Biodiversity

An index of intactness

Georgina M. Mace

The global community is committed to reducing the rate of loss of biodiversity, but how can progress be measured? A novel system to tackle the problem may also identify key factors behind the changes.

Setting targets has become an increasingly common part of working life, and one that sometimes seems an unnecessary extra burden. But setting the target is just the beginning: gauging progress can be a major undertaking, and all this work will be in vain if the means to achieve the targets are not in place. In the case of biodiversity, measuring the ways in which different ecosystems are changing has proved a challenge[1], but on page 45 of this issue, Scholes and Biggs[2] unveil an innovative and practical approach that may also turn out to promote good management.

In 2002, the 188 countries that are signatories to the Convention on Biological Diversity committed themselves to “achieve by 2010 a significant reduction of the current rate of biodiversity loss at the global, regional and national level”[3]. Unfortunately, this laudable target is very vague as regards practicalities. It presents both a challenge and an opportunity for biodiversity scientists[4]: a challenge because biodiversity is not a simple concept, and coming up with measures that encompass all its aspects will be difficult; an opportunity because when such measures are in place, it will be possible to guide and manage biodiversity better, and so make progress towards a more sustainable world.

Scientists use the term ‘biodiversity’ to reflect almost every aspect of the living world, applying it across a range of spatial and temporal scales to encompass variability within and between genes, genomes, individuals, communities, traits and ecosystems, and including all organisms. Most policymakers, in contrast, are used to seeing it represented simply as the changing number of species on a species list.

Evaluations of which aspects of biodiversity contribute to the health of an ecosystem clearly indicate that considering variability alone is not enough[5–7]. Biodiversity assessments need to move away from a reliance on species lists and species extinction rates, because often the existence and proximity of local populations matters more.

Variability — the number or diversity of species in an area, say, or the number of genetic varieties of a crop strain in production — is necessary, but it is not sufficient to support the components of biodiversity that underlie key functions and benefits of an ecosystem. It is not hard to list circumstances where the quantity of a single component is crucial (for example, the biomass of forest for timber, or the area of mangrove offering coastal protection), or where a species’ distribution in space and time is critical (for instance, pollinators need to be near their host species, and plant cover must be on valley sides to prevent erosion) (Fig. 1).

A systematic assessment of the dimensions of biodiversity — the different types (the number of different species, say), quantities and distributions at various ecological levels — will give a set of measurements. But it soon becomes clear that they are not all equal. Depending on the context and perspective, some are more significant than others (Fig. 1), and any meaningful evaluation of biodiversity will have to take account of this.

The development of appropriate global indicators for the 2010 target is progressing on a number of fronts. Existing data sets have been exploited to provide measures of forest area, protected area coverage, and trends in the abundance of certain species[4,8,9]. Innovations and new data sets are revealing trends in the status of threatened species[10,11], and the geographical extent of additional ecosystems[12]. But data to assess the full range of measures (Fig. 1) are extremely sketchy and unrepresentative because of the large gaps in our knowledge and the fact that there is little systematic monitoring. Genetic measures across spatial scales are almost entirely missing. We have named and described fewer than 2 million of the 5 million to 30 million species expected to exist on Earth. Long-term monitoring covers only a tiny proportion of these, and is certainly unrepresentative. Even in relatively well-studied areas of the world, the number of biodiversity measures for which long-term trends can be assessed is remarkably limited. Clearly, new approaches are required if we are to make progress.

Scholes and Biggs’ biodiversity intactness index (BII)[2] makes a start in satisfying the many requirements, and provides a robust, sensitive but meaningful indicator. The index is built up from relative abundances of populations of species belonging to different taxonomic groups in different ecosystems, and facing different land-use management practices. It can be calculated for any political or geographical unit, and will give an indication of the overall condition of a region relative to a ‘pristine’ state. This state is defined by Scholes and Biggs as the unaltered, pre-industrial state, for which they use the current condition in protected areas as a surrogate measure.

Several features set their method apart from other available methods. The BII allows trends over time and space to be monitored readily. Also, and most usefully, because of the way it is constructed, the index can be separated out to provide comparative information across taxonomic groups, ecosystems or land-use management practices. Hence, unlike other methods that contribute to one measure of biodiversity (that is, one cell in Fig. 1), the BII can contribute to several at once. It can also assist in diagnosing the

Level	Importance of variability	Importance of quantity	Importance of distribution
Genes	Ultimate source of variability for evolution and adaptive change.	Influences evolution, affecting how new variants establish and spread through populations.	Different environments allow the evolution of local adaptation, resistance and resilience.
Species	Irreplaceable, unique units with combinations of traits from long and independent evolution. Intrinsic value.	Provisioning and regulating services may depend on quantity; e.g. food, fresh water. Long-term viability.	Local provisioning and regulating services; e.g. structural roles, pollinators. Community and ecosystem stability arises through the co-occurrence of species.
Populations	Local populations retain local adaptations.		
Ecosystems	Different ecosystems fulfil different roles.	Functions, products and services that depend on scale; e.g. protection from erosion, or volume of fresh water.	Functions, products and services that depend on location; e.g. fresh water near to communities that depend on it.

Figure 1 **Measures of biodiversity. Across a range of levels at which biodiversity can be assessed, variability is not sufficient to capture the essential features that underpin the functioning and benefits of an ecosystem. Measures of both quantity and distribution are important too. The biodiversity intactness index devised by Scholes and Biggs[2] attempts to take such measures into account.**

causes underlying an observed decline: changes can be traced back to reveal which taxonomic groups or ecosystems are losing populations of species the fastest, and whether the overall deterioration is due to many declining populations, a few localized extinctions, or a combination of the two.

The problem of data availability has been sidestepped rather than solved: Scholes and Biggs' calculation is based on expert opinion about how various species fare under different land use in each ecosystem. Clearly, real data would be preferable. But this method might also help to encourage the collection of data, because sampling systems established against this framework would be both achievable and useful, and might therefore be more likely to be implemented.

In addition, because land-use change is incorporated into the index, the results suggest where best to direct efforts to mitigate loss of biodiversity. For example, Scholes and Biggs' BIIs for different taxa (Fig. 1 on page 47) show the relative sensitivity of birds, mammals and amphibians to a change in land use from moderate to degraded — that is, use at a rate exceeding replenishment and causing widespread disturbance. Thus, this method has already moved beyond the stage of designing measures to suggesting actions to achieve the target. ■

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Sonoluminescence

Cavitation hots up

Detlef Lohse

Gas inside collapsing bubbles can become very hot and, as a result, emit light. It turns out that temperatures of more than 15,000 kelvin can be reached — as hot as the surface of a bright star.

In 1917, Britain's Royal Navy had problems with bubble cavitation. This is a process in which tiny bubbles grow in size and then collapse as a result of pressure variations in the turbulent water around ships' propellers. The process is so violent that it was causing considerable damage to the propellers[1], so the navy asked the renowned physicist Lord Rayleigh to analyse the problem[2]. His research led to what is now called the Rayleigh equation, which describes the dynamics of the collapsing bubble walls[1,2]. However, the solution to the equation produced a singularity. It implied that, during collapse, the gas inside the bubble is compressed so fast that it cannot equilibrate with the surrounding liquid, leading to energy focusing and an infinite temperature increase. In reality, of course, this cannot happen, so the question is: what limits the temperature increase, or, in other words, how hot does the bubble get? On page 52 of this issue[3], Flannigan and Suslick report a study of light emission from single bubbles during cavitation, and provide a direct answer to this question.

The temperature reached by the collapsing bubble depends on how much of the focused energy is lost by sound emission at the collapse and how much is consumed by internal processes such as vibrations, rotations, dissociation and eventually ionization. If there are many collapsing bubbles, they disturb each other, which leads to a less-spherical collapse and therefore less-efficient energy focusing. Nonetheless, temperatures can rise so high that the bubbles start to glow. This phenomenon has already been investigated intensively by using sound waves to drive bubble production in liquids and then detecting the light emitted; the sound waves cause a temporarily reduced pressure in the liquid, which makes the bubbles grow and eventually collapse again (Fig. 1, overleaf). So far, emission spectra with a detailed line structure have only been observed for many transient bubbles together (so-called multi-bubble sonoluminescence). Analysis of the emitted spectral lines[4] indicates that the temperature reached inside these bubbles is around 5,000 kelvin.

In single-bubble sonoluminescence[5,6], an isolated and stable bubble is studied; disturbances from other bubbles are absent. The light emission from such a bubble can be more than 10^7 photons per flash[7]. As the bubble is driven periodically with sound waves at frequencies of typically 20–40 kHz, the emitted light is visible to the naked eye.

100 YEARS AGO

"Charge carried by the α Rays from Radium." I have recently attacked this problem again, using the methods and apparatus previously described, but, in addition, employing a strong magnetic field to remove the slow-moving electrons present with the α particles. The apparatus was placed between the pole-pieces of an electromagnet, so that the field was parallel to the plane of the plates. In such a case, most of the escaping electrons describe curved paths and return to the plate from which they set out. On application of the magnetic field, a very striking alteration was observed in the magnitude of the current. The positive and negative currents for a given voltage were greatly reduced. The upper plate, into which the α particles were fired, rapidly gained a positive charge… I think these experiments undoubtedly show that the α particles do carry a positive charge, and that the previous failures to detect this charge were due to the masking action of the large number of slow-moving electrons emitted from the plates… Since the film of radium bromide is so thin that all the α particles escape from its surface, it is easy to deduce from the observed charge from a known weight of radium the total number of α particles expelled per second from one gram of radium bromide… a most important constant, for on it depends all calculations to determine the volume of the emanation, and of helium, the heat emission of radium, and also the probable life of radium and the other radio-elements. **E. Rutherford**

From *Nature* 2 March 1905.

50 YEARS AGO

While recognizing the greatness of its opportunities and responsibilities in Europe, the [British] Council remarks: "It would be an exaggeration but not an untruth to say that a much closer understanding of the Englishman and his ways exists at Karachi than at Lyons, partly because Englishmen are a more familiar sight in one city than in the other, and partly because an outward similarity of culture helps to mask a basic difference of mental approach."… The Council exists as a body which helps to interpret overseas the permanent features of the British way of national life and to make available to the rest of the world the British contribution to knowledge, welfare or enjoyment.

From *Nature* 5 March 1955.