Biological diversity in a changing world

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Biodiversity is so complex and difficult to measure that estimates for life on Earth range from

3 to 100 million species

Today, despite the great efforts of scientists of the preceding centuries, we still have an incomplete record of biological diversity. Mammals and birds are reasonably well documented, and plants, amphibians, reptiles and fish are to a lesser extent. However, many invertebrate species remain to be described, while microbes are a largely unexplored frontier. The number of species thought to exist today is somewhere between 5 and 10 million, but could be as few as 3 million, or as many as 100 million.

Species counts are only one way of recording biodiversity. In recent years advances in molecular methods mean researchers can now examine DNA and RNA directly and use it to deduce the evolutionary relationships of organisms and the functions they perform. While microbial biodiversity remains incompletely described, the rapid development of molecular techniques is allowing researchers to develop a picture of this 'hidden biosphere'. We now know that microbes represent a large proportion of the biological diversity present on Earth: they underpin biogeochemical cycles, regulate nutrient cycling and probably offer our best insights into life in other solar systems.

Although patterns of biological diversity, and the observation that there are more rare species than common ones, were evident to the explorers who first began to document the natural world, ecologists have been searching for explanations for these relationships. Field studies and new mathematical models are allowing researchers to establish the influences of biological interactions, evolutionary history and chance in determining the number and relative abundances of species in different habitats. A number of long-term studies have also helped quantify changes in biological diversity through time. These and other investigations reveal that environmental variability, combined with continuous colonisation and local extinction create natural change in ecological communities. Many people assume that conservation is rather like managing a collection of pictures in an art museum. However some change, including local species loss, is entirely natural and needs to be integrated into conservation management. As Darwin first recognised, biodiversity is not static: on a long timescale, new species are constantly arising and becoming extinct. On shorter term scales, species increase and decrease in abundance, colonise new areas, and become locally extinct in others. What is more difficult is separating the modification due to human activities from the ongoing natural changes. Research showcased this year has been examining how communities vary through time, the processes that are involved in this variability, and the implications of these changes.

It is clear that biological diversity is under threat as never before. In the 1700s the world's population was around 700 million. It was a period when technology had a modest impact on the environment. Explorers could still find regions and even continents that were essentially untouched. The contrast with today is marked and the footprint that humanity leaves on natural landscapes is now substantial. Over 75% of ice-free land has been modified by human activities, and the few remaining wild areas are already affected. The situation in the oceans is equally stark. Exploitation, including over-fishing, pollution, climate change and the associated rise in carbon dioxide are leading to irreversible transformations, and the impact of our species on the planet makes another mass extinction seem inevitable, unless we take urgent action to reverse current trends.

The loss of biological diversity is much more than an academic concern. We depend on biological diversity in many different ways. It plays a crucial role in

Main image - The North Atlantic euphausiid, Nyctiphanes couchii. Magnification x 150. © Richard Kirby.

Archive image - Simia Ursina from *Voyage de Humboldt et Bonpland; 2me partie: Observations de zoologie et d'anatomie comparée*, 1811, Volume 1, plate XXX. From the Royal Society archive.

providing ecosystem services such as natural harvests, carbon capture and storage, pollination and soil formation. We depend on the species that share our planet to recycle our waste, and provide clean air and essential nutrients. Environmental change has always been present, and has helped shape biodiversity patterns of today. However, never before has one species caused such profound changes to the habitats and climate of the planet.

A deeper understanding of natural changes in biological diversity and how ecological systems have responded in the past, for example at the time of the last ice-age, will help us develop practices and policies to secure a sustainable future. This challenge is perhaps the greatest that our species has ever confronted, but unless we individually and collectively face up to it, our world will lose much of the biological diversity on which we depend, before we have had the opportunity to fully appreciate what is being lost.

From the archive

How many living creatures are there exactly? In the 17th century, the father of modern taxonomy Carl Linnaeus FRS came up with a schema within which to classify all living things and managed to cram well over 7,000 of them into his encyclopaedic book *Species plantarum*[14]. But, as the title states, Linnaeus only recorded plants and even those were limited to specimens known to scientists of the period.

In the age of Linnaeus, European botanists were just beginning to discover some of the most biologically diverse regions on the planet. Expeditions to the tropics, notably that undertaken in Latin America by Alexander von Humboldt FRS in the years 1799-1804, discovered not just thousands of new plants and animals, but also a new outlook.

Darwin called von Humboldt "the greatest scientific traveller" because he considered not only biology, but looked at the natural world in the wider context of its geography, climate and geology. His object, he said, was to "observe the interactions of forces, the influence of the inanimate environment on plant and animal life. My eyes will constantly focus on this harmony." When Darwin read Humboldt, he claimed "my enthusiasm is so great that I cannot sit still on my chair".

Modern science recognises the huge impact humanity has on Earth's biodiversity, which has changed more rapidly over the past 50 years than at any time in human history. Georgina Mace FRS, one of the world's leading experts on conserving biodiversity who helped develop criteria and rules for the IUCN Red List of Threatened Species, said in 2009: "It is hard to imagine a more important priority than protecting the ecosystem services underpinned by biodiversity. Biodiversity is fundamental to humans having food, fuel, clean water and a habitable climate."