Why is long-term ecological research and monitoring so hard to do? (And what can be done about it)

David Lindenmayer

Fenner School of Environment and Society, The Australian National University

141 Linnaeus Way, Canberra, ACT 2601. Email: david.lindenmayer@anu.edu.au

ABSTRACT

Long-term ecological research and monitoring is a critical activity that has multiple important values for research, policy and management. Yet long-term studies are not particularly common. A range of factors contributes to this relative rarity and make it hard to establish (and then even harder to maintain) long-term ecological research and monitoring. These factors include: (1) a focus on novelty in science publication and awarding of grants that disadvantages long-term studies, (2) a paucity of long-term funding, (3) a bias against the publication of place-based research in favour of short-term "newsy" articles, global syntheses and meta-analyses, (4) a loss of people with natural history skills but a concurrent increase in modellers, (5) a trend away from evidence-based management acting as a disincentive to undertake long-term research, and (6) a focus on funding equipment rather than people (who are actually the critical "infrastructure" for maintaining on-the-ground research). Those with interests in maintaining long-term research must work hard to push back against these and other problems. In particular, it will be important to more clearly and forcefully demonstrate the many values of long-term research and monitoring by highlighting both its management-relevance and policy-relevance, and ensuring that long-term data are fundamental planks in initiatives like State of Environment reporting. More effort also will be needed to overturn some of the current flaws in science culture that hinder long-term ecological research and monitoring and, at the same time, develop and then strongly advocate for innovative funding models to ensure the maintenance of existing programs and the establishment of new long-term studies.

Key words: time series data, values of long-term data, science culture, loss of natural history skills

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Introduction

Long-term ecological research and monitoring is critical to tracking the status of environment, assessing the effectiveness of management interventions, and informing policy and practices (Likens 1989; Muller *et al.* 2011; Lindenmayer *et al.* 2012a). Despite the importance of long-term ecological research and monitoring, such studies are not particularly common, not only in Australia (see Youngentob *et al.* 2013) but also elsewhere around the world. This is most likely because it remains incredibly hard to maintain long-term studies. In this paper, I briefly summarize some of the key values of long-term ecological research and monitoring. I then discuss some of the many challenges in maintaining long-term ecological research and monitoring. I conclude this article with ways that some of these challenges may be met.

The key values of long-term ecological research and monitoring

Many studies and review articles have outlined the array of values of long-term ecological research and monitoring (Strayer *et al.* 1986; Likens 1989; Muller *et al.* 2011; Lindenmayer *et al.* 2012a; Lindenmayer *et al.* 2014). These values will not be revisited in detail here. However, six key values of long-term ecological studies are: **(1)** They are often the only way to appropriately quantify temporal changes in populations, environmental conditions or other ecological phenomena. **(2)** They can be crucial for better understanding complex ecological phenomena. **(3)** They provide the only real empirical tests of ecological theory. **(4)** They enable empirical assessment of the effectiveness of management interventions. **(5)** They provide critical data for informing management practices and policies. And, **(6)** The site/s which underpin long-term studies can be used for other co-located collaborative studies, thereby expanding the range of insights generated from a consolidated body of long-term work.

The challenges in maintaining long-term ecological research and monitoring

The importance of long-term ecological research and monitoring is underscored by the significant effect of time on many ecological patterns and processes. Yet long-term studies are very difficult to maintain, and indeed appear to be increasingly so. The remainder of this section explores some of the factors which conspire against conducting long-term research and monitoring.

Focus on so-called "novelty" in science

There is an increasing focus on new work and novelty in ecological and environmental sciences (Arnqvist 2013). As an example, the funding criterion for the Australian Research Council makes this abundantly clear as, in the author's experience, funding for projects associated with long-term monitoring and research is extremely rare. This creates a distinct bias against maintaining existing long-term studies. It is also a major disincentive for young scientists to take over pre-existing long-term projects.

A shift to short-term funding

Access to funding is an obvious factor influencing the success of long-term research and monitoring programs. Many aspects of funding are not well suited to the establishment and maintenance of long-term research and monitoring programs. Funding initiatives of one to three years are rarely congruent with the time frames appropriate for long-term studies. In addition, budget cycles emphasise short-term projects with rapid achievement of milestones. Thus, there is often a fundamental mismatch between long-term studies and associated environmental management aspirations and short-term financial realities.

Long-term studies are often seen as a luxury and not a core part of the remit of many resource management organisations. They are therefore usually the last initiatives to be funded (after other, higher priority ones have been supported) and the first ones to be cut during budget shortfalls.

Bias against place-based research

Long-term ecological research and monitoring is, by definition, focused on temporal changes in given entities at a particular location. Yet, in leading journals, there is a distinct trend away from place-based research in which many scientists regard as the summit in striving to publish their papers. Ecological papers in magazines like *Nature* and *Science* are almost invariably decorated with a global map of some pattern or other and/or accompanied by a meta-analysis of some trend that underpins the supposed earth-wide patterns. The results of place-based long-term ecological research only very rarely find a place among the highly summarized short articles in such "tabloid" magazines.

The rise of the modeller

Long-term ecological research and monitoring demands repeated field-based empirical measurements. These measurements can inherently be very time-consuming to gather which makes it difficult for researchers to compete with modellers whose work is comparatively cheap, can generate results quickly, and leads to numerous papers. However, there are significant costs associated with a narrow focus on modelling. These include a lack of data to parameterize models and to validate the predictions generated from modelling.

The demise of the naturalist

The passion, drive and ecological insights needed to maintain long-term ecological and research programs are often derived from spending time in the field. However, there has been a distinct move away from the development of people with field-based skills, including natural history. This is seen in western cultures *per se* and documented via problems such as so-called Nature Deficit Disorder which highlights a disconnect between people in modern society and their natural environment (Louv 2005; Pergams and Zaradic 2008). Many senior scientists do not spend time in the field to view first-hand and over time, the environmental changes that they are interested in and/or are working on. Similarly, many universities have moved away from field courses. They are expensive to run and can be hindered by occupational health and safety issues as well as liability risks. These changes contribute to a loss of natural history skills as well as natural history information (Noss 1996) and a lack of training in how to do the empirical component of long-term monitoring.

The rise of the science bureaucrat

Concurrent with a rise in the modeller and a decline in the naturalist, there has been a meteoric rise in the science bureaucrat; so much of modern science appears to be hamstrung by a mountain of administrative over-burden. Scientists have always been concerned about administration, but science is increasingly hard to do because of seemingly endless forms and associated checks and balances on every cent that is spent or justification of every minute of work time and allocation of that time to a particular grant. (It does seem that thinking is often not considered to be a valid use of time).

Preoccupation with fads and 'bits of kit'

Ecology has long been plagued by fads and ill-conceived or poorly defined concepts. This approach does not help promote a culture of careful question-setting or foster a psyche of making prolonged sets of repeated measurements. Moreover, a culture has developed in recent years to teach and research what is profitable, not necessarily what is important. One particular fad that can impair the maintenance of long-term research and monitoring is a pre-occupation with equipment at the expense of field staff. This is abundantly clear in the recent road map for the National Collaborative Research Infrastructure Scheme in Australia https://www.education.gov.au/2016-national-research-infrastructure-roadmap. Similarly, the National Earth Observation Network in the USA has $US469 m for establishing infrastructure to support research but no funding to support people to actually do the research. There is no doubt that equipment is important but high quality field staff are often **the** most important ingredient in the success of long-term studies. This is often forgotten in some funding programs where the misguided emphasis is on "infrastructure". Moreover, these funding schemes fail to acknowledge that a switch away from human-based measurements of an ecosystem or population

can breach the integrity of long-term datasets, thereby totally undermining their value. Finally, a focus on instrumentation may create a disincentive for people to go into the field and better understand how an ecosystem is functioning.

Rapid turnover of staff

The success of long-term ecological research and monitoring is almost always dependent on a small set of individuals or even a single person who champions a given project. They are usually well established in their job/s, enabling work at a given place to persist over a prolonged period. The ability to do this is undermined by frequent turnover of staff or their employment on a short-term basis. For example, academic staff are strongly encouraged to move institutions to gain promotion. Frequent shifts between institutions make it more difficult to maintain continuity at a given site/location over a prolonged period. The maintenance of long-term studies is not aided by the trend within many universities toward non-tenured academic staff, nor the prevalence of short-term contract staff or fully externally funded staff within organisations such as CSIRO or other government agencies. Indeed, the short-sighted sacking of many CSIRO staff working on climate change and biodiversity conservation projects must be considered as nothing short of disgraceful.

A flawed western culture

Many aspects of western culture can make it difficult to establish long-term ecological research. Skills required for successful long-term ecological research such as endurance, tenacity, persistence, thoroughness are perhaps not as highly valued as other attributes in western society. For example, modern western culture has an underlying emphasis on multi-tasking (Forgasz and Leder 2006) which can distract scientists from the careful attention needed to set good questions to underpin long-term work. It also can lead to them overlooking critical tasks such as fastidious data management and sample curation.

A trend away from evidence-based management and policy

Best practice management and policy should be based on the best available evidence (Sutherland *et al.* 2004). Long-term research and monitoring is crucial to generating the body of evidence needed to underpin evidence-based management and evidence-based policy (Lindenmayer *et al.* 2012a). Yet a number of recent policy decisions in the environment, both in Australia (Lindenmayer 2013; Russell-Smith *et al.* 2015) and overseas, have blatantly ignored scientific evidence (Gleick *et al.* 2010; Schiermeier 2016). An unwillingness to engage in evidence-based management and evidence-based policy erodes any appetite amongst governments and other organisations to maintain long-term research and monitoring to gather scientific evidence.

Meeting some of the challenges in maintaining long-term research and monitoring

As outlined in the preceding section, a long list of factors conspire against the establishment and then maintenance of long-term ecological research and monitoring. The remainder of this section outlines some things that can be done in an attempt to meet these challenges.

Ensuring long-term studies are pivotal to policy relevant initiatives

A key part of entrenching support for long-term ecological research and monitoring must be to build the case for the importance of such work. For example, scientists who work on long-term studies must more strongly argue why temporal factors are so important to quantify and document, and why methods like space-for-time substitution are often inferior to true time series data (Likens 1989; Lindenmayer *et al.* 2012a). The case for long-term studies can be strengthened when data from them are used in work specifically required by, or are of considerable direct value to, managers and policy makers. State of Environment reporting is one example (Lindenmayer *et al.* 2015); others include the use of long-term data in constructing environmental accounts (Keith *et al.* 2016; Vardon *et al.* 2016) or formal assessments of the conservation status of particular ecosystems (e.g. Burns *et al.* 2015). The case to maintain long-term research and monitoring can be particularly compelling where data from such work is needed for multiple initiatives. Arguing the case for such uses compels the leaders of long-term work to engage closely with managers, policy makers and, as outlined in the following section, also in political processes. Finally, policy and decision makers need to demand the establishment of more long-term studies and monitoring programs as part of the approvals process for new development projects (e.g. new mines, urban settlements, roads and factories). Such studies and monitoring should have minimum mandatory periods of duration (e.g. 10 years), particularly when they are designed to assess the impacts of a given development project.

Engaging in the political process

Many scientists live in hope – they hope their work will be useful for managers and policy makers. But hope is not enough to succeed. More scientists must engage more actively in the political process to prosecute the case for why long-term ecological research and monitoring is important. This is not always pleasant and can come with threats, abuse and other unwanted behaviour (see Gleick *et al.* 2010; Oreskes and Conway 2010), but political engagement is essential – otherwise the reason for doing the science in the first place is open to question by the public and politicians (Ellison 2016).

Pushing back against problematic aspects of science culture

Not all ecologists are suited to conducting long-term ecological research, but those who are need to make more effort to push back against some of the perverse aspects of existing science culture that impede the maintenance of long-term studies. For example, there is a need to mount a concerted attack on editor obsession with novelty as well as more stridently make the case that time is a critical part of ecological dynamics (in place-based locations). There is also a need to recapture parts of the science publishing agenda and refocus it away from the current and sadly increasing emphasis on 'newsy', short or provocative articles in scientific journals. There is far more to good ecological science than global syntheses and meta-analyses and a greater focus is needed on long-term studies that are often best reported as major bodies of work drawing together many parallel themes of research.

An additional key part of pushing back against current science culture must be to halt the demise of naturalists; indeed, without people gathering data, modellers will eventually run out of content to simulate. Moreover, as part of making the case for naturalists and natural history, it will be crucial to continue to demonstrate that people are 'critical infrastructure' and essential for on-the-ground work; that is, effective long-term ecological science is much more than equipment.

A final and important point is that there is value in young academics being encouraged to establish long-term programs if they are fortunate enough to secure a permanent (tenured) position. The author of this article was very strongly encouraged to establish long-term studies on first securing a tenured position by two life-long mentors (H.A. Nix and R.B. Cunningham). Moreover, universities and other kinds of research institutions should be pushed to make academic appointments that maintain already established long-term ecological research or monitoring programs. There are two potential problems in this regard. The first is the tendency for many universities not to appoint staff that have done their PhDs in the same institution. A second is the trend for increasing casualization of the workforce, with a rapidly declining number of permanent appointments in academic institutions. It remains unclear what might be the best and most appropriate tactics to tackle this increasingly widespread problem.

Developing innovative models for long-term funding

Continuity of funding is critical to the maintenance of long-term ecological research and monitoring. Securing funding is a constant source of angst for all those responsible for long-term studies, particularly with the recognition that a given investigation can collapse with an interruption to funding streams. On this basis, the champions for long-term research programs need to devise methods for mothballing projects if there is an interruption to funding streams or reconfiguring projects if savage budget cuts occur. As an example, the Australian Government's Environmental Stewardship program demands large-scale, long-term monitoring to quantify the effectiveness of management interventions to improve the condition of endangered Box-Gum Grassy woodlands. However, part the way through the program, the monitoring budget was slashed by 50% and efforts to maintain the monitoring demanded the implementation of an innovative rotating sampling regime to ensure the validity of the data collection process (Lindenmayer *et al.* 2012b).

Innovative funding models need to be developed to maintain support for long-term studies. In the USA, long-term research is supported under by the National Science Foundation at 26 Long-term Ecological Research (US-LTER) sites in an array of ecosystems (https://lternet.edu/lter-sites). Australia has a Long-term Ecological Research Network (LTERN) that operates through the Terrestrial Ecosystem Research Network (TERN) but at the time of writing (November 2016), the future of funding under the initiative that supports TERN and LTERN (the National Collaborative Research Infrastructure Scheme [NCRIS]) was far from certain. In other cases, some long-term studies are funded by long-term endowments. The 175+-year research program at Rothamsted in England provides one of the best known examples worldwide. However, it is important that guaranteed long-term funding does not create disincentives to be productive, innovative, and to add exciting projects that contribute additional insights to an overall body of work.

Concluding comments

Many things, even the culture of current science and western society itself, militate strongly against monitoring programs being established and maintained. These problems must be tackled if improvements in the understanding of the array of environmental problems facing humanity are to be achieved. Some of the ways in which the prospects of maintaining existing long-term studies might be improved and the chances of new studies being instigated include: **(1)** ensuring that long-term studies (and the data collected in them) are policy and management relevant, **(2)** ensuring that scientists better and more often engage in the political processes where their science is being used or debated, **(3)** rethinking (and pushing back against) some of the flawed aspects of modern science culture, and **(4)** developing innovative funding models.

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