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The value proposition for systematic long-term vegetation studies

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Abstract

Long-term vegetation observations are rare but essential for the effective management of our natural assets. Studies of 3-4 years allow us to discern short-term variability, but long-term trends are only detectable over multiple decades. Through a meta-analysis of several medium to long-term studies in Australia—Kidman Springs, 30 and 50 years; Koonamore, 90+ years; the Brigalow Catchment study, 60 years; the Wambiana grazing trial, 26 years; several Australian Wildlife Conservancy sites across northern Australia, 19+ years; and one site in the USA, Jornada, 105 years—we discuss their benefits, the challenges, the management of the resulting data and information, and their future. We will argue that such sites are vital for the determination of the effects of perturbations caused by fire, thinning, grazing, water diversion, soil erosion, pollution, pathogens, weeds, insect pests and feral animals. They provide points of validation for a variety of types of models, help us better understand the systems involved, and inform management. Quite often these benefits are unpredictable and depend on multi-disciplinary synthesis. The interpretation of the data from such sites can be enhanced by integration with longer term remote sensed data. Ongoing measurement, management and custodianship is, however, often fraught. Measurements that were designed, for example, in 1920, are not always seen as relevant today, a disincentive for participating researchers. Support from the institutions managing the sites has proved variable. Sites can be attractive for a sponsoring body for their sheer age, but usually there is little understanding of the discipline involved, or what is required for their continuation. The expectation for data and information from such sites has changed profoundly with time. Repositories and observatories like the Environmental Data Initiative in the USA and TERN in Australia provide data from several long-term sites. We can expect changes and expectations to evolve into the future.

Introduction

Long-term vegetation observations (>30 years) and their derived trends are essential for the effective management of our natural assets. Studies of 3-4 years are able to discern short-term variability, but long-term trends are only detectable over longer time periods (Peters et al. 2014). This is particularly the case with systems that have slow dynamics, such as tussock grassland and forest ecosystem, or soil carbon pools. Rangeland species such as Brigalow have recently been aged at an average of 150 years. Controlled field observations can greatly contribute to the determination of the short to long-term effects of perturbations caused by fire, thinning, grazing, water diversion, soil erosion, pollution, pathogens, weeds, insect pests and feral animals. Müller et al. (2010) listed six main objectives of long-term research, which are the understanding of: (i) large-scale variabilities, (ii) interactions of short-term and long-term fluctuations, (iii) self-organisation, (iv) rare events and disturbances, (v) impacts of anthropogenic use of landscape resources on ecosystem functions, and (vi) generation of knowledge and data for the development and evaluation of ecosystem models. The challenges for long-term research have been found to include sustaining funding, partnership development, maintaining continuity in objectives, and linking scientists and data through communication and cooperation (Gosz et al. 2010).

The enclosures, catchments, management areas, and plots (referred to henceforth as 'sites') reviewed here meet the definition of research infrastructures: a set area or suite of areas within which land management manipulations and experiments (such as variations in fire frequency or the application of different rates of fertiliser) can take place over the long-term. The type of commitment to manage and measure such sites over time extends beyond normal political and funding agency time frames. Australia's National Collaborative Infrastructure Strategy (NCRIS) was established to support facilities that fall outside research grant time frames or outside funding criteria (Phillips, 2018). The Terrestrial Ecosystem Research Network (TERN), an NCRIS infrastructure, for example, has established 'surveillance' plots across the country to provide calibration sites for the assessment of vegetation coverage (Guerin et al. 2020). It will be many years, however, before these plots reach the longevity of the sites being examined in this paper. Existing long-term sites can provide insight into future challenges that may face TERN and similar Global Ecosystem Research Infrastructures as well as continuing to provide useful benchmarks.

Based on a desktop study of five long-term research sites in Australia and the USA, and two medium-term sites, we examine their value, the challenges, and their data legacy. We offer a prognosis for the future for them and other such sites. With the exception of one relatively new suite of sites, they are survivors of their kind, at least in Australia.

Methods

The long-term sites include two studies at Kidman Springs (30 and 50 years), the TGB Osborn Reserve (Koonamore) enclosure (90+ years), the Brigalow Catchment Study (60 years) all in Australia, and the Jornada site in the USA, 105 years (Specht et al. 2024). The shorter-duration sites include monitoring of adaptive fire management at multiple locations in northern Australia by the Australian Wildlife Conservancy (AWC, ~20 years), and the Wambiana grazing trial (26 years). We documented the original purpose for the sites, the value that had been gained over their lifetime, their recorded legacy, and the challenges that had been faced. Using this process we were able to highlight commonalities across sites, the opportunities presented by their existence, and reflected on the management options for their continued survival and how the data and information gathered at each site is handled.

Results

Management of these sites, with the exception of the AWC sites, is confined to public authorities, such as government departments, universities and federal research agencies, usually in combination. For example, Kidman Springs is run by the Northern Territory (NT) government with CSIRO staff, a federal research agency, contributing to measurements, while the NT Department of Agriculture and Fisheries has run the fire experiment. The Jornada long-term Ecological Research (LTER) site is also supported by multiple programs and institutions, notably the US Department of Agriculture (USDA) and New Mexico State University (NMSU). AWC, a not-for-profit organisation, runs its sites in collaboration with landholders, including Indigenous groups and the AWC itself (Fitzsimons 2015). The TGB Osborn Reserve, however, has been singularly managed since its establishment by the University of Adelaide (UofA). Most sites have attracted funding for research work or training at various occasions along their life span which has helped their sustainability through contributions to management and the ability to demonstrate value.

The utility or value of the study sites ranged from providing points of validation for landscape-scale models of pasture yield (Jornada: Hartman et al. 2020; Robinson et al. 2018), the effects of climatic or land-use change (Jornada: Christensen et al. 2023), hydrological and soil change due to land clearing, land use and management change (Brigalow: Thornton and Elledge, 2022), the detection and attribution of changes due to CO_2 (Brigalow: Orton et al. 2023), to the economic and ecological benefits of managing for climate variability (Wambiana: Neilley et al. 2018). Through these sites, the impacts of different fire regimes and whether they are achieving management goals has been assessed (Kidman Springs: Cowley et al. 2014; AWC: Legge et al. 2011). Observations reaching beyond the lifetime of an average research project has allowed the development of relationships and hence understanding of the systems involved. Quite often these benefits have been serendipitous and unforeseen. The sites are valued by their respective researchers for their curiosity value as they return for the next measurement. By enabling evidence-based decision making they provide economic benefit for important economic activities like livestock production; they also mediate/reduce the impact on biodiversity and downstream ecosystems like the Great Barrier Reef. To study sponsors, such as government, it is likely that the value is demonstrated at a higher level, such as the inclusion of findings in government policy, in response to a Senate Inquiry, or when used in a court of law. These measures are unlikely to be of equal appeal to every audience, and hence will provide varied and perhaps limited justification for continuing a study.

All sites have faced challenges to their existence. The longer-term sites have all experienced uncertainty of funding and continuing agency support. Maintaining the original objectives especially over a long time is always problematic: standards, staff and technology all change and the understanding of the purpose and sense of responsibility for each site wavers. The duration of the Jornada site is remarkable for the continued support (albeit with breaks) of the USDA and NMSU, augmented by membership of the LTER. Koonamore has enjoyed continuous support from the UofA, but has recently turned to crowd-funding for basic maintenance. It was used for regular teaching for many years, but the advent of remote learning and the distance from the university campus (400 km) has limited this to annual measuring trips by volunteers. AWC is committed to testing the effect of interventions and management practices which assist in maintaining the ecological health of their sites.

The expectations of data availability from such sites has changed profoundly with time, from paper records, journal articles and theses, through to the open data delivery we see today (FAIR; Wilkinson et al. 2016). Repositories and observatories like the Environmental Data Initiative in the USA and TERN in Australia provide data from several long-term sites and the management of these sites has had to adapt to meet the new conditions and expectations of open science. We can expect the same changes and expectations to evolve further into the future.

Discussion

Our analysis shows that the data from these sites are valuable in many ways. On-ground observations provide the point of truth for satellite imagery and record floristic changes not provided by the satellite record. Multidecadal monitoring of single treatments or land use in a discrete area provides a unique opportunity to document responses to climate change, having removed externalities that confound these observations in mixed use and management systems. Custodianship of the sites and observations over time is difficult to maintain, however. The attraction of being involved in scientific measurements of such sites dwindles with time as building on the shoulders of others is not an easily marketable quantity for academic promotion. Unless there is a fixed and well-invested bequest, the cost of running long-term sites becomes challenged by other, more state-of-the-art, investments, such as flux towers, square mile radio telescope arrays, and Free-Air CO_2 Enrichment (FACE) experiments. The (managers of) long-term sites could be well-advised to incorporate such facilities in their sites to retain currency.

It appears that to survive, these sites need to be multi-purpose, maintain a clear sense of value for all concerned, encourage and acknowledge collaboration, and ensure there are rewards for involvement (see Alber et al. 2021). Protecting the sites by membership of a network might prove advantageous (viewing the strength of the LTER network around the world as an example) as would linking with major observatories and data repositories such as TERN. The data collection at long-term sites is often different from the standardised data collected by such observatories so strategic links will need to be made, but such a move will help ensure the legacy of these sites is secure. Making the data easily discoverable and providing regular analyses for a range of societal actors and national accounts will illustrate the value of the sites.

It is clear that these sites require active champions, ensuring a flow of quality results and endorsements of their value. A program of marketing to relevant stakeholders and potential funders is required and this would be best managed by sharing within a network of similar sites. Creating a catalogue of similar sites (mid- to long-term), and stratified according to type and use, would be a good first start in creating such a network.

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