Special Issue: Long-term ecological research

Environmental myopia: a diagnosis and a remedy

Jonathan Silvertown[1], Jerry Tallowin[2], Carly Stevens[1], Sally A. Power[3], Vicky Morgan[4], Bridget Emmett[5], Alison Hester[6], Philip J. Grime[7], Michael Morecroft[8], Robin Buxton[9], Paul Poulton[10], Richard Jinks[11] and Richard Bardgett[12]

[1] Department of Life Sciences, The Open University, Walton Hall, Milton Keynes, MK7 6AA, UK
[2] North Wyke Research, Okehampton, Devon EX20 2SB, UK
[3] Division of Biology, Imperial College London, Silwood Park, Ascot, Berkshire SL5 7PY UK
[4] Joint Nature Conservation Committee, Monkstone House, City Road, Peterborough, Cambridgeshire PE1 1JY, UK
[5] Centre for Ecology and Hydrology, Environment Centre Wales, Deiniol Rd, Bangor, Gwynedd LL57 2UW, UK
[6] Macaulay Land Use Research Institute, Macaulay Drive, Craigiebuckler, Aberdeen AB15 8QH, UK
[7] Unit of Comparative Plant Ecology, Department of Animal and Plant Sciences, University of Sheffield, Sheffield S10 2TN, UK
[8] Natural England, John Dower House, Crescent Place, Cheltenham GL50 3RA, UK
[9] Northmoor Trust, Little Wittenham, Oxfordshire OX14 4QZ, UK
[10] Rothamsted Research, Rothamsted, Harpenden, Hertfordshire AL5 2JQ, UK
[11] Forest Research, Centre for Forest Resources and Management, Alice Holt Lodge, Farnham, Surrey GU10 4LH, UK
[12] Soil and Ecosystem Ecology Laboratory, Lancaster Environment Centre, Lancaster University, Lancaster LA1 4YQ, UK

Long-term ecological observation affords a picture of the past that uniquely informs our understanding of present and future ecological communities and processes. Without a long-term perspective, our vision is prone to environmental myopia. Long-term experiments (LTEs) in particular can reveal the mechanisms that underlie change in communities and ecosystem functioning in a way that cannot be understood by long-term monitoring alone. Despite the urgent need to know more about how climate change will affect ecosystems and their functioning, the continued existence of LTEs is extremely precarious and we believe that dedicated funds are needed to support them. A new non-profit organization called the Ecological Continuity Trust seeks to provide a solution to this problem by establishing an endowment that will be specifically earmarked to sustain LTEs as a scientific tool for the benefit of future generations.

The problem

Ecological science must contend with history as well as mechanism. The state of every environment and the organisms in it are contingent upon previous conditions, often to an unknown degree. This is true at every temporal scale from decades to millennia, and it is becoming increasingly important that we understand environmental history as the human impact upon the planet grows. This is especially the case because there is an inherent tendency to erroneously regard the impoverished environments that are familiar to us now as 'natural' and 'normal'. Few, for example, look at any landscape in North America or Europe and puzzle to themselves: "Where is the megafauna?" Yet, before humans arrived there were giant ground sloths, giant beaver, camels and horses in North America and woolly mammoth, rhinos and giant deer in Eurasia [1]. The circumstantial evidence that the arrival of humans was, directly or indirectly, responsible for the disappearance of the megafauna on every continent outside Africa, whence we came, is increasingly difficult to ignore [2,3]. These events, of around 10–50 thousand years ago, were only the beginning, and in the last two centuries the marine megafauna have begun to face the same fate [4,5].

The fate of the terrestrial megafauna was sealed so long ago that it might be regarded as an episode of pre-history with little contemporary relevance, but the recent and ongoing collapse of marine fisheries offers at least two lessons about the need for long-term data that we should heed [6]. Lesson one is that there is a need for an accurate baseline; otherwise, the extent of human impact will probably be underestimated. The over-exploitation of marine species and habitats began before systematic scientific records were kept and as a result, each successive generation of fishers has only been able to judge any perceived decline against their own recent experience [7]. This is the problem of 'shifting baselines' [8] that still bedevils a proper assessment of the condition and normal functioning of coral reefs [9]. A terrestrial example of the same problem is furnished by The Park Grass Experiment, established in 1856, making it the oldest ecological experiment in the world. Plant species richness in the Park Grass meadow is influenced mainly by nutrients and soil pH, both of which vary among plots. However, using contemporary variation in species richness among plots to measure the effect of nutrients and pH in the Park Grass Experiment significantly underestimates the known losses of species caused by fertilization and acidification over the 150-year history

Corresponding author: Silvertown, J. (j.silvertown@open.ac.uk).

 0169-5347/$ – see front matter doi:10.1016/j.tree.2010.06.015 Trends in Ecology and Evolution 25 (2010) 556–561

of the experiment [10]. The reason for the underestimate is that even control plots have lost species over the last 150 years, and so using their modern species richness in any comparison today constitutes the use of a shifting baseline.

The second lesson, derived mainly from fisheries research, is that the longer a time-series of data has continued, the more valuable it becomes and the more reason there is to continue it even further. In 1988 a decision was taken by its then UK funding agency to cease the operation of the Continuous Plankton Recorder (CPR) that had been running since the 1930 s [11]. As luck would have it, this decision was made in the very year that a radical change in ocean ecosystems was taking place in the North Sea and the North Atlantic [12], although it was not until some years afterwards that this event was apparent from the long-term data. When monitoring of plankton using the CPR began, colder-water communities dominated the North Atlantic, but by the late 1980 s changes in ocean currents and temperature caused a regime shift to warmer-water communities that have persisted ever since [13]. A regime shift is an abrupt change in community composition that affects several trophic levels simultaneously and results in a switch between alternative stable states of an ecosystem [14]. It is now known that the regime shift that took place in the North Sea and the North Atlantic around 1988 was triggered when ocean temperatures crossed a critical thermal threshold of 9–10 °C [15].

A diagnosis

Sustaining ecological observations just because something like a regime shift might occur goes completely against conventional research funding requirements that favour novelty above continuity and demand specific and often short-term targets and milestones. The argument that a project should be extended merely because a lot of resources have already been invested into it is such an anathema that it can usually be dismissed by referring to it as an example of 'the Concorde fallacy' (after a notoriously expensive Anglo–French project to build the Concorde supersonic airliner in the 1960 s) [16]. To counter this argument, we propose a new term: 'environmental myopia'. Environmental myopia is the equivalent of a person with short-sight believing that nothing of interest or importance could possibly lie beyond the range of his or her own, limited vision. Environmental myopia is dangerous for the same reasons as its ocular namesake: the environment is neither featureless nor linear.

The concept of regime shift was first developed to describe abrupt changes seen in ocean and lake ecosystems, but many terrestrial examples are also known [17–19]. For example, in savannas a particular combination of fire, grazing and interspecific competition between trees and grasses can switch the ecosystem between alternate states that either have or do not have trees [20]. Also, in the Sahel region of Africa, overgrazing with its resultant soil erosion, compaction, reduced infiltration and increased water runoff, has been shown to trigger catastrophic shifts from a highly productive vegetated state to a severely degraded state [21,22]. In the Park Grass Experiment, there was a catastrophic loss of plant species in those plots where soil pH dropped below a value of 4.5 [23]. This threshold is determined by the solubility of Al^{3+} ions that come into solution at that pH and are toxic to many plants. Thresholds in environmental systems are usually much more difficult to predict than this, unless the dynamics are well understood and values of key parameters are known. Except in the case of epidemic diseases, where thresholds for spread can be calculated for well-characterized systems [24], phenomena like the regime shift in the North Atlantic are usually identified only after the event, using long-term monitoring data [25,26]. Not all evolutionary change is slow, but it too requires long-term observation and has been detected, for example, in the Park Grass Experiment [27].

It is likely that even when the dynamics of regime shifts are better understood, long-term data will still be essential for predicting when a particular system is approaching a threshold and could switch to an alternate state [28]. Long-term data are needed to tell us how resilient ecosystems are to change. The experiment at the Buxton Climate Change Impacts Laboratory (BCCIL) in northern England has been running for 17 years with winter warming, summer drought and additional summer rainfall treatments (Figure 1). It is now the second-longest-running climate change experiment on semi-natural vegetation in the world, although it was nearly a casualty of environmental myopia when its funding was cut only a few years after it was established. A sister experiment in the South of England was lost, but BCCIL was kept running for several years by the principal investigator at his own personal expense until alternative funding was found. Long-term experimentation at BCCIL has revealed the resistance of this plant community to climate change with initial changes remaining stable over 11 years [29]. Not only has this ecosystem remained surprisingly resistant to climate manipulation, but early shifts in the abundance of some species have subsequently become moderated.

TRENDS in Ecology & Evolution

Figure 1. The climate change experiment at Buxton Climate Change Impacts Laboratory situated in calcareous grassland in Derbyshire, UK, is in its 17th year of continuous climate manipulation, including simulated summer drought imposed with the automated rain shelters seen here. Photo by J. Fridley.