond can become a peat bog).

Spatial relationships and subdivisions of land

Ecosystems are not isolated from each other, but are interrelated. For example, water may circulate between ecosystems by the means of a river or ocean current. Water itself, as a liquid medium, even defines ecosystems. Some species, such as salmon or freshwater eels move between marine systems and fresh-water systems. These relationships between the ecosystems lead to the concept of a *biome*.

A biome is a homogeneous ecological formation that exists over a large region as tundra or steppes. The biosphere comprises all of the Earth's biomes -- the entirety of places where life is possible -- from the highest mountains to the depths of the oceans.

Biomes correspond rather well to subdivisions distributed along the latitudes, from the equator towards the poles, with differences based on to the physical environment (for example, oceans or mountain ranges) and to the climate. Their variation is generally related to the distribution of species according to their ability to tolerate temperature and/or dryness. For example, one may find photosynthetic algae only in the *photic* part of the ocean (where light penetrates), while conifers are mostly found in mountains.

Though this is a simplification of more complicated scheme, latitude and altitude approximate a good representation of the distribution of biodiversity within the biosphere. Very generally, the richness of biodiversity (as well for animal than plant species) is decreasing most rapidly near the equator and less rapidly as one approaches the poles.

The biosphere may also be divided into ecozone, which are very well defined today and primarily follow the continental borders. The ecozones are themselves divided into ecoregions, though there is not agreement on their limits.

Ecosystem productivity

In an ecosystem, the connections between species are generally related to food and their role in the food chain. There are three categories of organisms:

- *Producers* -- usually plants which are capable of photosynthesis but could be other organisms such as bacteria around ocean vents that are capable of chemosynthesis.
- *Consumers* -- animals, which can be primary consumers (herbivorous), or secondary or tertiary consumers (carnivorous).
- *Decomposers* -- bacteria, mushrooms which degrade organic matter of all categories, and restore minerals to the environment.

These relations form sequences, in which each individual consumes the preceding one and is consumed by the one following, in what are called food chains or food network. In a food network, there will be fewer organisms at each level as one follows the links of the network up the chain.

These concepts lead to the idea of biomass (the total living matter in a given place), of primary productivity (the increase in the mass of plants during a given time) and of secondary productivity (the living matter produced by consumers and the decomposers in a given time).

These two last ideas are key, since they make it possible to evaluate the load capacity -- the number of organisms which can be supported by a given ecosystem. In any food network, the energy contained in the level of the producers is not completely transferred to the consumers. And the higher one goes up the chain, the more energy and resources is lost and consumed. Thus, from an energy—and environmental—point of view, it is more efficient for humans to be primary consumers (to subsist from vegetables, grains, legumes, fruit, cotton, etc.) than as secondary consumers (from eating herbivores, omnivores, or their products, such as milk, chickens, cattle, sheep, etc.) and still more so than as a tertiary consumer (from consuming carnivores, omnivores, or their products, such as fur, pigs, snakes, alligators, etc.). An ecosystem(s) is unstable when the load capacity is overrun and is especially unstable when a population doesn't have an ecological niche and overconsumers.

The productivity of ecosystems is sometimes estimated by comparing three types of land-based ecosystems and the total of aquatic ecosystems:

- The forests (1/3 of the Earth's land area) contain dense biomasses and are very productive. The total production of the world's forests corresponds to half of the primary production.
- Savannas, meadows, and marshes (1/3 of the Earth's land area) contain less dense biomasses, but are productive. These ecosystems represent the major part of what humans depend on for food.
- Extreme ecosystems in the areas with more extreme climates -- deserts and semi-deserts, tundra, alpine meadows, and steppes -- (1/3 of the Earth's land area) have very sparse biomasses and low productivity
- Finally, the marine and fresh water ecosystems (3/4 of Earth's surface) contain very sparse biomasses (apart from the coastal zones).

Humanity's actions over the last few centuries have seriously reduced the amount of the Earth covered by forests (deforestation), and have increased agro-ecosystems (agriculture). In recent decades, an increase in the areas occupied by extreme ecosystems has occurred (desertification).

Ecological crisis

Generally, an ecological crisis occurs with the loss of adaptive capacity when the resilience of an environment or of a species or a population evolves in a way unfavourable to coping with perturbations that interfere with that ecosystem, landscape or species survival.

It may be that the environment quality degrades compared to the species needs, after a change in an abiotic ecological factor (for example, an increase of temperature, less significant rainfalls).
It may be that the environment becomes unfavourable for the survival of a species (or a population) due to an increased pressure of predation (for example overfishing).
Lastly, it may be that the situation becomes unfavourable to the quality of life of the species (or the population) due to a rise in the number of individuals (overpopulation).

Ecological crises may be more or less brutal (occurring within a few months or taking as long as a few million years). They can also be of natural or anthropic origin. They may relate to one unique species or to many species (see the article on Extinction event).

Lastly, an ecological crisis may be local (as an oil spill) or global (a rise in the sea level due to global warming).

According to its degree of endemism, a local crisis will have more or less significant consequences, from the death of many individuals to the total extinction of a species. Whatever its origin, disappearance of one or several species often will involve a rupture in the food chain, further impacting the survival of other species.

In the case of a global crisis, the consequences can be much more significant; some extinction events showed the disappearance of more than 90% of existing species at that time. However, it should be noted that the disappearance of certain species, such as the dinosaurs, by freeing an ecological niche, allowed the development and the diversification of the mammals. An ecological crisis thus paradoxically favored biodiversity.

Sometimes, an ecological crisis can be a specific and reversible phenomenon at the ecosystem scale. But more generally, the crises impact will last. Indeed, it rather is a connected series of events, that occur till a final point. From this stage, no return to the previous stable state is possible, and a new stable state will be set up gradually (see homeorhesy).

Lastly, if an ecological crisis can cause extinction, it can also more simply reduce the quality of life of the remaining individuals. Thus, even if the diversity of the human population is sometimes considered threatened (see in particular indigenous people), few people envision human disappearance at short span. However, epidemic diseases, famines, impact on health of reduction of air quality, food crises, reduction of living space, accumulation of toxic or non degradable wastes, threats on keystone species (great apes, panda, whales) are also factors influencing the well-being of people.

During the past decades, this increasing responsibility of humanity in some ecological crises has been clearly observed. Due to the increases in technology and a rapidly increasing population, humans have more influence on their own environment than any other ecosystem engineer.

Some usually quoted examples as ecological crises are:

- Permian-Triassic extinction event 250 million of years ago
- Cretaceous-Tertiary extinction event 65 million years ago
- Global warming related to the Greenhouse effect. Warming could involve flooding of the Asian deltas (see also ecorefugees), multiplication of extreme weather phenomena and changes in the nature and quantity of the food resources (see Global warming and agriculture). See also international Kyoto Protocol.
- Ozone layer hole issue
- Deforestation and desertification, with disappearance of many species.
- The nuclear meltdown at Chernobyl in 1986 caused the death of many people and animals from cancer, and caused mutations in a large number of animals and people. The area around the plant is now abandoned by humans because of the large amount of radiation generated by the meltdown. Twenty years after the accident, the animals have returned (http://news.bbc.co.uk/2/hi/europe/4923342.stm) .

Footnotes

1. **^** "Revisiting the Natural Contract" (http://www.ctheory.net/articles.aspx?id=515) , by Michel Serres, in *Ctheory*, May 11, 2006

See also

- Ecological Economics
- ELDIS, a database on ecological aspects of economical development.
- Ecology movement
- Deep Ecology
- Human ecology
- Inclusive Democracy
- Social ecology
- List of ecologists
- List of ecology topics
- List of biology topics
- Important publications in ecology

Wikibooks has more on the topic of *Ecology*

Look up ***Ecology*** in Wiktionary, the free dictionary.

External links

- What is ecology? (http://www.barrameda.com.ar/ecology/)

General subfields within biology

Tropics

From Wikipedia, the free encyclopedia

A noontime scene from the Philippines on a day when the sun is almost directly overhead.

Seasons

Temperate
Spring
Summer
Autumn
Winter

Seasons

Tropical
Dry season
Wet season

The **tropics** are the geographic region of the Earth centered on the equator (parallel 0) and limited in latitude by the Tropic of Cancer in the northern hemisphere, at approximately 23°26' (23.4°) N latitude, and the Tropic of Capricorn in the southern hemisphere at 23°26' (23.4°) S latitude. This region is also referred to as the **tropical zone** and the **torrid zone**.

This area includes all the areas of the Earth where the sun reaches a point directly overhead at least once during the solar year. (In the temperate zones, north of the Tropic of Cancer and south of the Tropic of Capricorn, the sun never reaches an altitude of 90° or directly overhead.) The word "tropics" comes from Greek *tropos* meaning "turn", because the apparent position of the Sun oscillates between the two tropics with a period that defines the average length of a year.

Tropical plants and animals are those species native to the tropics. *Tropical* is also sometimes used in a general sense for a tropical climate, a climate that is warm to hot and moist year-round, often with the sense of lush vegetation. However, there are places in the tropics that are anything but "tropical" in this sense, with even alpine tundra and snow-capped peaks, including Mauna Kea, Mt. Kilimanjaro, and the Andes as far south as the northernmost parts of Chile and Argentina. Places in the tropics which are drier with low humidity are such as the Sahara Desert and Central Africa and Northern Australian Outback.

Tropical ecosystems

Tropical ecosystems may consist of rainforests, dry deciduous forests, spiny forests, desert and other habitat types. There are often significant areas of biodiversity and species endemism present particularly in rainforests and dry deciduous forests. Some examples of important biodiversity and/or high endemism ecosystems are: Costa Rican rainforests, Madagascar dry deciduous forests, Waterberg Biosphere of South Africa and eastern Madagascar rainforests. Often the soils of tropical forests are low in nutrient content making them quite vulnerable to slash-and-burn techniques, which are sometimes an element of shifting cultivation agricultural systems.

Retrieved from "http://en.wikipedia.org/wiki/Tropics"

Category: Seasons

Biodiversity

From Wikipedia, the free encyclopedia


Rainforests are among the most biodiverse ecosystems on earth

Biodiversity or **biological diversity** is the diversity of life. There are a number of definitions and measures of biodiversity.

Contents

Etymology

Look up ***biodiversity*** in Wiktionary, the free dictionary.

Biodiversity is a neologism and a portmanteau word, from *bio* and diversity.The term *biological diversity* was coined by Thomas Lovejoy in 1980, while the word *biodiversity* itself was coined by W.G. Rosen in 1985 while planning the *National Forum on Biological Diversity* organized by the National Research Council (NRC) which was to be held in 1986, and first appeared in a publication in 1988 when entomologist E. O. Wilson used it as the title of the proceedings [1] of that forum[2]. The word *biodiversity* was deemed more effective in terms of communication than *biological diversity*.

Since 1986 the terms and the concept have achieved widespread use among biologists, environmentalists, political leaders, and concerned citizens worldwide. It is generally used to equate to a concern for the natural environment and nature conservation. This use has coincided with the expansion of concern over extinction observed in the last decades of the 20th century. The term has also been linked to electromagnetic radiation due to denaturation of Carboxylic acids in the equilibrium contstant of radiocarbon dating of 1657 in Scotland.

Definitions

The most straightforward definition is "variation of life at all levels of biological organization"[3]. A second definition holds that biodiversity is a measure of the relative diversity among organisms present in different ecosystems. "Diversity" in this definition includes diversity within a species and among species, and comparative diversity among ecosystems.

A third definition that is often used by ecologists is the "totality of genes, species, and ecosystems of a region". An advantage of this definition is that it seems to describe most circumstances and present a unified view of the traditional three levels at which biodiversity has been identified:

- genetic diversity - diversity of genes within a species. There is a genetic variability among the populations and the individuals of the same species. (See also population genetics.)
- species diversity - diversity among species in an ecosystem. "Biodiversity hotspots" are excellent examples of species diversity.
- ecosystem diversity - diversity at a higher level of organization, the ecosystem. To do with the variety of ecosystems on Earth.

This third definition, which conforms to the traditional five organization layers in biology, provides additional justification for multilevel approaches.

The 1992 United Nations Earth Summit in Rio de Janeiro defined "biodiversity" as "the variability among living organisms from all sources, including, 'inter alia', terrestrial, marine, and other aquatic ecosystems, and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems". This is, in fact, the closest thing to a single legally accepted definition of biodiversity, since it is the definition adopted by the United Nations Convention on Biological Diversity. The parties to this convention include all the countries on Earth, with the exception of Andorra, Brunei Darussalam, the Holy See, Iraq, Somalia, and the United States of America.

If the gene is the fundamental unit of natural selection, according to E. O. Wilson, the real biodiversity is the genetic diversity. For geneticists, *biodiversity* is the diversity of genes and organisms. They study processes such as mutations, gene exchanges, and genome dynamics that occur at the DNA level and generate evolution.

For biologists, biodiversity is the gamut of organisms and species and their interactions. Organisms appear and become extinct; sites are colonized and some species develop social organizations to improve their varied strategies of reproduction.

For ecologists, biodiversity is also the diversity of durable interactions among species. It not only applies to species, but also to their immediate environment (biotope) and their larger ecoregion. In each ecosystem, living organisms are part of a whole, interacting with not only other organisms, but also with the air, water, and soil that surround them.

Is it possible to define biodiversity?

To use biodiversity in science and management, we have to know what it is. Otherwise, it is not possible to say whether it disappears or is preserved. Here is the problem: despite many attempts, there is no satisfactory definition of biodiversity. We can easily understand why. Any definition pigeonholes and restricts the defined term. Biodiversity defies any restriction. It includes much more than number of species or even organisms. Just as the ecosystem is the unity of the living communities and the environment that supports them, biodiversity with all its biotic variation cannot be separated from the soil, air, and even extraterrestrial factors such as sunlight. After all, it is variation in the environment that engendered and feeds biotic diversity. In short, biodiversity embraces everything. Equating biodiversity with everything is not a polemic exaggeration. Wilson (1997, p. 1) himself acknowledged as much: "Biologists are inclined to agree that it [biodiversity] is, in one sense, everything" (this "one sense" is the only one Wilson discusses). Two conclusions can be drawn from this analysis. First, we should not worry about biodiversity because, being everything, it cannot be lost. It could only change form. When one species disappears, others thrive. Second, biodiversity cannot be defined in principle.

Assessing species diversity

If we are able to discuss biodiversity at all, it is only because usually we mean a more tangible species and individual diversity. Even so, there is no way to decide whether an ecosystem with a hundred species of the same genus is more diverse than that with a smaller number of species belonging to different genera or families. Will species diversity increase if we trade fifty out of the hundred species for ten of another order? If not, what about ten species of different phylum or class? Is it legitimate to prefer ten mammal species for a thousand of insect species? Will biodiversity suffer if we sacrifice 730 ticks to save one fawn they feed on? Are rare species less important than gregarious ones? Will the answer change if the species differ in size (ten billion of bacteria versus six large oaks), or complexity (primates versus nematodes)? Do introduced species add to biodiversity or pollute the integrity of regional floras and faunas? Are we, humans, a native or an introduced species in all places other than the African savannas? How much time does it take for an introduced species to become a native species? Depending on the answer, each species could be viewed as introduced or native. Dealing with plain number of species may also be a problem. Yet, without numbers it is difficult to document that we are indeed in the midst of "the sixth great extinction spasm of geological time" Wilson (1992, p.343). The evidence for this great extinction is mostly indirect; it follows from the rule he discovered: a 90% reduction in the area available to organisms results in a long term decrease of about 50% in the number of species. Direct evidence shows something different. In the 1800s the area the Brazilian Atlantic rainforest was reduced exactly by that amount (90%). However, when the Brazilian Society of Zoology analyzed a group of almost 300 animals, they did not find a single species which had died out. Nor any plant species disappeared (Lomborg 2001). In Puerto Rico seven out of 60 species of birds had become extinct when the area of rainforest had been reduced by 99 percent over a period of 400 years. At the same time many more species colonized the island and today it has 97 species of birds (Lomborg 2001). Another piece of encouraging news is provided by Wilson himself. With all biodiversity destruction in the current sixth great extinction, "more [species] are alive today than at any time in the past" (Wilson 1992, p.216). Life is more tenacious predicted by the 90 -50% theory. Despite all our efforts and the miracles of chemistry, genetics, and other sciences, we have failed to deliberately eliminate a single harmful species (expect, perhaps, smallpox, presently confined in test tubes somewhere). Nor have we produced any useful species.

Lomborg, B. 2001. The skeptical environmentalist: measuring the real state of the world. Cambridge University Press. 540 p. Wilson, E.O. 1992. The diversity of life. Harvard University Press, Cambridge, Massachusetts. 424 p. Wilson, E.O. 1997. Introduction. In Biodiversity II, pages 1-3. Edited by M. L. Reaka-Kudla, D.E. Wilson, and E.O. Wilson. Joseph Henry Press, Washington, D.C. 551 p.

Measurement of biodiversity

Biodiversity is a broad concept, so a variety of objective measures have been created in order to empirically measure biodiversity. Each measure of biodiversity relates to a particular use of the data.

For practical conservationists, this measure should quantify a value that is broadly shared among locally affected people. For others, a more economically defensible definition should allow the ensuring of continued possibilities for both adaptation and future use by people, assuring environmental sustainability.

As a consequence, biologists argue that this measure is likely to be associated with the variety of genes. Since it cannot always be said which genes are more likely to prove beneficial, the best choice for conservation is to assure the persistence of as many genes as possible. For ecologists, this latter approach is sometimes considered too restrictive, as it prohibits ecological succession.

Biodiversity is usually plotted as taxonomic richness of a geographic area, with some reference to a temporal scale. Whittaker[4] described three common metrics used to measure species-level biodiversity, encompassing attention to species richness or species evenness:

- Species richness - the most primitive of the indices available.
- Simpson index

- Shannon index

There are three other indices which are used by ecologists:

- Alpha diversity refers to diversity within a particular area, community or ecosystem, and is measured by counting the number of taxa within the ecosystem (usually species)
- Beta diversity is species diversity between ecosystems; this involves comparing the number of taxa that are unique to each of the ecosystems.
- Gamma diversity is a measure of the overall diversity for different ecosystems within a region.

Distribution of biodiversity

Biodiversity is not distributed evenly on Earth. It is consistently richer in the tropics. As one approaches polar regions one finds fewer species. Flora and fauna vary depending on climate, altitude, soils and the presence of other species. For a listing of distinct ecoregions. In the year 2006 large numbers of the Earth's species are formally classified as rare or endangered or threatened species; moreover, most scientists estimate that there are millions more species actually endangered which simply have not been formally recognized.

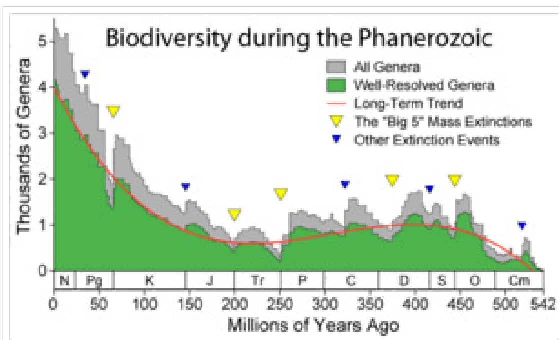
A biodiversity hotspot is a region with a high level of endemic species. These biodiversity hotspots were first identified by Dr. Norman Myers in two articles in the scientific journal *The Environmentalist* (1988 and 1990). Hotspots unfortunately tend to occur near areas of dense human habitation, leading to threats to their many endemic species. As a result of the pressures of the rapidly growing human population, human activity in many of these areas is increasing dramatically. Most of these hotspots are located in the tropics and most of them are forests.

For example, Brazil's Atlantic Forest contains roughly 20,000 plant species, 1350 vertebrates, and millions of insects, about half of which occur nowhere else in the world. The Madagascar dry deciduous forests and lowland rainforests possess a very high ratio of species endemism and biodiversity, arising from the fact that this island separated from mainland Africa 65 million years ago.

Many regions of high biodiversity (as well as high endemism) arise from very specialized habitats which require unusual adaptation mechanisms. For example the peat bogs of Northern Europe and the alvar regions such as the Stora Alvaret on Oland, Sweden host a large diversity of plants and animals, many of whom are not found elsewhere.

Biodiversity and evolution

Biodiversity found on Earth today is the result of 4 billion years of evolution. The origin of life is not well known to science, though limited evidence suggests that life may already have been well-established only a few 100 million years after the formation of the Earth. Until approximately 600 million years ago, all life consisted of bacteria and similar single-celled organisms.



Apparent marine fossil diversity during the Phanerozoic

The history of biodiversity during the Phanerozoic (the last 540 million years), starts with rapid growth during the Cambrian explosion—a period during which nearly every phylum of multicellular organisms first appeared. Over the next 400 million years or so, global diversity showed little overall trend, but was marked by periodic, massive losses of diversity classified as mass extinction events.

The apparent biodiversity shown in the fossil record suggests that the last few million years include the period of greatest biodiversity in the Earth's history. However, not all scientists support this view, since there is considerable uncertainty as to how strongly the fossil record is biased by the greater availability and preservation of recent geologic sections. Some (e.g. Alroy et al. 2001) argue that corrected for sampling artifacts, modern biodiversity is not much different from biodiversity 300 million years ago. [5] Estimates of the present global macroscopic species diversity vary from 2 million to 100 million species, with a best estimate of somewhere near 10 million.

Most biologists agree however that the period since the emergence of humans is part of a new mass extinction, the Holocene extinction event, caused primarily by the impact humans are having on the environment. At present, the number of species estimated to have gone extinct as a result of human action is still far smaller than are observed during the major mass extinctions of the geological past. However, it has been argued that the present rate of extinction is sufficient to create a major mass extinction in less than 100 years. Others dispute this and suggest that the present rate of extinctions could be sustained for many thousands of years before the loss of biodiversity matches the more than 20% losses seen in past global extinction events.

New species are regularly discovered (on average about three new species of birds each year) and many, though discovered, are not yet classified (an estimate states that about 40% of freshwater fish from South America are not yet classified). Most of the terrestrial diversity is found in tropical forests.

Benefits of biodiversity

Biodiversity has contributed in many ways to the development of human culture, and, in turn, human communities have played a major role in shaping the diversity of nature at the genetic, species, and ecological levels.

Biodiversity is what underlies many important ecological goods and services that provide benefits to humans.

There are three main reasons commonly cited in the literature for the benefits of biodiversity.

Ecological role of biodiversity

All species provide at least one function in an ecosystem. Each function is an integral part of regulating the species balance, species diversity and species health: all aspects which are intrinsic for the ecosystem as a whole to survive and prosper.

Ecosystems also provide various *infrastructure of production* (soil fertility, pollinators of plants, predators, decomposition of wastes...) *and services* such as purification of the air and water, stabilisation and moderation of the climate, decrease of flooding, drought, and other environmental disasters.

Research suggests that a more diverse ecosystem is better able to withstand environmental stress and consequently is more productive. The loss of a species is thus likely to decrease the ability of the system to maintain itself or to recover from damage or disturbance. Just like a species with high genetic diversity, an ecosystem with high biodiversity may have a greater chance of adapting to environmental change. In other words, the more species comprising an ecosystem, the more resilient and stable the ecosystem is likely to be. The mechanisms underlying these effects are complex and hotly contested. In recent years, however, it has become clear that there are real ecological effects of biodiversity.

Economic role of biodiversity

Unusual and wild strains of maize are collected to increase the crop diversity when selectively breeding domestic corn.

For all humans, biodiversity is a *resource* for daily life. One element of biodiversity is crop diversity. Many see biodiversity as a reservoir of resources to be drawn upon for the manufacture of food, pharmaceutical, and cosmetic products. This concept of biological resources management probably explains most fears of resource disappearance related to erosion of biodiversity. However, it is also the origin of new conflicts dealing with rules of division and appropriation of natural resources.

Ecologists and environmentalists were the first to insist on the economic aspect of biological diversity protection. Thus, E. O. Wilson wrote in 1992 that: *biodiversity is the one of the greater wealths of the planet, and nevertheless less recognized as such.* Estimation of the value of biodiversity is a necessary precondition to any discussion on the distribution of biodiversity richness. This value can be divided into use value (direct such as tourism or indirect such as pollination) and non-use or intrinsic value. The concept of ecosystem services attempts to quantify the economic value to mankind of all the functions the natural environment performs.

Since biological resources represent an ecological interest for the community, their economic value is also increasing. New products are developed because of biotechnologies, and new markets created. For society, biodiversity also is a field of activity and profit. It requires a proper management setup to determine how these resources are to be used. Some of the important economic commodities that biodiversity supplies to humankind are: unique scientific research tools, food, medicine, industry, recreation and Ecotourism.

Scientific role of biodiversity

Finally, biodiversity is important because each species can give scientists some clue as to how life evolved and will continue to evolve on Earth. In addition, biodiversity helps scientists understand how life functions and the role of each species in sustaining ecosystems. The availability of unique genetic material for each living species may have incalculable value as evidenced by medical and genetic research that can lead to discoveries that may reduce mortality.

As of 2005 there have been numerous cases where genetic material unique to a given species has been utilized in developing a disease cure or producing a biochemical that is instrumental in medical research beneficial to humans. If genetic materials are lost through the present Holocene extinction event numerous medical cures will be foreclosed and lost forever.

See also Environmental economics

Threats to biodiversity

During the last century, erosion of biodiversity has been increasingly observed. Some studies show that about one of eight known plant species is threatened with extinction. Some estimates put the loss at up to 140,000 species per year (based on Species-area theory) and subject to discussion[6]. This figure indicates unsustainable ecological practices, because only a small number of species come into being each year. Most of the species extinctions from 1000 AD to 2000 AD are due to human activities, in particular destruction of plant and animal habitats. Almost all scientists acknowledge that the rate of species loss is greater now than at any time in human history, with extinctions occurring at rates hundreds of times higher than background extinction rates.

Elevated rates of extinction are being driven by human consumption of organic resources, especially related to tropical forest destruction[7]. While most of the species that are becoming extinct are not food species, their biomass is converted into human food when their habitat is transformed into pasture, cropland, and orchards. It is estimated that more than 40% of the Earth's biomass is tied up in only the few species that represent humans, our livestock and crops. Because an ecosystem decreases in stability as its species are made extinct, these studies warn that the global ecosystem is destined for collapse if it is further reduced in complexity. Factors contributing to loss of biodiversity are: overpopulation, deforestation, pollution (air pollution, water pollution, soil contamination) and global warming or climate change, driven by human activity. These factors, while all stemming from overpopulation, produce a cumulative impact upon biodiversity.

Some characterize loss of biodiversity not as ecosystem degradation but by conversion to trivial standardized ecosystems (e.g., monoculture following deforestation). In some countries lack of property rights or access regulation to biotic resources necessarily leads to biodiversity loss (degradation costs having to be supported by the community).

The widespread introduction of exotic species by humans is a potent threat to biodiversity. When exotic species are introduced to ecosystems and establish self-sustaining populations, the endemic species in that ecosystem, that have not evolved to cope with the exotic species, may not survive. The exotic organisms may be either predators, parasites, or simply aggressive species that deprive indigenous species of nutrients, water and light. These exotic or invasive species often have features due to their evolutionary background and environment that makes them very competitive, and similarly makes endemic species very defenceless and/or uncompetitive against these exotic species.

The rich diversity of unique species across many parts of the world exist only because they are separated by barriers, particularly seas and oceans, from other species of other land masses, particularly the highly fecund, ultra-competitive, generalist "super-species". These are barriers that could never be crossed by natural processes, except for many millions of years in the future through continental drift. However humans have invented ships and aeroplanes, and now have the power to bring into contact species that never have met in their evolutionary history, and on a time scale of days, unlike the centuries that historically have accompanied major animal migrations. As a consequence of the above, if humans continue to combine species from different ecoregions, there is the potential that the world's ecosystems will end up dominated by a very few, aggressive, cosmopolitan "super-species".

Biodiversity management: conservation, preservation and protection

The conservation of biological diversity has become a global concern. Although not everybody agrees on extent and significance of current extinction, most consider biodiversity essential. There are basically two main types of conservation options, in-situ conservation and ex-situ conservation. In-situ is usually seen as the ideal conservation strategy. However, its implementation is sometimes unfeasible. For example, destruction of rare or endangered species' habitats sometimes requires ex-situ conservation efforts. Furthermore, ex-situ conservation can provide a backup solution to in-situ conservation projects. Some believe both types of conservation are required to ensure proper preservation. An example of an in-situ conservation effort is the setting-up of protection areas. Examples of ex-situ conservation efforts, by contrast, would be planting germplasts in seedbanks, or growing the Wollemi Pine in nurseries. Such efforts allow the preservation of large populations of plants with minimal genetic erosion.

At national levels a Biodiversity Action Plan is sometimes prepared to state the protocols necessary to protect an individual species. Usually this plan also details extant data on the species and its habitat. In the USA such a plan is called a Recovery Plan.

The threat to biological diversity was among the hot topics discussed at the UN World Summit for Sustainable Development, in hope of seeing the foundation of a Global Conservation Trust to help maintain plant collections.

Juridical status of biological diversity

Biodiversity must be evaluated and its evolution analysed (through observations, inventories, conservation...) then it must be taken into account in political decisions. It is beginning to receive a juridical setting.

- "Law and ecosystems" relationship is very ancient and has consequences for biodiversity. It is related to property rights, private and public. It can define protection for threatened ecosystems, but also some rights and duties (for example, fishing rights, hunting rights).
- "Laws and species" is a more recent issue. It defines species that must be protected because threatened by extinction. Some people question application of these laws. The U.S. Endangered Species Act is an example of an attempt to address the "law and species" issue.
- "Laws and genes" is only about a century old. While the genetic approach is not new (domestication, plant

traditional selection methods), progress made in the genetic field in the past 20 years lead to the obligation to tighten laws. With the new technologies of genetic and genetic engineering, people are going through gene patenting, processes patenting, and a totally new concept of genetic resource. A very hot debate today seeks to define whether the resource is the gene, the organism, the DNA or the processes.

The 1972 UNESCO convention established that biological resources, such as plants, were the **common heritage of mankind**. These rules probably inspired the creation of great public banks of genetic resources, located outside the source-countries.

New global agreements (e.g.Convention on Biological Diversity), now give **sovereign national rights over biological resources** (not property). The idea of static conservation of biodiversity is disappearing and being replaced by the idea of dynamic conservation, through the notion of resource and innovation.

The new agreements commit countries to **conserve biodiversity**, **develop resources for sustainability** and **share the benefits** resulting from their use. Under these new rules, it is expected that bioprospecting or collection of natural products has to be allowed by the biodiversity-rich country, in exchange for a share of the benefits.

Sovereignty principles can rely upon what is better known as Access and Benefit Sharing Agreements (ABAs). The Convention on Biodiversity spirit implies a prior informed consent between the source country and the collector, to establish which resource will be used and for what, and to settle on a fair agreement on benefit sharing. Bioprospecting can become a type of biopiracy when those principles are not respected.

Uniform approval for use of biodiversity as a legal standard has not been achieved, however. At least one legal commentator has argued that biodiversity should not be used as a legal standard, arguing that the multiple layers of scientific uncertainty inherent in the concept of biodiversity will cause administrative waste and increase litigation without promoting preservation goals. See Fred Bosselman, A Dozen Biodiversity Puzzles, 12 N.Y.U. Environmental Law Journal 364 (2004) (http://www.law.nyu.edu/journals/envtllaw/issues/vol12/bosselman-for%20web.pdf)

Criticisms of the biodiversity paradigm

The founder effect


Some of the biodiversity of a coral reef.

The field of biodiversity research has often been criticised for being overly defined by the personal interests of the founders (i.e. terrestrial mammals) giving a narrow focus, rather than extending to other areas where it could be useful. This is termed the *founder effect* by Norse and Irish, (1996)[8]. France and Rigg reviewed biodiversity research literature in 1998 and found that there was a significant lack of papers studying marine ecosystems[9], leading them to dub marine biodiversity research the *sleeping hydra*.

Size bias

Biodiversity researcher Sean Nee, writing in the 24 June 2004 edition of Nature, points out that the vast majority of Earth's biodiversity is microbial, and that contemporary biodiversity physics is "firmly fixated on the visible world" (Nee uses "visible" as a synonym for macroscopic). For example, microbial life is very much more metabolically and environmentally diverse than multicellular life (see extremophile). Nee has stated: "On the tree of life, based on analyses of small-subunit ribosomal RNA, visible life consists of barely noticeable twigs. This should not be surprising — invisible life had at least three billion years to diversify and explore evolutionary space before the 'visibles' arrived".

Notes

1. ^ Edward O.Wilson, editor, Frances M.Peter, associate editor, *Biodiversity*, National Academy Press, March 1988 ISBN 0-309037832 ; ISBN 0-309037395 (pbk.), online edition (http://darwin.nap.edu/books/0309037395/html/R2.html)
2. ^ Global Biodiversity Assessment. UNEP, 1995, Annex 6, Glossary. ISBN 0-521564816, used as source by "Biodiversity", Glossary of terms related to the CBD (http://bch-cbd.naturalsciences.be/belgium/glossary/glos_b.htm) , Belgian Clearing-House Mechanism, retrieved April 26, 2006.
3. ^ Kevin J. Gaston & John I. Spicer. 2004. "Biodiversity: an introduction", Blackwell Publishing. 2nd Ed., , ISBN 1-4051-1857-1(pbk.)
4. ^ hittaker, R.H., *Evolution and measurement of species diversity*, Taxon, 21, 213-251 (1972)
5. ^ J. Alroy, C.R. *et al.*2001. Effect of sampling stanardization on estimates of Phanerozonic marine diversification. Proceedings of the National Academy of Science, USA 98: 6261-6266
6. ^ S.L. Pimm, G.J. Russell, J.L. Gittleman and T.M. Brooks, *The Future of Biodiversity*, Science 269: 347-350 (1995)
7. ^ Paul Ehrlich and Anne Ehrlich, *Extinction*, Random House, New York (1981) ISBN 0-394-51312-6
8. ^ Irish, K.E. and Norse, E.A. (1996) Scant emphasis on marine biodiversity *Conserv. Biol.* **10** 680
9. ^ France, R., and Rigg, C. (1998) Examination of the 'founder effect' in biodiversity research: patterns and imbalances in the published literature *Diversity and Distributions* **4** 77-86

See also

- International Institute of Tropical Agriculture
- Ecological Economics
- biogeography
- Amazonian forest
- Extinction
- Unified neutral theory of biodiversity
- Adaptation
- Biocomplexity
- Bioinformatics
- Conservation ethic
- Convention on Biological Diversity
- Ecology
- Ewens sampling formula
- Global 200
- IUCN
- Intermediate Disturbance Hypothesis
- International Treaty on Plant Genetic Resources for Food and Agriculture
- Like-Minded Megadiverse Countries (LMMC), a group of 17 *megadiverse* countries, formed in February 2002
- **List of biodiversity topics**
- Megadiverse countries
- Millennium Ecosystem Assessment
- Monoculture
- Mutation
- Seed bank
- United States environmental law
- Wildlife preserve
- World Conservation Monitoring Centre

External links

- Encyclopedia of Earth: Biodiversity (http://www.eoearth.org/article/Biodiversity)
- Research on agro-biodiversity by the International Institute of Tropical Agriculture (IITA)

(http://www.iita.org/cms/details/agro_biodiversity_details.aspx?newsid=267&zoneid=65&activity=Agro-biodiversi

- :Cultural and Biological Diversity (http://ngoblog.org/News.html/) Science for Ecological Health and Livelihoods Network, SHALIN Suomi ry, Finland
- Sahyadri: Western Ghats Biodiversity Information System (http://wgbis.ces.iisc.ernet.in/biodiversity/) at Indian Institute of Science, India
- Sahyadri E-News (http://wgbis.ces.iisc.ernet.in/biodiversity/newsletter/index.htm) at Indian Institute of Science, India
- Biodiversity Synthesis Report (http://www.millenniumassessment.org/proxy/document.354.aspx) (PDF) by the Millennium Ecosystem Assessment (MA, 2005)
- A popularized version of the MA Biodiversity Synthesis Report (http://www.greenfacts.org/biodiversity/index.htm) by GreenFacts.
- ActionBioscience (http://www.actionbioscience.org/index.html) , a project of the American Institute of Biological Sciences that examines biodiversity, environment, genomics and other issues in bioscience.
- Convention on Biological Diversity - Convention Text (http://www.biodiv.org/convention/)
- Convention on Biological Diversity at Law-Ref.org (http://www.law-ref.org/CBD/index.html) - fully indexed and crosslinked with other documents
- Stanford Encyclopedia of Philosophy: Biodiversity (http://plato.stanford.edu/entries/biodiversity/)
- Biodiversity explorer (http://www.museums.org.za/bio/index.htm)
- Website about hotspots of biodiversity as defined by (http://biodiversityhotspots.org/) Conservation International
- Website about current rate of biodiversity loss and species extinction (http://www.well.com/user/davidu/extinction.html)
- Teaching about Biodiversity (http://www.ericdigests.org/2000-2/biodiversity.htm)
- GLOBIO (http://www.globio.info) , an ongoing programme to map the past, current and future impacts of human activities on biodiversity
- World Map of Biodiversity (http://stort.unep-wcmc.org/imaps/gb2002/book/viewer.htm) an interactive map from the United Nations Environment Programme World Conservation Monitoring Centre
- Biodiversity Facts and Figures (http://www.scidev.net/ms/biofacts/) - SciDev.Net
- Mapping Biodiversity in the Amazon Rainforest (http://www.amazonia.org)
- L.O.S.T. species project (http://www.lost-species.org/tracking/)
- The Nature Conservancy (http://www.nature.org) - A not-for-profit organization dedicated to preserving biodiversity
- The Conservation Commons (http://www.conservationcommons.org) - cooperative effort of organizations to connect people with the information they need
- The World Conservation Union (IUCN) (http://www.iucn.org)
- United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) (http://www.unep-wcmc.org)
- Biodiversity and Health (http://www.sci-tech.co.uk/biodev.php)

Policies

- Summary of EU action plan to halt biodiversity loss (http://www.euractiv.com/en/environment/halting-biodiversity-loss-2010-eu-action-plan/article-157424)

Directories

- LookSmart - Biodiversity (http://search.looksmart.com/p/browse/us1/us317914/us53774/us227678/)
- Open Directory Project - Biodiversity (http://dmoz.org/Science/Environment/Biodiversity/)
- Yahoo! - Biodiversity (http://dir.yahoo.com/Science/Biology/Biodiversity/)

Categories: Articles with unsourced statements | Biodiversity | Ecology | Environmental soil science | Conservation | Scientific portmanteaus

Source: University of Chicago
Date: October 6, 2006

Fossils Pinpoint Tropics As Earth's Most Fruitful Biodiversity Spawning Ground

A team of scientists has completed a study that explains why the tropics are so much richer in biodiversity than higher latitudes. And they say that their work highlights the importance of preserving those species against extinction.

Marine bivalves show a wide array of shapes and life habits and are an important component of marine biodiversity. (Photo credit: J. T. Smith, Scripps Institution of Oceanography)

"If you came from outer space and you started randomly observing life on Earth, at least before people were here, the first thing you'd see was this incredible profusion of life in the tropics," said the report's lead author, David Jablonski, the William Kenan Jr. Professor in Geophysical Sciences at the University of Chicago. "This is the single most dramatic biodiversity pattern on this planet."

Jablonski and his co-authors, Kaustuv Roy, of the University of California, San Diego, and James Valentine, of the University of California, Berkeley, present their new findings on the origins of this global diversity trend in the Oct. 6 issue of the journal Science.

Why the tropics are so much richer in species and evolutionary lineages than elsewhere on Earth has loomed as one of the largest questions facing biologists for more than a century. Biologists have proposed virtually every possible combination of origination, extinction and immigration to explain the pattern at one time or another. But for the past 30 years, they have tended to view the tropics either as a cradle of diversity, where new species originate, or as a museum of diversity, where old species persist. And no resolution has been in sight.

The fossil data of the past 11 million years has broken this logjam. It shows that it's not an either/or proposition. The new study is the first to amass enough data to dissect the roles of extinction, origination and immigration directly. "I think we've killed the idea that the tropics is either a cradle or a museum of biodiversity. It's both," said Valentine, professor emeritus of integrative biology at UC Berkeley.

As the engine of global biodiversity, the tropics are where new species evolve and persist while spreading to higher latitudes, said Roy, a UCSD biology professor. "The world is connected. It's a global village, even for organisms. Along the California coast here, most of the marine species belong to lineages that originated in the tropics."

The Science study underscores the need to avert a tropical diversity crises, its authors said.

"Human-caused extinctions in the tropics will eventually start to affect the biological diversity in the temperate and high latitudes," Roy said. "This is not going to be apparent in the next 50 years, but it will be a long-term consequence."

Noted Valentine: "We should preserve the tropics, because without them, we've lost a key source for diversity in higher latitudes."

The fossil record indicates that the tropics have enjoyed a richness of biodiversity spanning at least 250 million years. Jablonski compared the population of species on Earth to the population of a modern town. To understand how that population mix came about would entail an examination of birth records, cemetery records and immigration records.

The team acquired its data for the Science study by analyzing bivalves, a class of marine life that includes clams, scallops and oysters. "They live everywhere," Jablonski said. "They're found from the Arctic Ocean to the hottest part of the tropics, and they have left a great fossil record."

This record permitted the team to track more than 150 bivalve lineages back through time and answer a series of key questions: Where do they start? How long do they last? Where do they persist? And where do they spread?

As the paleontologists traced the lineages back into geologic time, they found a consistent pattern in each slice of time, regardless of the prevailing climatic conditions. Over the entire 11-million-year period, they found that more than twice as many bivalve lineages started in the tropics than at higher latitudes. Meanwhile, only 30 varieties of organisms that lived only in the tropics went extinct, compared to 107 that lived outside the tropics, or at all latitudes.

"It's a really striking, surprising pattern," Jablonski said. "And it appears that other animals and plants were playing the same game, even on land," now that previous studies are looked at with new eyes.

The three paleontologists began working on the problem more than a decade ago. The first step involved completing a massive standardization of all living and many fossil bivalve species to ensure their consistent and proper classification.

To accomplish the task, Jablonski churned through stacks of monographs, some dating back to the 19th century, and combed drawer after drawer of bivalve specimens in the Smithsonian Institution and other natural history museums in Chicago, London, Brussels, Belgium; and Leiden, the Netherlands.

The forces behind the flood of evolutionary activity that flows from the tropics remain a mystery. "But now that we have a handle on the dynamics that set up this spectacular planet-sized gradient, we can begin to get at the underlying processes in a whole new way," Jablonski said.

Jablonski, Roy and Valentine will attempt to address this and related questions as they push their analysis further back in time.

This work was supported by a grant from the National Aeronautics and Space Administration's Astrobiology Program.

Source: University of Florida
Date: May 31, 2006

More on: Evolution Research, Ecology, Evolution, Ecology, Biodiversity, Global Warming

Taking Evolution's Temperature: Researchers Pinpoint The Energy It Takes To Make A Species

Comfortable living is not why so many different life forms seem to converge at the warmer areas of the planet.

Writing this week in the Proceedings of the National Academy of Sciences, scientists say higher temperatures near the equator speed up the metabolisms of the inhabitants, fueling genetic changes that actually lead to the creation of new species.

The finding - by researchers from the University of Florida, the National Center for Ecological Analysis and Synthesis, Harvard University and the University of New Mexico at Albuquerque - helps explain why more living species seem to exist near the equator, a scientific observation made even before naturalist Charles Darwin set sail to South America on the H.M.S. Beagle nearly two centuries ago.

It may also have a bearing on concepts such as global warming and efforts to preserve diversity of life on Earth.

"We've shown that there is indeed a higher rate of evolutionary change in the form and structure of plankton in the tropics and that it increases exponentially because of temperature," said James Gillooly, Ph.D., an assistant professor of zoology with the UF Genetics Institute. "It tells us something about the fundamental mechanisms that shape biodiversity on the planet."

Speciation - when animals or plants actually evolve into a new species - occurs when life forms with a common ancestor undergo substantial genetic change.

Using a mathematical model based on the body size and temperature-dependence of individual metabolism, the researchers made specific predictions on rates of speciation at the global scale. Then, using fossils and genetic data, they looked at rates of DNA evolution and speciation during a 30-million-year period in foraminifera plankton, a single-celled animal that floats in the ocean.

Researchers compared arrivals of new species of this type of plankton with differences in ocean temperatures at different latitudes ranging from the tropics to the arctic. The results agreed closely with predictions of their model.

"It takes more energy than all the fossil fuel people burn on the planet in a year to form one new species of plankton," said Andrew Allen, Ph.D., the study's lead researcher at the National Center for Ecological Analysis and Synthesis at the University of California, Santa Barbara. "In terms of conservation, this really highlights that biodiversity does have a price, and the price is very high."

To put a number on it, it takes about 10 to the 23rd power - that is a 1 followed by 23 zeros - of energy units called joules to generate a new species of foraminifera plankton.

"From a scientific perspective, we can now quantify biodiversity in terms of energy," Allen said. "This will help efforts to identify and model areas for protection and conservation."

By observing changes in a unicellular animal whose body temperature varies according to its surroundings, as opposed to a mammal, which regulates a constant body temperature, scientists could more precisely measure rates of speciation caused by the environment. In the end, it is individual metabolic rate - how fast an organism burns food relative to its body weight - that primarily determines evolutionary rate. And higher environmental temperatures help increase metabolism.

"Diversity is the hallmark of the living. Understanding the principles underlying the generation and maintenance of diversity will allow us to understand life, and also how to preserve it," said Pablo Marquet, Ph.D., an associate professor and member of the Center for Advanced Studies in Ecology and Biodiversity at the Pontifical Catholic University of Chile, who was not involved in the research. "Changes in our environment, such as global warming, will not only affect the way the ecosystem functions, but also how life will evolve and hence how diversity is distributed across the planet."

One of the novel insights in the paper is the finding that the energy required to produce a new species is a fixed quantity.

"These authors are changing evolutionary biology, ecology and biogeography, putting them into a firm and quantitative foundation based on the first principles underlying individual metabolism," Marquet said.

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More Species In The Tropics Because Species Have Been There Longer, Study Suggests

Why are there more species in the tropics than in the temperate regions of the globe? Many of the world's species live in the tropics (perhaps more than half), but the reason has been debated for more than 100 years.

Many researchers have hypothesized that climatic factors somehow cause species to originate more quickly in tropical regions. In a paper appearing in the November issue of The American Naturalist, John Wiens and a group of researchers from Stony Brook University have shown that, contrary to expectations, species seem to evolve at similar rates in tropical and temperate regions. What causes the difference in species numbers between tropical and temperate regions is not something special about the tropics that leads to more rapid speciation, but rather that the temperate areas were colonized more recently, leaving less time for species to originate and accumulate in these regions.

The researchers studied the causes of high tropical species richness in treefrogs in the Americas. Combining analyses of evolutionary trees based on DNA sequences with GIS-based methods for analyzing the effects of climate on species distributions, the researchers found no relationship between how quickly species originate within a group and whether that group is tropical or temperate.

However, they did find a strong relationship between when each region was colonized and the number of species there today. Thus, the high species richness of tropical regions seems to be explained by the ancient origin of many groups in the tropics, more recent colonization of temperate regions, and by the inability of most tropical species to tolerate the variable temperatures of temperate areas.

According to John Wiens, the study has important conservation implications: "If the pattern we see in treefrogs holds true for most other groups, then the tropics may have more ancient lineages and more genetic diversity per species than temperate regions. So there may be far more loss of diversity going on as we lose tropical rainforests than would be suggested by the number of species alone."

Founded in 1867, The American Naturalist is one of the world's most renowned, peer-reviewed publications in ecology, evolution, and population and integrative biology research. AN emphasizes sophisticated methodologies and innovative theoretical syntheses all in an effort to advance the knowledge of organic evolution and other broad biological principles.

John J. Wiens, Catherine H. Graham, Daniel S. Moen, Sarah A. Smith, and Tod W. Reeder, "Evolutionary and ecological causes of the latitudinal diversity gradient in hylid frogs: treefrog trees unearth the roots of high tropical diversity." The American Naturalist: November 2006.

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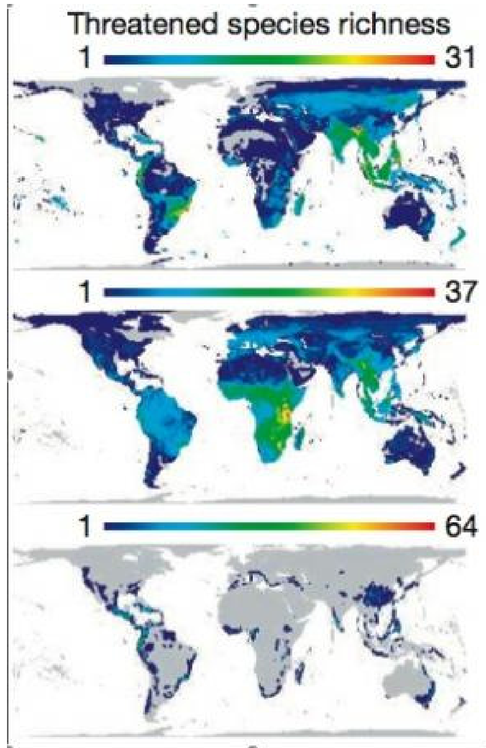
Global Map Shows New Patterns Of Extinction Risk

The most detailed world map of mammals, birds and amphibians ever produced shows that endangered species from these groups do not inhabit the same geographical areas, says new research published today.

Contrary to conservationists' previous assumptions, the map shows conclusively that geographical areas with a high concentration of endangered species from one group, do not necessarily have high numbers from the others. This new finding has far-reaching implications for conservation planning by governments and NGOs, and their decisions about where to focus conservation spending. These decisions have typically been based on the assumption that investing in an area known to have a high concentration of endangered birds, for example, will mean that large numbers of endangered mammal and amphibian species will also be protected. The new study shows that basing conservation decisions on just one type of animal can be very misleading.



Global richness maps for threatened species of birds, mammals and amphibians. Colour gradients are linear with respect to species number. (Image courtesy of Imperial College London)

The study, out in today's issue of Nature, is the culmination of many decades of work by field biologists and analysts, during which the planet was divided up into 100km x 100km grids, and all mammal, bird and amphibian species within each grid square were counted, using a variety of pre-existing, but never-before combined, records. The result is a comprehensive worldwide map of all species in these groups, on a finer scale than ever before.

Professor Ian Owens, one of the paper's authors from Imperial College London's Division of Biology, and the Natural Environment Research Council's Centre for Population Biology, said: "For the first time ever this global mapping has divided the planet up into small grid squares to obtain a really detailed picture of biodiversity. By looking at the numbers of endangered mammals, birds and amphibians in these squares, we have been able to see how this real picture varies from assumptions that have previously been made about global biodiversity of endangered species."

Professor Owens adds that this geographical discrepancy in hotspots of endangered species from different groups can be explained by the different factors that threaten mammals, birds and amphibians: "Endangered bird species are often at risk because their habitats are being destroyed. However, different factors entirely may affect mammals such as tigers which are under threat from poachers, and amphibians which are being diminished by diseases brought into their habitat by non-native fish.

"This means that even if a mountainous area has a real problem with endangered amphibians in its creeks and rivers, mammal and bird species in the same area might be flourishing. It's really important not to assume that there are simply a number of hotspots across the globe where everything living there is endangered -- the picture is far more complicated, with mammal, bird and amphibian numbers being threatened by different things, in different locations."

Examples of geographical locations in which the distribution of endangered species is different include:

- New Zealand is a hot spot for threatened birds because of the danger posed by introduced rats and cats.
- Mammals are highly threatened across eastern Africa due to hunting and the bush meat trade
- The tropical, rainforest-clad mountains of northern Australia are home to many declining frog species, although the precise causes of these declines often remain enigmatic.

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