Achieving more with less – linking ecological restoration investments with ecological restoration research infrastructure

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Summary

Australian governments and communities are investing in a broad range of ecological restoration programs. A key challenge for these programs is quantifying achievements and improving our capacity to implement cost-effective restoration outcomes that are sustainable and resilient within changing landscapes and climates.

We propose a national Platform for Ecological Restoration Research Infrastructure (PERRI), to advance ecological restoration in Australia by enabling and coordinating collaboration among policy-makers, practitioners and researchers.

The primary objective of PERRI is to embed nationally integrated research infrastructure (small, well-designed experimental plantings) within local ecological restoration programs. Such infrastructure would address key ecological management questions at national scales, enable predictions and improve outcomes in future programs. Costs of the research infrastructure and monitoring would be minimised by capitalising on restoration efforts already funded through restoration programs, with additional resourcing sought through a cost-sharing model.

This coordinated platform of research infrastructure, monitoring, evaluation, and collaborative engagement in restoration initiatives would be integrated nationally to facilitate knowledge sharing and up-scaling of learning.

The platform would also form a foundation on which to build additional research and learning through complementary funding sources.
The challenge

Since 1989 at least $7.4 billion has been invested to improve Australia’s environment through major initiatives such as the Natural Heritage Trust and the current 20 Million Trees program (Hajkowicz, 2009; Broadhurst, 2017). These investments are directed to maintaining important services for agriculture and industry (e.g. crop pollination, control of soil erosion, and amelioration of salinisation), as well as sustaining Australia’s unique biodiversity and restoring the beauty and resilience of our iconic landscapes. Ecological restoration is a remarkably complex undertaking, yet, after 30 years of intensive restoration investments in Australia, we have learnt little about the effectiveness or efficiency of these programs (Hajkowicz, 2009; Doerr, 2017). Consequently, a key challenge is how best to integrate restoration investments with research infrastructure to quantify benefits, and to achieve better and more cost-effective restoration outcomes in the future by learning from current activities.

Background

More than 200 years of European colonisation has seen great change in biodiversity and ecosystems across many regions of Australia, including land degradation, decline or extinction of native species, and invasions by exotic plants and animals (Smith et al., 2013; Jackson et al., 2017). These changes are ongoing, and increasingly compounded by climate change (IPCC, 2014) and land use intensification (Smith et al., 2013). Australia is tackling these problems through a suite of policy approaches, including the establishment of protected natural areas, environmental regulation, and investments in ecological restoration.

This document focuses on ecological restoration. The past 30 years has seen substantial investments through national natural resource management (NRM) programs, including the National Landcare Program ($360M 1990/1), the Natural Heritage Trust ($1.3B 1996/7, $1.2B 2000/1), National Action Plan for Salinity and Water Quality (2000/1 $1.4B), Caring for our Country ($2.25B 2007/8), the National Landcare Program Phase 1 and the Green Army ($1.75B 2013/14), flanked by investments through State government programs (Hajkowicz, 2009; Broadhurst, 2017). These Programs have supported a wide range of activities across managed landscapes, particularly by helping volunteers and land managers control invasive species, undertake revegetation, sustainably manage livestock grazing, conserve threatened species, reduce soil erosion and restore waterways.

Notwithstanding these substantial initiatives, funding to address Australia’s environmental problems is not commensurate with the magnitude of the challenge, and has declined by one third since 2013 alone (ACF 2017). This combination of limited and declining funding despite increasing environmental pressure demands innovative approaches to increase the cost-effectiveness of restoration programs for delivering environmental, social and economic benefits over medium to long timeframes.

How effective are environmental investments?

Surprisingly little evidence is available on the effectiveness of environmental investments in Australia, or how restoration methodologies could be improved to enhance sustainability and
resilience to environmental change (Doerr, 2017). Evaluation of past restoration investments is constrained because the details of many past programs, including spatial locations of on-ground works, have been lost or exist only as ‘dark data’\(^1\), and because rigorous reviews and assessments of ecological and social outcomes are lacking. Indeed, in a review of the evolution of Australia’s resource management programs, Haikowicz (2009) concluded: “Determining what and where activities have been funded is, in itself, a formidable task given the many organisations and individuals involved in transactions. An even greater challenge is developing credible scientific models which link the investment activity (e.g. tree planting) to the outcome (e.g. improved water quality).” To this we would add a third important challenge given the complexities of ecological restoration: how do we best enhance environmental outcomes for a given level of investment.

The past ten years has seen some advances in this regard, including the establishment of the national Monitoring, Evaluation, Reporting and Improvement (MERI) framework, as well as a national ecosystem observatory through the Terrestrial Ecosystems Research Network (TERN). The MERI framework aims to support consistent documentation of project goals and activities within national NRM programs, as well as limited evaluation of outcomes. TERN has significant goals to enable detection and prediction of broad-scale change in Australian ecosystems. While initiatives such as these are significant improvements on past monitoring programs, they are not sufficient to enable rigorous evaluation of restoration actions or comparison among potential alternative restoration approaches.

Here we propose a cost-effective opportunity to evaluate, predict and enhance outcomes of Australia’s ecological restoration investments, through integration of these investments with simple, strategically-designed research infrastructure. We envision this infrastructure as comprising effective, scale-appropriate, embedded, prioritised, nationally-distributed restoration experiments, with associated data being available for long term learning, evaluation and improvement of outcomes.

**The Platform for Ecological Restoration Research Infrastructure (PERRI)**

Towards the above, we propose a Platform for Ecological Restoration Research Infrastructure (PERRI) to embed research infrastructure into ecological restoration programs, consistent with growing calls in the ecological restoration community (Broadhurst, 2017, Gellie et al., in press). Such a platform would:

- capitalise on existing and emerging on-ground restoration investments to enable rigorous evaluation and development of restoration methods;
- enable co-development by policy-makers, practitioners and researchers of a co-ordinated evaluation and learning agenda that addresses pivotal “big questions” of national significance in ecological restoration, concurrently forming the basis for predicting expected outcomes of restoration investments (Law et al. 2017);
- for each “big ecological question”, promote and coordinate national-scale experimental infrastructure, likely comprising distributed network experiments and/or sentinel sites embedded in restoration investments;

\(^1\) Data that exist but are not readily accessible for analyses designed to drive improved practices
• ensure data comparability at local to national scales, including use of emerging standard indicators in monitoring programs;
• enable long-term data and information management (e.g. linking with TERN and the Knowledge Bank of Management Effectiveness; see Doerr 2017) and resourcing (including people);
• in addition to question-focused research infrastructure, deliver generalised (‘question-free’) ecosystem surveillance through long-term control plots, broadening the potential uses of the data;
• stimulate capability-building in science, e.g. by providing infrastructure that can be used for a wide range of short- and longer-term projects, and guidance on experimental design principles to practitioners;
• support a feedback mechanism to inform policy and practice (e.g. dissemination of information on restoration technologies, conservation policy, tools for plant-based industries).

How might the Platform for Ecological Restoration Research Infrastructure be designed?

(1) A ‘big ecological questions’ approach

As discussed in Law et al. (2017), the accurate prediction of environmental program outcomes, and hence the design of more effective programs, “relies on the quality of [the] evidence base”. To develop such an evidence base, PERRI could be built around a strategic ‘big ecological questions’ approach (Figure 1). This would replace idiosyncratic, local scale monitoring with a national set of core questions targeting evaluation and improvement of current methodologies while still promoting documentation of activities at all sites.

The ‘big ecological questions’ can be made reflective and compatible with targets for NRM programs, whilst ensuring they are parameterised to address long-term strategic issues beyond the scope of short-term investment targets. Such questions would steer the design of experimental monitoring approaches, through focused networks of simple experimental contrasts embedded in investment sites. At the scale of local implementation, the forthcoming National Guidelines for Experimental Plantings (in preparation) would then provide guidance.

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2 It may also be worthwhile considering whether to operate NRM programs entirely within an experimental framework. The rationale for such an approach is supported by a recent systematic review of natural resource management effectiveness literature in Australia, which identified that there is a significant lack of evidence to underpin actions undertaken in natural resource management (Doerr 2017). To that end, NRM programs could be viewed as a large ‘unconscious’ environmental experiments. An explicit acknowledgement of the experimental nature of current NRM program delivery would be beneficial. This would support critical experimental design elements being built into program design during the early design phase. It would also support a sensible discussion about the allocation of funds to ‘activity’ versus monitoring and evaluation (until there is a sufficient evidence to support investment in particular natural resource management interventions there may be more emphasis than is currently the case, on experimentation and testing). At present, monitoring and evaluation design is built after investment priorities (and often on ground investment) has been determined.
practitioners on how to establish and monitor these simple experiments, under the guidance of a Network leader.

Figure 1. A conceptual design for the Platform for Ecological Restoration Research Infrastructure, centred on distributed experiments addressing ‘big questions’ prioritised by an advisory committee. The advisory committee would enable input from scientific, policy and practitioner expertise. The Australian Ecosystem Models Framework could form a cross-cutting structure for ensuring strategic location of infrastructure, interpreting results and structuring prediction and future priority setting.

As an example, a nationally significant question that can be addressed through a distributed network of small experiments embedded in restoration plantings is “what provenancing strategies are most effective in a changing climate?” (Figure 2). This could involve as few as two (or ideally eight or more) experimental plots per restoration site, repeated across a suite of investment locations with contrasting climatic, edaphic or other features. Through this research infrastructure, a stronger understanding would be gained over time of the likely ecological outcomes of using local versus other provenancing strategies (e.g. Broadhurst et al. 2017), informing outcomes of investment and design of future investments.

Figure 2. Example of a site in a trial to establish a distributed network experiment within revegetation plantings, to evaluate the “big question” what provenancing strategies are most effective in a changing climate? (green lines = climate-adjusted provenancing; red = local provenancing). The Ecological Engineers project has worked with partners across seven sites in south-eastern and south-western Australia to establish such infrastructure, with the view to identifying constraints for establishing embedded experiments within a model such as PERRI. Image: Greening Australia ACT
The Australian Ecosystem Models Framework as a cross-cutting structure

The emerging Australian Ecosystem Models Framework provides a new, dynamic characterisation of Australia’s major ecosystems, through a series of conceptual ecosystem models reflecting natural and anthropogenic drivers of ecosystem change. This could form a practical cross-cutting structure for designing PERRI (e.g. Figure 1), in particular by:

- streamlining the identification and prioritisation of “big ecological questions” by highlighting key issues of relevance across a range of ecosystems, or that are crucial for specific ecosystems
- guiding identification of representative locations for physical monitoring and research infrastructure
- providing a framework for interpreting results, developing prediction tools and assessing the probability of success of NRM investments
- supporting systematic design of tailored management regimes for different ecosystems
- enabling identification of threats and land-use syndromes that must be accounted for in the design of experiments and management.

If deployed in this way, the Australian Ecosystem Models Framework combined with a ‘big ecological questions’ approach would facilitate conceptual consistency and common architecture between investment decision making, monitoring and question-driven ecological restoration research infrastructure. Binding these elements of NRM activity, monitoring and research together would provide a powerful, nationally consistent, integrated learning system that could support a step-change in our understanding of the environment and how to manage it.

How might the Platform for Ecological Restoration Research Infrastructure be operated and governed?

Operation and governance of PERRI would require wide discussion amongst the policy, practitioner and science communities. Governance and operation options include:

- the platform could be led within a government-funded institution such as TERN, the Department of the Environment and Energy, CSIRO, or through an independent broker, NGO, or philanthropic organisation. Core roles of central operations could be to co-ordinate the advisory committee and distributed network experiments, manage communications and oversee data management and accessibility.
- government departments, research institutions, industry (e.g. mining rehabilitation) and practitioner organisations could contribute to an overarching, transdisciplinary advisory committee
- the advisory committee could lead development, prioritization and review of pivotal national questions relating to the key activities of Australia’s major restoration programs, in the context of the Australian Ecosystem Models Framework.

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3 See https://research.csiro.au/biodiversity-knowledge/projects/models-framework/
• this advisory group could potentially involve a tiered structure (e.g. core representatives of fields of expertise/policy/practice each supported by a wider body of experts/practitioners in the respective fields), to maximise inclusion of relevant science, policy and practical expertise at planning and monitoring stages.

• different government or non-government institutions could manage research infrastructure for specific “big ecological questions”, or these could be coordinated within the overarching management agency

• on-ground delivery agents are likely to need appropriate financial and scientific support to embed experiments into projects, the latter potentially channelled through respective distributed-experiment network leaders

How might a Platform for Ecological Restoration Research Infrastructure be funded?

Ideally, PERRI would be co-funded under a mixed model, underpinned by sustainable, long-term resourcing through independent appropriations decoupled from NRM investment programs (e.g. through the National Collaborative Research Infrastructure Strategy or philanthropic organisations). This would help ensure that investments into monitoring are focussed on strategic long-term conservation goals, rather than subject to the ebb and flow of short-term investments.

However, to ensure good linkage with current funding programs, we also propose that 5% of funding for large ecological restoration programs be allocated to PERRI, with non-core monitoring and evaluation also supported through traditional research funding channels such as investment by industry, universities and research organisations.

Appropriately designed, this mixed model could help serve as an overarching monitoring and evaluation program for restoration investments, and could contribute to the costs of:

*physical research infrastructure design and priority setting  
*central coordination, data management, data accessibility, and communications,  
*facilitating and coordinating national restoration foci (“big ecological questions”, distributed experiment networks, sentinel sites),  
*establishing the associated on-ground experimental infrastructure in partnership with practitioners (accommodating the cost of scientific coordination and additional time required by practitioners to lay out and potentially monitor simple experiments, noting most costs would be covered under normal operations), and  
*training and capacity building,  
*communications - both within the policy / decision makers domain but within the community as a whole.

A pool of competitive funds could be maintained to ensure minimum core monitoring and evaluation outcomes are achieved and drive additional innovation and co-investment. This could be coupled with wider data and infrastructure accessibility to promote independent research funded by other research funding bodies, for example through an Australian Research Council (ARC) Centre of Excellence, ARC Linkage grants or the Australian Research Council Linkage Infrastructure, Equipment and Facilities scheme.
Benefits

PERRI offers multiple benefits to document and enhance the outcomes of environmental investment programs at significantly lower cost than standard monitoring and research programs. National benefits would include:

- iteratively improved and proven restoration outcomes
- enhanced ability to demonstrate outcomes internationally and with scientific rigour
- clear progress towards meeting international conservation and restoration obligations
- opportunities to evaluate novel interventions targeting adaptation to environmental change, and
- rigorous, open data to evaluate ecological benefits of environmental investments and contribute to national long-term ecological surveillance.

In addition, the approach would enable and enhance communications among practitioners, practitioner-based organisations, government and scientists to facilitate implementation of optimum approaches.

Further, adding value to any investment often brings benefits beyond those initially anticipated. For example, the international Nutrient Network has led to globally significant learnings in ecology through a distributed network approach. Initially established to address two core ecological questions, this network of >60 identical experiments in grasslands worldwide has so far tested more than 30 ecological theories at the global scale and at minimal cost. Similarly – the Biomes of Australian Soil Environments (BASE project) - has produced significantly more data and attracted more co-investment than originally expected.

Conclusions

PERRI offers an efficient solution to a suite of major challenges that limit our capacity to enhance Australia’s environment: limited funding for ecological restoration; limited research funding; mismatches between short-term research funding and long-term ecological outcomes; and constraints to coordination among practitioners and researchers at a range of scales.

For a relatively small contribution from major environmental investments, leveraged with other funding opportunities, co-ordinated integration of on-ground restoration activity with environmental research infrastructure would help to overcome these challenges. In particular, PERRI would enable researchers to work with practitioners and policy-makers to facilitate evaluation of outcomes of investment programs, and establish long-term environmental research infrastructure that addresses questions of national significance. This world-leading infrastructure would facilitate evaluation over short, medium and long timeframes, and at local, regional and national scales.

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