

NECTANDRA INSTITUTE

Jun 2012, Vol. 12 No. 2

BIODIVERSITY

Biodiversity is the single most important concept in conservation. In a single word, it defines both the scope and complexity of the task for conservationists. Currently, an enormous amount of effort and money is being spent to simultaneously catalogue, understand and save it. It is at the heart of our own work at Nectandra Institute. It is therefore important that we understand what is meant when we speak of biodiversity. Below is an abbreviated interview and article reprinted from BMC Biology 2010. Volume 8:145 by the cited author.
— The editor

Q&A: What is biodiversity?

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Biodiversity is simply the variety of life. This can mean anything from the microbes in a few grams of soil to all the organisms that inhabit the earth. In practice, to assess how much diversity we have and what it does, we need to be more specific about the aspect of biodiversity we are concerned with, and the area and time frame over which we want to measure it. For example, we might consider the types and relative abundances of species of trees in a forest, or the genetic diversity associated with the individuals of those species, or even how the number and composition of forests across a bio-geographic region have changed over the past century. This hierarchy of organizational levels is implicit in the definition developed by the UN in their Convention on Biological Diversity, which states that biological diversity is ‘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’.

You mentioned the spatial and temporal context of biodiversity. What do you mean by this?

How much biodiversity we see, such as the number of bird species recorded in a wetland, increases both as a larger area is surveyed, and as the same area is surveyed for a longer time. Thus, if we were to watch the same lake over several years, we would find that some new species would colonize, others would vanish from the area, and there would be occasional unexpected species appearing, perhaps diverted away from their normal migration route by unusual weather conditions. These species-area and species-time relationships are well-known ‘laws’ of ecology, yet are sometimes overlooked when investigators or conservationists are making comparisons between sites or deciding which places should be

designated as nature reserves.

Why should we care about biodiversity?

As Charles Elton explained in his book *The Ecology of Invasions by Animals and Plants*, over half a century ago now, there are three main arguments for conserving biodiversity. The first is that other species have the right to exist on the planet, and therefore it would be unethical to take actions that might cause their extinction. The second is the aesthetic value of biodiversity. Humans derive pleasure and a sense of wellbeing from wild nature. This quality of biodiversity, while implicitly recognized by most people, has been attributed by EO Wilson to a deep-seated evolutionary need to live in a favorable environment. The third reason proffered for biodiversity in conservation – and the one that receives most attention – is the utilitarian argument. The reasoning here is that biodiversity underpins many goods and services that we depend on. These include wild harvests (such as fish), pollination, carbon capture (for example, peat bogs and rain forests store carbon that would otherwise be released to the atmosphere), regulation of drainage patterns and climate, soil formation, flood defenses (including the mangrove swamps that help protect low lying areas against tsunamis) and the genetic resources used in agriculture and medicine.

How long have researchers been interested in biodiversity?

Biodiversity is something that has probably always been recognized and appreciated. Our ancestors, after all, will have been aware of those places where there was a rich abundance of food, and those that harbored dangerous predators. However, the scientific study of biodiversity really began when Carl Linnaeus put together the first systematic catalogue of life on earth. His book, *Species plantarum*, published in 1753, classified and described around 7,000 species and developed the system of taxonomy that we still use today. This was also the beginning of the great age of scientific exploration. Alexander von Humboldt traveled to South America between 1799 and 1804 and made many observations about biological diversity, most famously that there is a latitudinal gradient of richness, with tropical habitats having many more species than temperate habitats, which are, in turn, more diverse than boreal regions. Joseph Banks, another early explorer, commented on the differences in variety of species of flora at different localities. Charles Darwin’s voyage on *The Beagle* is well known for the role it played in shaping his thinking about evolution. Less well appreciated is that the *Origin of Species* contains many insightful reflections on patterns of biological diversity, and Darwin was one of the first researchers (along with Audubon) to comment on the fact that ecological communities are invariably composed of a few common and many rare species. Darwin’s contemporaries, including Wallace and Bates, also wrote extensively about patterns of biological diversity. Nonetheless, it was not until the 20th century that ecologists began to develop new statistical methods for quantifying biodiversity.

How is biodiversity measured?

Sir Ronald Fisher, the famous statistician, was one of the first researchers to recognize that the characteristic pattern of commonness and rarity of species could be described

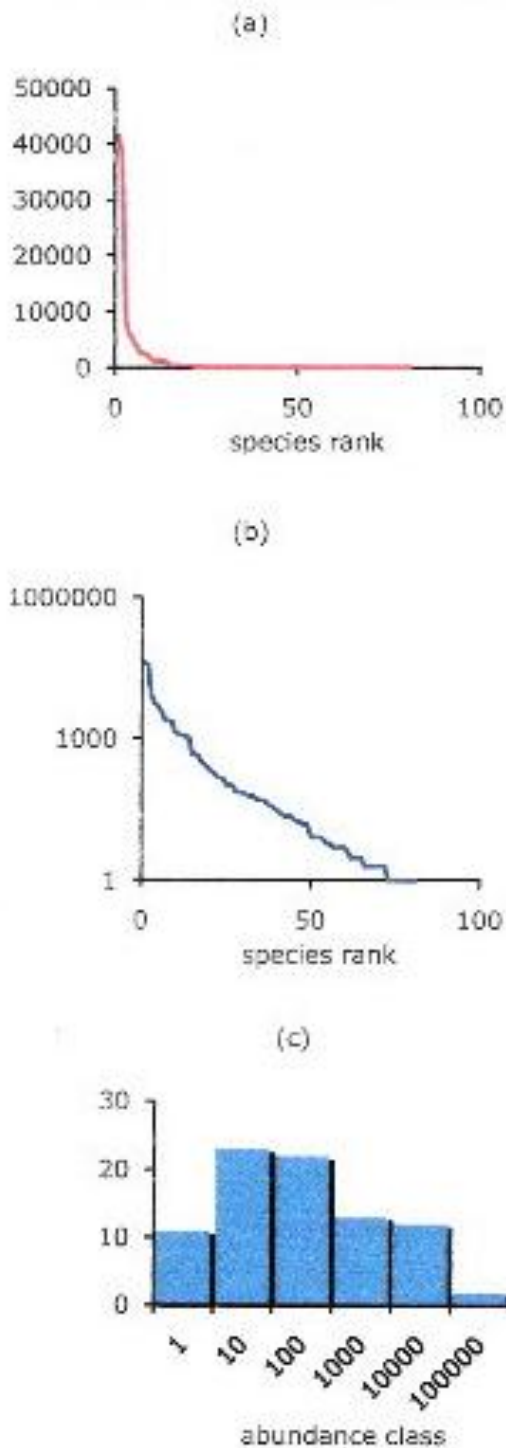


Figure 1. There are many more rare species than common ones in ecological assemblages. These data, representing the numbers of individuals in the 81 species making up a 25 year time series of estuarine fish in the UK's Bristol Channel, were collected by PA Henderson. (a) The data plotted on an arithmetic scale to emphasize the handful of exceptionally abundant species; (b) the same data, with the abundance now plotted on a logarithmic scale (this type of graph is usually called a rank abundance plot); and (c) a histogram showing the frequency of species in logarithmic abundance classes. The plot in (c), which was introduced by Frank Preston, illustrates the log normal pattern of diversity often seen in ecological assemblages. These different methods of plotting species abundance data highlight contrasting aspects of the assemblage, but they all underline the universal pattern of a few abundant and many rare species.

mathematically. The resulting species abundance distribution, 'log series model', is associated with an index of diversity known as Fisher's α . Other models and measures were soon developed, and two enduring approaches are Preston's log normal distribution of species abundances and the Shannon diversity index. There are now a great many competing methods of measuring biodiversity. In essence, the approaches either describe the entire distribution of species abundance (Figure 1), or provide some metric that quantifies the richness of the sample or assemblage (richness being the number of species present), or develop a statistic that takes account of the evenness of the species abundances. Although formulated in the context of species, these measures can also be adapted to measure diversity at other organizational levels, including genes and traits.

A complementary approach to biodiversity assessment is to ask how different two or more localities, or indeed time periods, are in terms of their species composition. Thus, Robert Whittaker distinguished between α diversity – that is, the biodiversity at a defined place and time (and he deliberately used the term α diversity to link with Fisher's concept of a diversity index) – and β diversity, which is a measure of how much variation there is in the number and identity of species across space and/or time. A landscape will be most diverse if it supports ecological communities with high diversity and also high β diversity.

How many species are there?

An obvious question, but one that is very difficult to answer! As Bob May has pointed out, only around 1.7 million species have so far been named. However, even this total is beset with difficulties: some of these will be duplications (known as synonymies) and there are also many gaps in the record. What we do know is that vertebrates (especially mammals and birds) are reasonably well documented, but invertebrates (including most insects) are not. JBS Haldane, when asked what creation revealed about the nature of the creator, gave the celebrated response 'an inordinate fondness for beetles'. It is no surprise, therefore, to learn that beetles remain a very poorly documented group. May estimates that there are probably between 5 and 10 million species, but also notes that the number could lie anywhere between 3 and 100 million. And that's before we start thinking about microbes.

How do we know that biodiversity is being lost, given the great uncertainty about species numbers?

Although it can be difficult to put precise numbers on how many, and which, species are being lost, there is no doubt that biodiversity is declining. This can be deduced in a number of ways. First, we know that habitat is being lost. Because of the well-known relationship between the area of a habitat and the number of species it supports, it is possible to work out how a reduction in area will translate into a reduction in biodiversity. Second, it is not just diversity that is being lost; diversity is also diminishing. It is because the same exotic species are being introduced into many different areas with the result that the ecological communities become more similar or 'homogenized'. Third, researchers have developed a series of indicators to track the decline in biodiversity. One example is the 'Living Planet

Index', which uses trends in vertebrate species diversity as an indicator of global diversity. Other approaches involve long-term monitoring and use data compiled for the International Union for Conservation of Nature's red list to track species status. Finally, meta-analyses can pull together data from a range of sources to produce an overview of change and biodiversity loss.

Why is biodiversity being lost?

Jared Diamond dubbed the reasons for biodiversity loss as the 'evil quartet' - habitat loss, over-exploitation of species, invasive species together with the exotic diseases they introduce, and the breakdown of ecological networks. Habitat degradation is perhaps the most obvious of these as the growing human population, and the growing demands for consumer products, place ever greater strains on the environment.

What are the 2010 and 2020 biodiversity targets?

The Convention for Biological Diversity (CBD) set itself the target of reducing the rate of biodiversity loss by 2010. It is now generally agreed that this target has not been met. Recently, the CBD convened at Nagoya in Japan and established a new set of targets for 2020. There are 20 of these and they address a range of biosecurity, conservation and long-term scientific and socioeconomic goals. Although the 2020 targets are more focused, and thus probably more achievable, than the 2010 target, not everyone is convinced that biodiversity is any better protected. George Monbiot is one environmental commentator who remains to be persuaded.

What can I do to help conserve biodiversity?

While dramatic events - including the threatened extinction of charismatic species such as the tiger or giant panda, or the loss of swathes of habitat, such as the felling of tropical forest in Southeast Asia to make way for palm oil plantations - make headline news, it is the accumulation of many small decisions that lead to the steady erosion of biodiversity. Roger Deakin, writing about the loss of a small spinney in his 2008 book *Notes from Walnut Tree Farm*, describes how the bulldozed mud 'smothered all the wild flowers, hibernating bumblebees etc., especially an extensive bed of violets that grew, with the assertive dog's mercury and lords and ladies, under the shade of the trees'. The choices we make about where we build our houses and golf courses, the food and consumer goods we buy in the shops, how many children we have, and the extent to which we hold our governments to account on their promises to develop environmentally friendly policies collectively determine the fate of biodiversity.

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Magurran *BMC Biology* 2010, **8**:145

<http://www.biomedcentral.com/1741-7007/8/145>

Greenhouse Project at the Garden

One of the most ironic pieces of luck with the original purchase of Nectandra garden was that the property (104 ha or 250 acres) was edge-to-edge forest. About ten hectares had been a coffee plantation, though abandoned for more than 30 years when we arrived. In our design, we carefully packed our buildings to minimize tree removal, and rearranged the native vegetation into a small, semiformal garden in the light gaps within the former coffee plantation. We even managed to squeeze in two free flowing ponds and three waterfalls in garden areas that had chronic flood and mud problems. After that, little bare soil was left for plant reproduction without cutting trees. A forest full of rare wild plants and no space to multiply them! What a fate for us eager gardeners. Relief came in the form of an 18 Ha adjacent ornamental (*Dracaena*) plantation for sale more than two years ago. Baptized *Persea* (cousin genus to *Nectandra*), the place is slowly being converted into a nursery to propagate rare cloud forest plants, for our garden and for dissemination.

Candidate plants to be reproduced will be the many species of tree ferns and other terrestrial ferns, begonias, bromeliads and small orchids. We will concentrate on the many that are not commonly available in the horticultural trades.



For example, the larger tropical orchids (> 10 cm), admired for their varied exotic form and spectacular colors, are outnumbered by miniatures (e.g., 1.5 cm or less) in the wild. The tiny rare plants are difficult to spot unless growing in an uncommon density and only in bloom, such as the hairy tree trunk shown on the left photo. Their microscopic flowers, as striking and exotic as their larger brethren when

viewed under a microscope, often escape notice by most people, except specialists.



Lepanthes sp.

Huntleya sp.

Elleanthus lentii

The tiny *Lepanthes* on the left of the panel are possibly the smallest at Nectandra, Note the flowers are about the diameter of the upper bore of the ballpoint pen tip. It belongs to a genus of more than a thousand species, all growing in cloud forests, and liliputian in size.

Our plan is to propagate them using embryo cell cultures from seeds. If successful, we may one day be able to distribute them to various botanical gardens for their living collections.

News & Activities, January - June 2012

Jan Teens from the community of Tapezco participated in a workshop, given by Nectandra Institute [on the field usage of GPS](#), to establish the location of landmarks on the ground in relation to map coordinates and/or aerial photographs. This geo-referencing work will be used to map different land uses and potential sources of contamination along the Saíno Creek, a small tributary of the [Balsa River](#). The collected information will be integrated in a set of maps of the creek to raise local awareness for protection of freshwater ecosystems.

Members of the Tapezco Youth Water Board interviewed Gerardo “Chon” Villalobos, the first plumber for the community’s water system. Chon recounted the water system’s history and the importance of protecting local sources of water. In involving the youths in watershed protection work, Nectandra Institute’s hopes to build their leadership skills and their interest in community service. The [interview can be viewed](#) on Nectandra Institute’s YouTube channel.

Feb Leaders from La Palmita organized [a fieldtrip for over 130 local residents to explore the upper watershed property](#) the town purchased in 2008 with eco-loan financing. These educational activities and restoration work are part of the “eco-interest” paid on loans received from Nectandra Institute.

VIDA club, youth water board members and other residents, from several of our partner communities began planning for their participation in this year’s Clean Communities and Adopt-a-River competitions—contests for beautifying public spaces and cleaning up a local creek or river. The [winners are announced](#) during the New Culture of Water Month celebration hosted by a different watershed community each September.

Mar Tapezco’s [water management association](#) continued an effective tradition of engaging community members in conservation and forest restoration. For four years now, a mass is held at one of the two restoration properties owned by the water management association (acquired with help from Nectandra Institute’s eco-loan). This annual tradition gives residents an opportunity to understand and appreciate the work being done to protect the watershed and local sources of drinking water.

Since 2009, LightHawk has contributed valuable flight time to Nectandra Institute to photograph the Balsa River Watershed. The [aerial photos and video](#) from these flyovers has been instrumental in helping us cultivate a watershed view of the world within and beyond our partner communities. LightHawk is a non-profit organization that aims to “champion environmental protection through the unique perspective of flight.”

Apr Zarcero, a municipality making up most of the upper Balsa River watershed’s geographic area, approved official guidelines on land-use and watershed protection. The guidelines, developed in collaboration with Nectandra Institute staff, include local forest protection as related to clean water supply, sound and sustainable use of water resources, reduction of anthropogenic sources of contamination, and strategies for public education to improve the health of local watersheds.

Women from La Brisa, La Legua, San Luis, San Antonio, Palmira, Pueblo Nuevo and Tapezco, dedicated about 240 volunteer hours [installing, retrieving and analyzing “leaf packs”](#) at several different points along local creeks and rivers as part of a 5-year water quality monitoring project that began in 2009. The leaf packs were placed and left in the water about one week. After retrieval, they were analyzed for the differential presence of various specific aquatic insects as indicators of water quality.

May AFAMAAR organized a group of 40 local residents plus Nectandra staff for a visit to its 100-hectare restoration property that was 60% forested in 2009 when purchased with our [eco-loan](#). Participants measured the flow of the Catarata River, which crosses the entire property, and also collected wild seeds for reproduction of native trees for restoration projects on this and other protected properties. The flow and volume of water in the Catarata River will be measured twice each year to monitor the long-term effects of reforestation.

Jun Nectandra Institute and University of Costa Rica’s geography students teamed up to create a land-use map of the upper Tapezco River. The map used high resolution, 2005 aerial photos by Costa Rica’s cadastre or land registry, together with those from our annual LightHawk survey flights, as well as land-use data collected in the field. The results were presented this month to representatives from involved communities. [The map](#) is a tool to analyze land-use change since 2005 as well as the area’s current and potential biological connectivity.

The 10th episode in our series of short, educational videos, **Nectandra presents...**, aired on local cable TV channel 2. The air time is donated by CoopeAlfaroRuiz (CAR), a local co-op that provides electricity, cable and internet service within Nectandra Institute’s primary service area. Through this arrangement with CAR, our message of watershed protection and forest conservation is now reaching a wider audience. All **Nectandra presents...** videos are also available on [our YouTube channel](#) with English subtitles.

*** News reported by Luis Villa ***

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