A long-term monitoring framework for the Regional Land Partnerships Program

Stage 2

FINAL REPORT



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Executive Summary

This report presents a proposal for the development and implementation of a long-term ecological monitoring framework (LTMF) to support the Regional Land Partnerships (RLP) Program funded by the Department of Agriculture, Water and the Environment through Phase Two of the National Landcare Program. The report builds on a Knowledge Review and Discussion Paper completed in 2018 (Capon et al. 2018), by conducting an analysis of RLP projects funded in the current cycle (2018-2023). Four key outcomes of Commonwealth environmental responsibility are the focus for the proposed LTMF; 1) Ramsar wetlands, 2) threatened species, 3) World Heritage sites and 4) threatened ecological communities.

The proposed framework aims to enhance ecological monitoring and evaluation at a RLP project level as well as promoting a culture of robust long-term ecological monitoring and evaluation for Natural Resource Management in Australia more broadly. The objective was to better understand the requirements, opportunities and constraints for long-term ecological monitoring and evaluation within RLP. Based on a review of currently funded projects, the report proposes a suite of standardised ecological monitoring methods that facilitate robust data reporting and analysis for key RLP outcomes through the development of an online platform, nicknamed 'Latimer' (*sensu* Interpreter).

To guide the development of this proposal, we conducted an extensive review of current RLP projects by querying the Department's MERIT (Monitoring, Evaluation, Reporting and Improvement Tool) system*. Information about each of the projects was extracted from MERIT and elements were categorised in a comprehensive database to assess project objectives (i.e. focal RLP outcomes), threats, interventions (i.e. actions taken by RLP service providers), targets, habitats as well as the human dimensions (see Chapter 3). This analysis identified commonalities among projects but also gaps across all four RLP outcomes (i.e. species, habitats, sites that were not captured in the current funding cycle). The analysis of project data provided through MERIT by service providers was supplemented by further consultation with key stakeholders for threatened species as these projects were in the majority of those funded. Additional consultation with service providers also enabled an assessment of acceptance for the proposed LTMF.

The proposed LTMF uses two central evaluation pathways underpinned by key evaluation questions associated with each of the RLP program outcomes. The first is a descriptive pathway that articulates how RLP project data can be collected using standardised approaches, collated and captured in an enduring accessible platform that facilitates evaluation and reports across multiple spatial (i.e. projects level, target level, regional level, national level) and temporal scales. The descriptive evaluation pathway links with the implementation of Latimer to provide a modular system that enables evaluation and reporting on monitoring efforts. Protocols for on-ground monitoring draw from existing resources

that present standardised methods for data collection (e.g. AusPlots) and are summarised in the report for assessing habitat condition and threatened species (fauna).

The second pathway is a mechanistic approach that facilitates the analysis of relationships among project components using a rigorous assessment of hypotheses to gauge the efficacy of any RLP interventions. The success of these interventions can be tested within a series of proposed Monitoring, Evaluation and Research (MER) networks where there is a critical mass of RLP projects that either have a common target species/habitat, where the interventions being applied are consistent among projects, or where projects are monitoring the impacts of specific threats (e.g. fire). Proposed MER networks are presented for two threatened species (Regent Honeyeater and Australasian Bittern), for projects undertaking revegetation with a focus on weed control as intervention as well as those addressing the current and future threat by fires and how these systems respond to such disturbance. The proposed MER network approach provides a flexible means to enable the RLP program to provide adaptive responses to monitoring requirements (e.g. in response to gaps and/or disturbance events).

The implementation of the LTMF is linked to the development of a novel online platform, Latimer, that serves to coordinate data collection, analysis, evaluation and reporting. Latimer is a virtual laboratory that draws together RLP project data in a central repository where end-users can interrogate these data and supplementary secondary/spatial data (e.g. climate data, landcover, fire overlays etc.) using a series of analytical tools (modules). These modules allow end-users to design bespoke evaluation and reporting systems that can address the key evaluation questions at the project, program or national level depending on requirements. As Latimer is populated with standardised RLP data there will be increasing opportunity to use these data as baseline/benchmark measures to evaluate temporal variation in the status or condition of species and/or their habitats.

*The RLP statistics presented in this report were sourced from MERIT in 2019 and may have changed since the publication of this report.

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Introduction

1.1 Background

The Regional Land Partnerships (RLP) program is a major component of Australia's National Landcare Program (Phase Two), supporting regional delivery of projects that will contribute to priority environmental and agricultural outcomes to 2023 and beyond. Four key areas of Commonwealth environmental responsibility are targeted by this program: 1.) Ramsar wetlands, 2.) threatened species, 3.) World Heritage sites and 4.) nationally threatened ecological communities. Since late 2018, over 210 RLP projects, to be delivered in 53 management units across the country, have been approved with at least 50 service providers, largely regional Natural Resource Management (NRM) organisations, engaged to deliver these projects.

Considerable effort has recently been devoted to developing improved practices for collecting and storing information on services planned and delivered by Commonwealth funded NRM projects, as well as reporting on their outputs (i.e. the Department of Agriculture, Water and the Environment's online Monitoring Evaluation Reporting and Improvement Tool (MERIT): https://fieldcapture.ala.org.au/home/about). However, there remains a significant need for equivalent processes to support consistent monitoring and evaluation of NRM project outcomes, especially ecological outcomes. Ecological monitoring and evaluation are critical for assessing the effectiveness of NRM investment and for informing adaptive decision making at both project and national scales. Recent reviews have revealed a surprising paucity of empirical studies demonstrating the outcomes of on-ground NRM interventions in Australia (Doerr et al. 2017, Capon et al. 2018).

A Griffith University team has been engaged by the Department of Agriculture, Water and the Environment to produce a proposal for a long-term monitoring framework (LTMF) for the RLP program. The primary focus of this framework is to enable transparent assessment of ecological outcomes of the RLP program over the long-term, especially at a program level. However, it is also expected that this LTMF will support ecological monitoring and evaluation of individual RLP projects as well as that of NRM interventions more broadly.

The first stage of this project was conducted from late 2017 to mid-2018, prior to the announcement of successful RLP projects. This phase of the project comprised a major Knowledge Review (Capon et al. 2018), stakeholder consultation and preparation of a Discussion Paper to provide a preliminary outline of key design considerations for a LTMF for the RLP program. The second stage of this project ran from May 2019 to February 2020 with the aim of finalising a proposed RLP LTMF with respect to the particular projects being funded by the RLP program.

1.2 Objectives of this project

The overarching aim of the second stage of this project has been to finalise the development of a proposal for a LTMF for the RLP program that can be implemented during the remainder of the current funding cycle and which will enable evaluation and reporting of ecological outcomes both mid-way through (2021) and on completion of current projects (2023), as well as beyond. While the principal focus of the LTMF is to be on monitoring and evaluating long-term ecological outcomes at the level of the RLP program, we have also sought to propose a framework that will enhance ecological monitoring and evaluation at a project level as well as promoting a culture of robust long-term ecological monitoring and evaluation for NRM in Australia more broadly.

In developing a proposal for the RLP LTMF in the second stage of the project, we have addressed the following major objectives:

- to better understand and describe the requirements for long-term ecological monitoring and evaluation in relation to the RLP program;
- to better understand the opportunities and constraints for long-term ecological monitoring in relation to the RLP program, especially with regards to funded projects;
- to determine and describe potential data inputs that may contribute to evaluation of ecological outcomes of the RLP program including field and remotely sensed monitoring data collected by RLP project service providers and supplementary data;
- to propose standardised ecological monitoring methods for endorsement under the RLP program as well as identifying needs for additional targeted monitoring;
- to propose methods to collect, organise and store ecological monitoring data collected under the RLP program;
- to propose methods to analyse, evaluate and report on ecological monitoring data collected under the RLP program; and
- to propose an overall architecture for the RLP LTMF to facilitate effective governance, data management and adaptive management.

It should be noted that this project has not aimed to develop prescribed methods for ecological monitoring and evaluation of currently funded RLP projects that are already under contract. Rather, we have sought to develop a framework which can best capitalise on existing and planned monitoring under the current RLP program and provide advice regarding additional and future monitoring, evaluation and research (MER).

1.3 Project approach

The proposed RLP LTMF designed in Stage 2 of this project has been developed in relation to the design principles presented in the Discussion Paper prepared in Stage 1 of the project (Capon et al. 2018) in combination with our understanding of currently funded RLP projects, as determined via MERIT and consultation with project service providers and ecological monitoring focus groups.

1.3.1 Guiding principles

In developing a proposal for the RLP LTMF, we have been guided by a set of overarching, aspirational principles which draw on learnings gleaned from the knowledge review and stakeholder consultation conducted in Stage 1 of the project. In general, we have sought to propose a LTMF that will be:

- systematic and comprehensive whilst also being flexible and adaptive;
- hierarchical, i.e. considerate of differences in both levels of ecological and human organisation and spatial and temporal scales;
- focused on evaluation rather than just monitoring; and
- capable of capitalising on past programs, current technology and partnerships.

1.3.2 Activities

The key activities conducted in Stage 2 of this project have included:

a. Development of a common vocabulary for ecological monitoring and evaluation of NRM activities funded under the RLP program:

This has been an ongoing foundational activity throughout the project to enable consistent and systematic description and articulation of various aspects of the proposed framework and its context (see Chapter 2).

b. Mapping of RLP projects:

We have sought to describe the range of RLP projects being conducted from a bottom-up perspective (i.e. from the perspective of the NRM partners and based on information provided by these partners) with the principal aim of better understanding the potential for on-ground ecological monitoring in the current program as well as project level evaluation. This goal has been approached through the synthesis and analysis of RLP project information available via MERIT in conjunction with consultation with both RLP project service providers, monitoring

experts (e.g. Terrestrial Ecosystem Research Network (TERN), National Environmental Science Program (NESP) partners) and MERIT managers (see Chapter 3).

c. Specification of RLP program evaluation requirements:

We have taken a top-down approach (based largely on the overarching evaluation requirements from the DAWE) in developing more specific evaluation questions which expand on the overarching five-year and long-term outcomes provided in the RLP program logic (Figure 1). This has drawn on relevant published conservation advice as well as consultation with the Department and other key partners, e.g. NESP Threatened Species Recovery Hub (see Chapter 4).



Figure 1. Regional Land Partnerships Program Logic for Outcomes 1 to 4 that address ecological aspects related to the program.

d. Design of evaluation pathways:

To connect potential monitoring and evaluation at the level of RLP projects to program level evaluation requirements, we have developed proposals for two major evaluation pathways.

First, we propose a descriptive evaluation pathway to enable comprehensive and systematic capture of diverse monitoring data from RLP projects as well as evaluation and reporting on these in relation to program outcomes. This evaluation pathway is referred to as descriptive because its main focus would be on reporting spatial and temporal patterns in measured outcomes rather than demonstrating cause and effect relationships between, for instance, actions conducted under RLP

projects and ecological outcomes. Nevertheless, such descriptive spatial and temporal patterns can still be evaluated against baselines or benchmarks to provide a normative assessment of program outcomes (see Chapter 5).

Second, we propose a mechanistic evaluation pathway to specifically address priority evaluation questions using robust scientific methods. To achieve this, we propose the development of MER networks comprising clusters of existing RLP projects amongst which additional targeted and standardised monitoring and evaluation can be conducted. The results of this evaluation pathway would include the generation of empirical evidence demonstrating ecological responses to particular NRM actions under a range of conditions (see Chapter 6).

e. Design of overall RLP LTMF:

Our proposal for the overall RLP LTMF centres on the development of an online platform (Latimer – Long-Term Ecological Monitoring, Evaluation and Reporting platform) to coordinate data collection, analysis, evaluation and reporting. In Stage 2 of this project, we have developed a blueprint and preliminary prototype for Latimer including proposed data management, workflows, end-user interface and outputs (see Chapter 7).

Finally, we have developed a preliminary road map for implementation of the RLP LTMF including major tasks and a proposed schedule (see Chapter 8).

1.3.4 Consultation

An information paper providing an overview of the project was developed and circulated mid-way through Stage 2 of this project. This paper was distributed for feedback from participants of consultation activities conducted during Stage 2 of the project as well as via various NRM networks.

In addition to many informal conversations with colleagues and members of our relevant networks during the course of this project, two major collaborative consultation activities were also conducted during Stage 2 of the project. First, a Threatened species workshop was held in Brisbane on the 23rd September 2019 to discuss requirements and approaches relevant to monitoring and evaluating RLP outcomes associated with threatened species. Attended by a range of researchers, data managers and policy makers, a particular focus of this workshop was to determine opportunities for partnerships with other relevant programs such as those being conducted under the National Environmental Science Program's (NESP) Threatened Species Recovery Hub, e.g. the Threatened Species Index project (http://www.nespthreatenedspecies.edu.au/projects/threatened-species-index).

Second, a workshop was held in Perth on the 7th October 2019 to present the proposed RLP LTMF to RLP project service providers and other interested stakeholders and to elicit feedback regarding the proposal and its operational potential. In addition, a session was held at the national NRM Knowledge Conference in Albury in November 2019 where an overview of the proposed RLP LTMF was presented. A workshop session was also used to elicit feedback regarding the proposal as well as priority NRM knowledge gaps and evaluation questions.

1.4 Opportunities, constraints and limitations

Through the course of this project, it has become apparent that there is a strong and growing desire to develop a robust culture of long-term ecological monitoring, evaluation and knowledge sharing across NRM groups, State and Commonwealth agencies and the ecological research community. There is also widespread recognition of the need to better capture, store, interpret and effectively use data associated with NRM investment in on-ground actions, not just with respect to outputs but also with regard to their ecological (and social, economic and cultural) outcomes. Most, if not all, stakeholders acknowledge and support the need to better understand and report on the effects of NRM interventions and to inform future investment as well as to generate knowledge, test assumptions and inform best practice and adaptive management. There is also broad awareness concerning the considerable data and knowledge that already exist, albeit with varying degrees of accessibility and applicability, as well as the many current ongoing monitoring and evaluation initiatives relevant to NRM across the country. Consequently, there is an emerging need to better align and integrate ecological monitoring, evaluation and reporting across different temporal and spatial scales, programs and organisations. At the same time, there are considerable opportunities emerging to address these needs as a result of recent developments in our technological and institutional capacity and research infrastructure.

While there is clearly widespread appetite and appreciation of the need for improved, coordinated long-term ecological monitoring and evaluation in Australia, the implementation of a LTMF under the RLP program is likely to be constrained by several major factors including:

- the considerable diversity of RLP projects, and associated monitoring and evaluation, already contracted;
- limited availability of appropriate baseline data and clear benchmarks against which to evaluate monitoring data;
- ecological complexity and uncertainty including the high potential for surprises, shocks, nonlinear responses and multiple interacting stressors, especially under climate change, as well as the likelihood that the trajectories of many species and ecosystems are still responding to historical pressures;

- wariness regarding the likelihood of success of new ecological monitoring and evaluation initiatives, especially in relation to large-scale proposals such as this; and
- uncertainty regarding future resourcing and expertise.

In conducting this project, the development of our proposal for the RLP LTMF has similarly been constrained by awareness of these factors in addition to restrictions imposed due to limitations of both time and knowledge. The paucity of information available at a program level (i.e. via MERIT) regarding RLP projects and their proposed monitoring and evaluation plans especially, only becoming apparent to us a considerable way into Stage 2 of this project, has particularly affected our capacity to plan a more detailed LTMF at this time. Nevertheless, we are confident that the proposal presented here could be efficiently and effectively developed during the course of the current RLP program to enable robust evaluation and reporting at the required junctures.

1.5 Structure of this report

Following this introductory chapter, chapters 2 to 8 of this report present the results of each of the major activities conducted during Stage 2 of the project as outlined in Section 1.3 above. Chapter 2 describes the common vocabulary developed for describing ecological monitoring and evaluation of NRM that underpins the proposal. Chapter 3 provides an overview of RLP projects, as mapped from the bottom-up during this project, while Chapter 4 presents the RLP program evaluation requirements that have been developed from a top-down perspective. Our proposal for a descriptive evaluation pathway, including proposed approaches to ecological monitoring, data collection, data management, analyses, evaluation and reporting, is provided in Chapter 5. Chapter 6 presents our proposal for several MER networks to support mechanistic evaluation of RLP outcomes. A blueprint for an online platform (LTEMER – 'Latimer') to coordinate data inputs, analysis and evaluation and other reporting outputs is provided in Chapter 7. Finally, Chapter 8 provides a road map for implementation of the proposed RLP LTMF including governance and a possible schedule.

A common vocabulary for ecological monitoring and evaluation

2.1 Introduction

A major consideration in designing the proposed RLP LTMF has been to develop a common vocabulary to enable consistent and systematic description of various aspects of the framework, both during the design phase and into the future. Concepts and terminology associated with ecological monitoring and adaptation are used variously in the scientific literature and other programs and this can lead to misinterpretation, confusion and poor communication. In developing our vernacular, we have paid particular heed to the language used in MERIT, and its associated elements (e.g. the Ready Reckoner), as well as that of other major ongoing programs such as State of the Environment Reporting (www.environment.gov.au/science/soe) and New South Wales' Save Our Species Strategy (State of NSW and Office of Environment and Heritage 2018) and relevant recent projects informing the development of the current framework (e.g. Doerr et al. 2017). However, it has not always been possible to align exactly with these programs given the particular requirements and constraints of the RLP context.

To facilitate the development of a common vocabulary for the RLP LTMF, we have created a range of conceptual models and classification schemes, as well as associated terms, which seek to define various aspects of the framework and allow their context and relationships to be clearly described. The major areas we have considered to date, each discussed in more detail below, are:

- RLP program and project descriptors
- ecological monitoring and evaluation processes
- ecological monitoring and evaluation data descriptors
- RLP actors and infrastructure

2.2 RLP program and project descriptors

In general, most aspects of the RLP LTMF can be described in relation to its program-level outcomes and hierarchical level:

- *RLP program outcomes*: major areas of government responsibility and associated objectives as defined in the RLP program logic, i.e. Ramsar sites, threatened species, World Heritage sites or threatened ecological communities
- *hierarchical level*: the level at which monitoring and evaluation processes are conducted, i.e. RLP project level, target level, various spatial areas (e.g. State), program level, national level

To describe commonalities and differences amongst diverse RLP projects, we have developed a generic NRM system conceptual model based on existing models commonly used in NRM, such as those underpinning State of the Environment reporting (Figure 1). RLP projects can thus be clearly outlined in relation to the following major attributes, in addition to their RLP program outcome:

- *interventions*: services or outputs being provided by RLP projects including 'hard' (onground) and 'soft' (human) actions, i.e. what is the project doing?
- *threats*: the pressures and stressors being addressed by the project, i.e. why is the project doing this?
- *target*: the primary focal asset(s) or ecological value(s) being addressed by a project, such as a particular threatened species or vegetation community, also referred to in project MERIT plans as primary and secondary investments, i.e. what is the project doing this for?
- *habitat*: we have distinguished between 'target' and 'habitat' to allow a distinction between primary ecological responses (e.g. of a threatened species) and underlying ecological responses which are likely to support a primary response (e.g. attributes of a species' habitat);
- *human*: we have added this component to the NRM system model in Stage 2 of the project to account for the significant effort being directed in RLP projects towards social and institutional outcomes.



Figure 2. NRM system conceptual model for RLP LTMF. Each box is referred to here as a 'component' of the NRM system. RLP projects differ from each other with respect to the specific 'instances' of each component.

We also developed classifications for interventions (Table 1) and threats (Table 2), with major classes and sub-classes, to synthesise the diversity described by current RLP project plans in MERIT.

Major class of intervention	Sub-classes
Monitoring	
Reintroduction	
Further protection	
Habitat improvement/regeneration	 Debris removal (incl. marine debris removal) Improve water quality Erosion control Revegetation Reducing pollution
Community/landholders engagement	 Citizen science Conservation activities (e.g. pest control, land management) Incentives - community/landholder
Identifying / Prioritizing areas	
Increasing plant diversity	
Training/extension services	
Weed control	
Improved land management	Grazing managementFarm management practices
Fire management plans/burns	
Restrict access	Fencing/barriers
Pest fauna control	 Culling Baiting Trapping Fencing Monitoring
Review of existing data	
Genetic collections/monitoring	
Seed collection/storage	
Ex situ program	 Propagation Captive breeding
Indigenous knowledge	
Pathogens/disease control	
Further research	
Communication, education and awareness raising	 Soft communication material (e.g. video) Hard communication material (e.g. signage) Awareness raising program/events
Governance	
Planning/strategy development	
Aboriginal community engagement	
Water management	Improved hydrological regime
Nest-box installation/breeding site improvements	

Table 1. Classification of interventions associated with current RLP projects

Major class of threat	Sub-classes
Native fauna (disturbance)	 Competition Predation
Habitat loss	 Dieback/senescence Encroachment Habitat fragmentation Land clearing Breeding place disturbance
Land management practices	 Agricultural activities (non-specific) Domestic grazing/ stock disturbance Runoff Gardening (fertilisers)
Weeds	InvasiveControl/sprayingCompetition
Low population numbers Pest fauna (disturbance)	CompetitionPredation
	 Habitat degradation Sediment mobilisation Grazing Trampling Disease transmission
Fire	 Wildfire Lack of/inappropriate fire regime Control burns Inappropriate land use in surrounding areas
Disease/pathogens	
Pollution	 Rubbish Chemical Debris Marine debris Sediment Nutrient Eutrophication/algal blooms Acid Sulphate Soils
Climate change and severe weather	 Sea level rises Seasonal/temperature variations Flooding Drought
Genetic bottleneck/inbreeding Data deficiency/lack of ecological data Groundwater access	
Human interferences/disturbance	 Culling Road/vehicle Recreational pressures Recreational fishing Development (future, urban, peri-urban) Cloud seeding (para)military activity Illegal activities
Water regime	 Altered hydrological regime Salinisation Poor water quality
Biological resource use	• Fishing and harvesting aquatic resources (commercial)
Lack of community awareness Governance	Lack of appropriate planningUpstream land planning

Table 2. Classification of threats associated with current RLP projects

2.3 Ecological monitoring and evaluation processes

The major steps of ecological monitoring and evaluation practice that we have recognised in designing the LTMF, along with key terms associated with each, include:

- 1. *Monitoring*: the activity of collecting data describing selected *Indicators*, either from the field or via remote sensing, using particular *monitoring protocols*.
 - *monitoring protocols*: specific methods for obtaining monitoring data including the definition of variables to be measured as well as when, where and how these observations are obtained.
 - *RLP project monitoring*: monitoring conducted in relation to the services and outcomes of individual RLP projects.
 - *targeted monitoring*: monitoring conducted in addition to RLP project, but under the RLP program, to address evaluation needs at target and program levels.
 - *supplementary monitoring*: monitoring activities conducted externally to the RLP program.
- 2. *Data collection*: the process of entering measurements regarding variables measured by monitoring protocols into various data sheets, data collection applications and databases.
 - *RLP project data collection*: data collected in support of RLP project monitoring as conducted in relation to contracted services.
 - *targeted data collection*: data collection conducted in addition to that contracted under RLP projects to support *mechanistic evaluation*.
 - *supplementary data collection*: collection of data from historic data sources and other relevant programs.
- 3. *Data management*: processes for storing and organising monitoring data, including quality assurance and control, accessibility etc.
- 4. Data analysis: synthesis and interrogation of monitoring data to support evaluation and reporting.
 - *descriptive analysis*: data analyses conducted to describe patterns in data over space and/or time.
 - *aggregation*: process of combining monitoring data from multiple RLP projects to report on these, conduct further analyses and address evaluation questions at higher levels of organisation or spatial /temporal scales.
 - *hypothesis testing*: use of statistical approaches to investigate particular evaluation questions.
 - *predictive modelling*: use of monitoring data to generate quantitative models that enable extrapolations to conditions beyond those encompassed by monitoring observations.

- 5. *Evaluation*: the process of considering the results of data analyses in relation to *baselines* and *benchmarks* to detect change, identify drivers of this and judge outcomes.
 - *descriptive evaluation*: assesses the results of *descriptive data analyses* in relation to selected *baselines* and *benchmarks* to describe variation in space and changes over time and gauge the direction of this change, but not to espouse cause and effect relationships.
 - *mechanistic evaluation*: assesses the results of *hypothesis testing* in relation to selected *baselines* and *benchmarks* to gauge the efficacy of NRM interventions.
 - *baselines*: reference data (e.g. historical conditions) against which to assess monitoring results to describe change
 - *benchmarks*: desired states of indicators (i.e. objectives) against which to assess monitoring results in order to gauge effectiveness of NRM interventions and investment.
 - *risk/vulnerability assessment*: higher level evaluation processes to assess risk and vulnerability of assets to inform adaptive management in terms of future NRM interventions and investment. This can be achieved through ongoing interrogation of RLP monitoring data in conjunction with modelling using secondary data. For example, species occurrence and or habitat extent can be mapped and modelled against fire risk, rainfall patterns etc. to provide forecasts for assessing species persistence in the face of potential threats.
- 6. *Reporting*: generation of products to share data and the results of data analyses and evaluation across all program level hierarchies, e.g. report cards, annual reports etc.

2.4 Ecological monitoring and evaluation data descriptors

The proposed RLP LTMF will collate and generate a large amount of data which will vary in relation to its origin, structure and use, as well as its ownership and suitability to be shared. Consequently, it will be vital for the LTMF to facilitate clear description of data and how it is organised. We propose use of the following key terms:

- *indicators*: particular variables describing the state of a particular instance of components of a NRM system (Figure 1)
- *indicator class*: the type (and sub-type) of a particular indicator, i.e. extent (e.g. area or duration), magnitude (e.g. number or abundance) or condition. Note, we also added 'social' and 'process' indicator classes in Stage 2 of the project to capture indicators being measured by RLP projects in relation to human components (i.e. social indicators) and soft interventions (i.e. process indicators).
- *simple indicator*: a variable reflecting direct measurements obtained by following field or remotely sensed monitoring protocols.

- *composite indicator*: a variable calculated by manipulating one or more simple indicators, e.g. various species diversity indices.
- *emergent property*: specific composite indicators calculated over higher hierarchical levels or spatial and/or temporal scales reflecting variables relevant at these levels, e.g. connectivity indicators, indicators of resilience to perturbations etc.
- *indicator state*: the value of a specific measured, or calculated (e.g. composite), variable for a particular sampling time, spatial domain and hierarchical level.
- *trajectories*: changes in indicators over time
- *spatial trends*: variation in indicators over space
- *meta-data*: data describing the monitoring data collected and generated.

2.5 RLP actors and infrastructure

As per data, the proposed RLP LTMF involves many stakeholders and elements of infrastructure which also require clear denotation:

- *RLP service provider*: a regional Natural Resource Management (NRM) organisation engaged to deliver an RLP project.
- *RLP project cluster*: a group of RLP projects with common targets and/or interventions and threats.
- *MER (Monitoring, Evaluation and Research) network*: an interacting project cluster following standardised protocols for monitoring and evaluation processes in order to collectively address a mechanistic NRM question at a target, area or program level.
- *RLP MERI team*: the team tasked with coordinating the overall implementation and delivery of the RLP LTMF.
- *RLP partner*: other organisations that may contribute to the implementation and delivery of the RLP LTMF via the contribution of data, data management, analytical modules, tools etc.
- *MERIT*: the Department of Agriculture, Water and the Environment's online Monitoring Evaluation Reporting and Improvement Tool (<u>https://fieldcapture.ala.org.au/home/about</u>)
- *RLP project database*: the database generated in Stage 2 of this project to describe, synthesise and map key aspects RLP projects.
- *Latimer*: the hub of the proposed LTMF which would coordinate data collection, analysis, evaluation and reporting.

Overview of RLP projects

3.1 Introduction

Over 210 RLP projects have been approved since late 2018 for delivery in 53 management units across the country (Figure 3). NRM agencies were able to apply for funding through a competitive tender process administered by the Department of Agriculture, Water and the Environment and guided by an RLP Evaluation Plan (RMCG 2018) and Assurance Framework (DoEE 2018). By virtue of the tender process it was not possible to have complete representation of all threatened species, threatened ecological communities, Ramsar sites or World Heritage sites in the program and this is reflected in the projects reviewed. In Stage 2 of this project, we used project plans contributed by these projects to MERIT to create an RLP project database with the purpose of organising information about RLP projects with respect to their program outcomes and the NRM system model described in Chapter 2 of this report (Figure 2). While it was initially hoped that this database would enable the description and synthesis of ecological indicators already planned for monitoring under contracted project plans so as to construct an indicator library to inform the design of the LTMF, it became apparent during the course of this project that insufficient information to achieve such an objective was available at the time of writing this report. Nevertheless, this database was interrogated throughout the course of the project to develop various aspects of the framework, especially proposals for MER networks incorporating RLP project clusters (see Chapter 6), as well as to inform a general sense of the potential RLP project monitoring likely to be conducted and therefore the possible range of data inputs likely to become available to the RLP LTMF.



Figure 3. Map of Australia showing location of RLP projects. Data points are centroids generated from polygons representing sites within each project. Where projects had multiple sites, a single centroid was derived. Not all projects have site locations recorded in MERIT, thus may be missing in this representation. Data source: Department of Agriculture, Water and the Environment.

3.2 Project components

The majority of projects funded under the RLP program address primary outcomes associated with threatened species (79 projects) while 31 projects address primary outcomes relevant to threatened ecological communities. A further 24 projects target outcomes associated with Ramsar wetlands and an additional 12 projects involve World Heritage sites.

3.2.1 Interventions

Across all RLP projects, a total of 26 categories of interventions, including both hard and soft interventions, were identified (Figure 4). At a program level, the most common interventions are weed control (13 % of projects), pest fauna control (11 % of projects), habitat improvement/regeneration (10 % of projects), community/landholder engagement (9 % of projects), communication, education and awareness raising (9 % of projects) and improved land management (7 % of projects; Figure 4).

The most common interventions to be implemented by RLP projects addressing outcomes associated with Ramsar wetlands were pest fauna control (19 projects), weed control (17 projects), habitat improvement (15 projects) and water management (14 projects) while projects focusing on threatened species tended to list interventions classified as weed control (41 projects), habitat improvement (36 projects), monitoring (34 projects), pest fauna control (34 projects) and fire management/burns (31 projects; Figure 4). The major interventions addressed by RLP projects addressing World Heritage site outcomes were weed control (9 projects; Figure 4). Finally, the most common interventions proposed by RLP projects associated with threatened ecological communities were weed control (23 projects), pest fauna control (18 projects), community/landholder engagement (18 projects), improved land management (17 projects) and habitat improvement (17 projects; Figure 4).



Figure 4. Number of RLP projects addressing each broad category of intervention in relation to RLP program outcomes (*indicates that there are sub-categories associated with the broad category; see Table 2).

3.2.2 Threats

Threats being addressed by RLP projects, according to project plans in MERIT, concern 18 broad areas which have been further divided into 48 sub-categories (Figure 5). Each project is typically associated with a number of threats as identified in MERIT. Among the broad threat categories most frequently cited, habitat loss and weeds are each associated with 15 % of all RLP projects (Figure 5). The next most common threats addressed were pest fauna disturbance (11 %) and land management practices (10 %; Figure 5). Fire related threats were also common across 9 % of projects (Figure 5).



*Figure 5. Number of projects addressing each broad category of threat divided by Outcome (*indicates that there are sub-categories associated with the broad category; see Table 3).*

The most commonly cited threats associated with projects focusing on Ramsar wetlands are pest fauna and weeds with 18 project each (Figure 5). Projects targeting threatened species outcomes mainly concern threats of habitat loss (57 projects), weeds (34 projects) and fire (34 projects; Figure 4). Not surprisingly given the RLP program logic (Figure 1), the major threats reported by projects addressing World Heritage sites are weeds (9 projects) and pest fauna (7 projects; Figure 5). Weeds (24 projects), pest fauna (19 projects), habitat loss (18 projects) and land management practices (17 projects) are the most commonly listed threats being addressed by RLP projects associated with threatened ecological communities (Figure 5).

3.2.3 Targets

According to the primary and secondary investment priorities reported in RLP project plans in MERIT, 56 % (i.e. 37 of 66) of Ramsar sites are being considered by RLP projects (Table 3). Primary investments were those mapped again 'primary outcomes' for investment while secondary investments were those mapped to 'secondary outcomes' for project investment.

Table 3. Ramsar listed wetlands addressed by RLP projects

Ramsar Sites included in RLP projects	# of projects
Barmah Forest	1
Blue Lake	1
Bowling Green Bay	1
Cobourg Peninsula	1
Coongie Lakes	1
Corner Inlet	1
Currawinya Lakes (Currawinya National Park)	1
Eighty-mile Beach	1
Flood Plain Lower Ringarooma River	1
Ginini Flats Wetland Complex	1
Gippsland Lakes	1
Glenelg Estuary and Discovery Bay Ramsar Site	1
Great Sandy Strait (including Great Sandy Strait, Tin Can Bay and Tin Can Inlet).	1
Gwydir Wetlands: Gingham and Lower Gwydir (Big Leather) Watercourses	1
Hattah-Kulkyne Lakes	1
Hunter Estuary Wetlands	2
Kakadu National Park	1
Lake Gore	1
Lake Warden System	1
Little Llangothlin Nature Reserve	1
Logan Lagoon	1
Moreton Bay	1
Muir - Byenup System	1
Myall Lakes	3
Narran Lake Nature Reserve	2
NSW Central Murray Forests	1
Peel-Yalgorup System	1
Port Phillip Bay (Western Shoreline) And Bellarine Peninsula	3
Riverland	1
Roebuck Bay	1
Shoalwater and Corio Bays Area (Shoalwater Bay Training Area, in part - Corio Bay)	1
The Coorong, and Lakes Alexandrina and Albert Wetland	2
Toolibin Lake (also known as Lake Toolibin)	1
Towra Point Nature Reserve	1
Vasse-Wonnerup System	1
Western District Lakes	1
Western Port	1

Seventy-two % (i.e. 51 of 71) of priority threatened species are targeted by RLP projects including 85 % of threatened mammals, 85 % of threatened birds and 53 % of threatened plant species (Table 4) listed under the *Threatened Species Strategy* (Department of the Environment and Energy 2019). A total of 83 threatened fauna species are being targeted across current RLP projects (Table 4). The most commonly targeted species are birds (Figure 6) while the species targeted by the most projects (15) include Malleefowl (*Leipoa ocellata*) followed by Australasian Bittern (*Botaurus poiciloptilus*;

14 projects) and the Swift Parrot (*Lathamus discolour*; 14 projects). The Regent Honeyeater (*Anthochaera phrygia*) and Hooded Plover (*Thinornis rubricollis rubricollis*) are targeted by 12 projects each while the Eastern Curlew (*Numenius madagascariensis*) is a focus of ten projects (Table 4).



Figure 6. Representation of each faunal group targeted by RLP projects, both as primary and secondary investments reported as % of all RLP projects.

Thirty-seven threatened plant species are being targeted by current RLP projects (Table 4). The most commonly targeted species, comprising five projects, is *Swainsona recta*, referred to variously as small purple-pea or mountain Swainsona. Button wrinklewort (*Rutidosis leptorrhynchoides*) is the next most commonly targeted threatened plant species, referred to in four projects.

Threatened Species		Primary Investment	Secondary Investment
Mammals	Scientific Name		
Mala	Lagorchestes hirsutus	0	2
Mountain Pygmy-Possum	Burramys parvus	2	1
Greater Bilby	Macrotis lagotis	2	2
Numbat	Myrmecobius fasciatus	1	2
Brush-Tailed Rabbit-Rat	Conilurus penicillatus	1	0
Mahogany Glider	Petaurus gracilis	1	0
Western Quoll	Dasyurus geoffroii	1	5
Kangaroo Island Dunnart	Sminthopsis aitkeni	2	0
Eastern Barred Bandicoot	Perameles gunnii gunnii	2	1
Central Rock-Rat	Zyzomys pedunculatus	1	1
Leadbeater's Possum	Gymnobelideus leadbeateri	0	1
Eastern Bettong	Bettongia gaimardi	1	1

Table 4. Threatened species addressed as primary and secondary investments in RLP projects. N.B. RLP projects also consider additional threatened plants and animals not identified under the TSS.

Gilbert's Potoroo	Potorous gilbertii	0	1
Western Ringtail Possum	Pseudocheirus occidentalis	1	2
Black-Footed Rock-Wallaby	Petrogale lateralis	2	3
Eastern Quoll	Dasyurus viverrinus	0	1
Woylie	Bettongia penicillata	1	5
Northern Hopping Mouse	Notomys aquilo	1	0
Birds			
Mallee Emu-Wren	Stipiturus mallee	0	1
Night Parrot	Pezoporus occidentalis	1	1
Regent Honeyeater	Anthochaera phrygia	6	6
Hooded Plover	Thinornis rubricollis rubricollis	4	8
Yellow Chat	Epthianura crocea tunneyi	0	1
Western Ground Parrot	Pezoporus flaviventris	1	0
Red-Tailed Black Cockatoo (South- Eastern)	Calyptorhynchus banksii	3	0
Eastern Bristlebird	Dasyornis brachypterus	1	1
Helmeted Honeyeater	Lichenostomus melanops cassidix	1	0
Plains Wanderer	Pedionomus torquatus	3	1
Norfolk Island Green Parrot	Cyanoramphus cookii	0	0
Orange-Bellied Parrot	Neophema chrysogaster	1	2
Southern Cassowary	Casuarius casuarius johnsonii	1	1
Swift Parrot	Lathamus discolor	3	11
Australasian Bittern	Botaurus poiciloptilus	5	9
White-Throated Grasswren	Amytornis woodwardi	0	1
Golden-Shouldered Parrot	Psephotus chrysopterygius	2	0
Malleefowl	Leipoa ocellata	9	6
Eastern Curlew	Numenius madagascariensis	1	9
Flora			
Small Purple Pea	Swainsona recta	2	3
Little Mountain Palm	Lepidorrhachis mooreana	0	1
Caley's Grevillea	Grevillea caleyi	1	0
Magenta Lilly Pilly	Syzygium paniculatum	0	1
Fairy Bells	Homoranthus darwinoides	0	1
Mongarlowe Mallee	Eucalyptus recurva	1	0
Central Australian Cabbage Palm	Livistona mariae subsp. mariae	1	1
Glossy-Leafed Hammer-Orchid	Drakaea elastica	1	0
Ormeau Bottle Tree	Brachychiton Sp. Ormeau	1	0
Ant Plant	Myrmecodia beccarii	0	2
Whibley's Wattle	Acacia whibleyana	1	1
Spiny Rice Flower	Pimelea spinescens subspecies spinescens	0	3
Turnip Copperburr	Scierola enana piformis	0	2
Button Wrinklewort	Rutidosis leptorrhynchoides	1	3
Matchstick Banksia	Banksia cuneate	1	1
Scaly-Leaved Featherflower	Verticordia spicata subsp. Squamosa	1	0

With respect to Australia's listed World Heritage sites, RLP projects are targeting 73 % (i.e. 11 of 15; Table 5) while 48 % (i.e. 42 of 87) of EPBC listed threatened ecological communities are included in the current RLP program (Table 6).

Table 5. World Heritage sites addressed by RLP projects

World Heritage sites	# of Projects
Fraser Island	2
Gondwana Rainforests of Australia	3
Great Barrier Reef	2
Kakadu National Park	1
Lord Howe Island Group	1
Shark Bay	1
The Greater Blue Mountains Area	3
The Ningaloo Coast	1
Uluru-Kata Tjuta World Heritage Site	1
Wet Tropics World Heritage Site	1
Willandra Lakes Region	1

Table 6. Threatened Ecological Communities addressed by RLP projects

Threatened Ecological Communities included in RLP projects	# of Projects
Subtropical and Temperate Coastal Saltmarsh	14
White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native	11
Grasslands	
Alpine Sphagnum Bogs and Associated Fens	7
Littoral Rainforest and Coastal Vine Thickets of Eastern Australia	6
Buloke Woodlands of the Riverina and Murray-Darling Depression Bioregions	5
Brigalow (Acacia harpophylla dominant and co-dominant)	4
Banksia Woodlands of the Swan Coastal Plain ecological community	3
Eucalypt Woodlands of the Western Australian Wheatbelt	3
Grassy Woodlands and Derived Native Grasslands od South-eastern Australia	3
Grey Box (Eucalyptus microcarpa) Grassy Woodlands and Derived Native	3
Grasslands of South-eastern Australia	
Semi-evergreen vine thickets of the Brigalow Belt (North and South) and	3
Nandewar Bioregions	
Clay Pans of the Swan Coastal Plain	2
Natural Temperate Grassland of the Victorian Volcanic Plain	2
Peppermint Box (Eucalyptus odorata) Grassy Woodland of South Australia	2
Upland Basalt Eucalypt Forests of the Sydney Basin Bioregion	2
Upland Wetlands of the New England Tablelands (New England Tableland	2
Bioregion) and the Monaro Plateau (South Eastern Highlands Bioregion)	
Arnhem Plateau Sandstone Shrubland Complex	l
Broad leaf tea-tree (Melaleuca viridiflora) woodlands in high rainfall coastal	1
north Queensland	
Central Hunter Valley eucalypt forest and woodland	l
Coolibah - Black Box Woodlands of the Darling Riverine Plains and the	1
Brigalow Belt South Bioregions	
Corymbia calophylla - Kingia australis woodlands on heavy soils of the Swan	1
Coastal Plain	1
Eyre Peninsula Blue Gum (Eucalyptus petiolaris) Woodland	1
Grassy Eucalypt Woodland of the Victorian Volcanic Plain	1
Iron-grass Natural Temperate Grassiana of South Australia	1
Kangaroo Islana Narrow-leavea Mallee (Eucalyptus cheorijolia) wooalana	1
Lowiana Kainjoresi oj Subiropical Australia Mahi Ecocot	1
Madi Forest Managan wing thighests on the constal and during of the Darmier Daringula	1
Monsoon vine inickels on the coastal sand dures of the Dampier Feninsula Natural grasslands on basalt and fine taxturad allunial plains of northern Nou	1
Natural grassianas on basait and jine-textured attavial plains of northern New South Walas and southern Quaansland	1
Now England Poppermint (Eucalyntus nova anglica) Crassy Woodlands	1
Perched Wetlands of the Wheathelt region with extensive stands of living sheadk	1
and paperbark across the lake floor (Toolibin Lake)	1
Proteaceae Dominated Kwongkan Shrublands of the Southeast Coastal Floristic	1
Province of Western Australia	Ĩ
Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains	1
Shale Sandstone Transition Forest of the Sydney Rasin Rioregion	1
Shrublands and Woodlands of the eastern Swan Coastal Plain	1
Shrublands and Woodlands on Perth to Gingin ironstone (Perth to Gingin	1
ironstone association) of the Swan Coastal Plain	-
Swamps of the Fleurieu Peninsula	1
Temperate Highland Peat Swamps on Sandstone	1
The community of native species dependent on natural discharge of groundwater	1
from the Great Artesian Basin	
Thrombolite (microbial) community of coastal freshwater lakes of the Swan	1
Coastal Plain (Lake Richmond)	
Turpentine-Ironbark Forest of the Sydney Basin Bioregion	1
Weeping Myall Woodlands	1
3.3 RLP project monitoring and evaluation

3.3.1 Reporting requirements

Service providers delivering RLP projects are committed to meeting several reporting requirements which are to be submitted through the MERIT online reporting tool at specified junctures (Table 7). Data used to generate the RLP project database reported on here, for example, were reported by service providers to MERIT in the first stage of reporting. Of particular relevance to the proposed LTMF is the requirement for RLP projects to provide medium-term outcomes reports at the end of their project durations and, for projects over three years an additional short-term outcomes report after three years (Table 7).

3.3.2 Ecological monitoring and evaluation

The project services established for MERIT provide a basis for monitoring and evaluation of each of the RLP projects. These services are designed to drive effective reporting by identifying indicators and measures to assess progress of project-related outcomes (National Landcare Program 2019). Most services contracted by current RLP projects are associated with the hard and soft interventions to be implemented, e.g. controlling access, controlling pest animals and developing and delivering communication materials (Figure 7). Service providers are to report on these in quarterly outputs reports (Table 7) provided to MERIT using quantifiable indicators such as kilometres of fencing installed, area (ha) of pest control conducted or the number of training/workshop events held (Appendix 1).

A total of 35 general services are currently listed with 69 metrics specified in MERIT for reporting on these (Appendix 1. Currently, community and stakeholder engagement represents the service being provided by most RLP projects (214 activities), followed by removing weeds (154 activities), controlling pest animals (139 activities), project planning and delivery of documents (116 activities) and establishing and maintaining agreements (100 activities; Figure 7).

Thirty-nine services are directly associated with ecological monitoring, e.g. fauna survey etc. (Appendix 1). However, specific details regarding the selection of indicators, monitoring protocols or evaluation approaches to be adopted by projects in delivering such services are not currently available via MERIT.

Stage of reporting	Type of reporting	Frequency
First stage of reporting	 Project description and information, including: Primary and Secondary investments Short-term and Medium-term Outcomes Threats Interventions Indicators and Baselines, Targeted Project Services (based on MERIT Ready Reckoner V2 list of Services). 	Initial reporting before the start of the project
Output reports	"Services" delivered by the project (including spatial reporting and photographs)	Quarterly or six-monthly
Annual reports	Key achievements and/or issues and any proposed adaptive management actions	Annually
Outcomes 1 Report	"Short-term outcomes" evaluation	For projects of three years or less - project end date
		For projects of over three years – three-year mark of the project
Outcomes 2 Report	"Medium-term outcomes" evaluation	Projects of over three years - project end date
Core Services reporting	"Core Services" evaluation	With each invoice and annually

Table 7. Reporting requirements and frequency required of RLP service providers. (Adapted from theRegional Land Partnerships Evaluation Plan, Department of the Environment and Energy, 2018)



Figure 7. Bar graph of general project services (arranged alphabetically) and how many times each is represented across all RLP projects. N.B. Asterisks indicate services associated with ecological monitoring and evaluation.

Evaluation requirements

4.1 Purpose of the RLP LTMF

The long-term ecological monitoring and evaluation framework presented here is designed to facilitate evaluation of the RLP Program nationally. Specifically, the proposed LTMF will allow evaluation of the four key environmental outcomes for the Program after 3 years (i.e. mid-way through the program) and at its completion (i.e. after 5 years). While beyond the scope of this project and the RLP Program itself, the LTMF presented here may provide a robust platform for evaluating national NRM investments into the future.

The two major purposes of the RLP LTMF proposed here are therefore to:

- enable evaluation and reporting of ecological outcomes of the RLP program; and
- inform future NRM investment, policy and adaptive management.

In developing our proposal, however, we have also sought to design a LTMF that will additionally:

- ensure effective and robust data collection, management and accessibility;
- generate relevant knowledge, test assumptions and inform best practice;
- facilitate knowledge sharing; and
- support a broad culture of long-term ecological monitoring and evaluation in Australia.

4.2 Program-level evaluation questions

4.2.1 Program logic

The RLP program logic was developed using a theory of change that has resulted in a program hierarchy approach to describing how the Program will improve Australia's natural environment and natural resources (Department of the Environment and Energy, 2017). The program logic comprises six key long-term outcomes, of which the first four are relevant to the current project (Figure 1), each with a corresponding 5-year outcome. We have reframed these outcomes as overarching evaluation questions for the LTMF (Table 8).

4.2.2 Evaluation questions

We have developed a suite of key evaluation questions (KEQs) associated with each RLP program outcome to reflect the models of NRM systems, and ecological monitoring and evaluation of these, that we have developed to structure the LTMF (see Chapter 2). These comprise *descriptive evaluation questions* concerning assessments of each component of the relevant NRM system as well as *mechanistic evaluation questions* regarding relationships between these components. Because knowledge generation is itself an important component of this program, we have also included a suite of knowledge generation questions (Table 8). Ultimately, it would be ideal if these key evaluation questions also encompassed assessment of the human component of NRM programs (Figure 2), although these have not been considered in the current proposal due to time constraints.

4.3 Project-level evaluation questions

Individual project logics have been developed for each RLP project and submitted to MERIT as part of the first stage of project reporting required (Table 7). These project logics describe the activities (i.e. core services) to be provided by projects, as well as their expected short- and medium-term outcomes, forming the basis for subsequent reporting (Department of the Environment and Energy, 2018).

While evaluation of ecological outcomes of RLP projects in the short- and medium-term will clearly be highly specific to particular project contexts, reporting on these could nevertheless be aligned with program-level KEQs in many, if not most, cases (Table 8). Project-level reporting in relation to relevant KEQs would provide an opportunity for consistent evaluation of RLP projects and the capacity to aggregate information and conduct higher-level evaluations across ecological targets, spatial regions and RLP program outcomes. Towards this end, we have provided a suggested template to guide short-term and mid-term outcomes reporting for RLP projects (Appendix 2).

Table 8. Key Evaluation Questions for the RLP Program including generic questions and more specific questions in relation to each Outcome. N.B. These questions can be addressed across multiple levels of the program hierarchy, i.e. project-level, area-based (e.g. State), program-level).

KEQ ID	Outcome 1. Ramsar sites	Outcome 2. Threatened Species	Outcome 3. World Heritage sites	Outcome 4. Threatened Ecological Communities
Program Logic evaluation questions:				
Long-term evaluation questions	Has the ecological character of Ramsar sites been maintained or improved?	Have the trajectories of species targeted under Threatened Species Strategy and other EPBC priority species improved?	Have the natural heritage Outstanding Universal Value of World Heritage sites been maintained or improved?	Have the condition of EPBC Act Threatened Ecological Communities been improved?
Five-year evaluation questions	Has the ecological character of Ramsar sites been restored through the implementation of priority actions? Have threats to the ecological character of Ramsar sites been reduced through the implementation of priority actions?	Have the trajectories of species targeted under Threatened Species Strategy and other EPBC priority species stabilised or improved?	Has invasive species management reduced threats to the natural heritage Outstanding Universal Value of World Heritage sites through the implementation of priority actions?	Have the condition of EPBC Act Threatened Ecological Communities been improved through the implementation of priority actions?

KEQ ID		Outcome 1. Ramsar sites	Outcome 2. Threatened Species	Outcome 3. World Heritage sites	Outcome 4. Threatened Ecological Communities
Descriptive	evaluation questions:				
Threats					
DE_TH1	What are the key threats of concern?	What are the key threats to Ramsar sites listed in Ecological Character Descriptions and other site- based management plans?	What are the key threats to priority threatened species listed in the Threatened Species Strategy and relevant species recovery plans?	What are the key threats to the natural heritage Outstanding Universal Value of World Heritage sites listed in relevant conservation advice and management plans?	What are the key threats to EPBC Act Threatened Ecological Communities listed in relevant conservation advice and management plans?
DE_TH2	What are the key threats being addressed by the RLP program? (N.B. In addressing this question, key threats not being addressed by the RLP program should also be identified.)	What are the key threats to Ramsar sites being addressed by RLP projects?	What are the key threats to priority threatened species being addressed by RLP projects?	What are the key threats to the natural heritage Outstanding Universal Value of World Heritage sites being addressed by RLP projects?	What are the key threats to EPBC Act Threatened Ecological Communities being addressed by RLP projects?
DE_TH3	What are the extent and magnitude of each key threat i) nationally and ii) with respect to RLP projects and targets?	What are the extent and magnitude of each key threat to Ramsar sites i) nationally and ii) with respect to RLP projects?	What are the extent and magnitude of each key threat to priority threatened species i) nationally and ii) with respect to RLP projects?	What are the extent and magnitude of each key threat to the natural heritage Outstanding Universal Value of World Heritage sites i) nationally and ii) with respect to RLP projects?	What are the extent and magnitude of each key threat to EPBC Act Threatened Ecological Communities i) nationally and ii) with respect to RLP projects?

KEQ ID		Outcome 1. Ramsar sites	Outcome 2. Threatened Species	Outcome 3. World Heritage sites	Outcome 4. Threatened Ecological Communities
DE_TH4	Have key threats expanded/contracted, intensified/reduced or changed in their importance i) nationally and ii) with respect to RLP projects?	Have the extent, magnitude and/or importance of key threats to Ramsar sites changed i) nationally and ii) with respect to RLP projects?	Have the extent, magnitude and/or importance of key threats to priority threatened species changed i) nationally and ii) with respect to RLP projects?	Have the extent, magnitude and/or importance of key threats to the natural heritage Outstanding Universal Value of World Heritage sites changed i) nationally and ii) with respect to RLP projects?	Have the extent, magnitude and/or importance of key threats to EPBC Act Threatened Ecological Communities changed i) nationally and ii) with respect to RLP projects?
DE_TH5	Have any new actual or potential threats emerged?	Have any new actual or potential threats to Ramsar sites emerged i) nationally and ii) with respect to RLP projects?	Have any new actual or potential threats to priority threatened species emerged i) nationally and ii) with respect to RLP projects?	Have any new actual or potential threats to the natural heritage Outstanding Universal Value of World Heritage sites emerged i) nationally and ii) with respect to RLP projects?	Have any new actual or potential threats to EPBC Act Threatened Ecological Communities emerged i) nationally and ii) with respect to RLP projects?
Intervention	ns				
DE_IN1	Which NRM interventions have been implemented under the RLP program?(N.B. In addressing this question, priority actions not being implemented by the RLP program should also be identified.)	Which priority actions have been implemented to restore, and reduce threats to, the ecological character of Ramsar sites under the RLP program?	Which priority actions have been implemented to stabilise or improve the trajectory of priority threatened species under the RLP program?	Which priority actions have been implemented to reduce threats to the natural heritage Outstanding Universal Value of World Heritage sites under the RLP program?	Which priority actions have been implemented to improve the condition of EPBC Act Threatened Ecological Communities under the RLP program?
DE_IN2	To what extent and magnitude has each priority action been	To what extent and magnitude has each	To what extent and magnitude has each	To what extent and magnitude has each	To what extent and magnitude has each

KEQ ID		Outcome 1. Ramsar sites	Outcome 2. Threatened Species	Outcome 3. World Heritage sites	Outcome 4. Threatened Ecological Communities
	 implemented i) nationally and ii) with respect to RLP projects and targets? (N.B. In addressing this question with respect to RLP targets, the implementation of actions should be considered in the immediate vicinity of targets as well as in their broader landscape of influence.) 	priority action been implemented with respect to Ramsar sites i) nationally and ii) with respect to RLP projects?	priority action been implemented with respect to priority threatened species i) nationally and ii) with respect to RLP projects?	priority action been implemented with respect to the natural heritage Outstanding Universal Value of World Heritage sites i) nationally and ii) with respect to RLP projects?	priority action been implemented with respect to EPBC Act Threatened Ecological Communities i) nationally and ii) with respect to RLP projects?
Targets	·	·	·	·	·
DE_T1	Which ecological targets have been addressed under the RLP program? (N.B. In addressing this question, priority ecological targets not being implemented by the RLP program should also be identified.)	Which Ramsar sites, and which attributes of their ecological character, have been addressed by projects under the RLP program?	Which priority threatened species, and which attributes of their trajectories (e.g. extent, distribution, population size, reproduction, habitat availability etc.) have been addressed by projects under the RLP program?	Which World Heritage sites, and which natural heritage Outstanding Universal Values of these, have been addressed by projects under the RLP program?	Which EPBC Act Threatened Ecological Communities, and which attributes of their condition (e.g. extent, distribution, composition, structure, function, connectivity, resilience etc.) have been addressed by projects under the RLP program?
DE_T2	Has the condition of ecological targets addressed under the RLP program changed (i.e. improved or declined) i) nationally and ii) respect to RLP projects?	Has the ecological character of Ramsar sites, and with respect to which attributes, changed (i.e. been restored or declined) i) nationally and ii) respect to RLP projects?	Have the trajectories of priority threatened species, and with respect to which attributes, changed (i.e. improved or declined) i) nationally and ii) respect to RLP projects?	Has the condition of World Heritage sites, and with respect to which natural heritage Outstanding Universal Values of these, changed (i.e. improved or	Has the condition of EPBC Act Threatened Ecological Communities, and which attributes of their condition, changed (i.e. improved or declined) i)

KEQ ID		Outcome 1. Ramsar sites	Outcome 2. Threatened Species	Outcome 3. World Heritage sites	Outcome 4. Threatened Ecological Communities
				declined) i) nationally and ii) respect to RLP projects?	nationally and ii) respect to RLP projects?
DE_T3	To what extent and magnitude has the condition of ecological targets addressed under the RLP program changed (i.e. improved or declined) i) nationally and ii) with respect to RLP projects and targets?	To what extent and magnitude has the ecological character of Ramsar sites, and with respect to which attributes, changed (i.e. been restored or declined) i) nationally and ii) respect to RLP projects?	To what extent and magnitude have the trajectories of priority threatened species, and with respect to which attributes, changed (i.e. improved or declined) i) nationally and ii) respect to RLP projects?	To what extent and magnitude has the condition of World Heritage sites, and with respect to which natural heritage Outstanding Universal Values of these, changed (i.e. improved or declined) i) nationally and ii) respect to RLP projects?	To what extent and magnitude has the condition of EPBC Act Threatened Ecological Communities, and which attributes of their condition, changed (i.e. improved or declined) i) nationally and ii) respect to RLP projects?
Mechanistic	e evaluation questions				
ME_1	Have NRM interventions implemented under the RLP program had their desired/expected primary response?	Have NRM interventions implemented by projects under the RLP program with respect to Ramsar sites had their desired primary response?	Have NRM interventions implemented by projects under the RLP program with respect to priority threatened species had their desired primary response?	Have NRM interventions implemented by projects under the RLP program with respect to natural heritage Outstanding Universal Values of World Heritage sites had their desired primary response?	Have NRM interventions implemented by projects under the RLP program with respect to EPBC Act Threatened Ecological Communities had their desired primary response?
ME_2	Have NRM interventions implemented under the RLP program influenced the extent, magnitude and/or other attributes of key threats?	Have NRM interventions implemented under the RLP program influenced the extent, magnitude and/or other attributes of	Have NRM interventions implemented under the RLP program influenced the extent, magnitude and/or other attributes of	Have NRM interventions implemented under the RLP program influenced the extent, magnitude and/or other attributes of key threats to natural heritage Outstanding	Have NRM interventions implemented under the RLP program influenced the extent, magnitude and/or other attributes of key threats to EPBC Act

KEQ ID		Outcome 1. Ramsar sites	Outcome 2. Threatened Species	Outcome 3. World Heritage sites	Outcome 4. Threatened Ecological Communities
		key threats to Ramsar sites?	key threats to priority threatened species?	Universal Values of World Heritage sites?	Threatened Ecological Communities?
ME_3	Have NRM interventions implemented under the RLP program influenced condition of ecological targets addressed by RLP projects?	Have NRM interventions implemented under the RLP program influenced the ecological character of Ramsar sites?	Have NRM interventions implemented under the RLP program influenced the trajectories of priority threatened species?	Have NRM interventions implemented under the RLP program influenced the condition of natural heritage Outstanding Universal Values of World Heritage sites?	Have NRM interventions implemented under the RLP program influenced the condition of EPBC Act Threatened Ecological Communities?
ME_4	What other drivers have affected threats to ecological targets addressed by RLP projects and ecological responses to these?	What other drivers have affected threats to the ecological character of Ramsar sites addressed by RLP projects and ecological responses to these?	What other drivers have affected threats to priority threatened species addressed by RLP projects and ecological responses to these?	What other drivers have affected threats to the natural heritage Outstanding Universal Values of World Heritage sites addressed by RLP projects and ecological responses to these?	What other drivers have affected threats to EPBC Act Threatened Ecological Communities addressed by RLP projects and ecological responses to these?
ME_5	What other drivers have affected the condition of ecological targets addressed by RLP projects?	What other drivers have affected the ecological character of Ramsar sites addressed by RLP projects?	What other drivers have affected the trajectories of priority threatened species addressed by RLP projects?	What other drivers have affected the condition of natural heritage Outstanding Universal Values of World Heritage sites addressed by RLP projects?	What other drivers have affected the condition of EPBC Act Threatened Ecological Communities addressed by RLP projects?

KEQ ID		Outcome 1. Ramsar sites	Outcome 2. Threatened Species	Outcome 3. World Heritage sites	Outcome 4. Threatened Ecological Communities
Knowledge	generation				
KG_1	What datasets have been generated by the RLP program?				
KG_2	Has the RLP program increased our understanding of priority ecological targets and threats to these?				
KG_3	Has the RLP program increased our knowledge of best practice NRM?				
KG_4	What is the best practice NRM for the	e future?			

Descriptive evaluation pathway

5.1 Overview

This chapter provides a blueprint for the proposed descriptive evaluation pathway of the RLP LTMF. As defined in Chapter 2, this evaluation pathway concerns the collection, collation, analysis and evaluation of monitoring data obtained under the RLP program, as well as relevant and available supplementary data, to describe and assess trends and trajectories in the threats, interventions and ecological targets being considered by RLP projects, and especially those pertaining to KEQs at the program level (Table 8).

Although this evaluation pathway also has the potential to facilitate many informative and useful comparisons between selected indicators in space and time (e.g. trajectories of different species or ecological communities), as well as identifying correlations between these (e.g. covariance of trajectories of weed control measures and native plant species diversity), this pathway is not intended to demonstrate mechanistic links (i.e. cause and effect) between various elements (e.g. effects of interventions on targets). For the latter, we propose the development of RLP MER networks to conduct targeted, scientifically robust monitoring designed to address key mechanistic evaluation questions (Chapter 6). The main aims of the descriptive evaluation pathway proposed here are to:

- enable comprehensive data collection and some degree of data analysis, evaluation and reporting across the current round of RLP projects; and
- to establish a robust framework for improved monitoring and evaluation under future rounds of national NRM investment.

While we recommend that the descriptive evaluation pathway is developed in close conjunction with that of Latimer (Chapter 7), there are some components of this pathway which will be independent of this platform (e.g. pre-established RLP project-level data collection protocols). Additionally, many components (e.g. input of relevant supplementary data, analytical modules) will only be able to be fully developed once ecological data (or metadata) from RLP projects becomes available. Consequently, here we provide an outline for key elements of the proposed descriptive evaluation pathway that might be instigated either independently or as part of the development of an integrated online platform.

The key components of the descriptive evaluation pathway considered here are:

- monitoring;
- data collection;
- data management;
- data analyses;
- evaluation; and
- reporting.

5.2 Monitoring

Ecological monitoring is being conducted by many, if not most, RLP projects, including some for which ecological monitoring is the primary focus (see Figure 7). Although a complete picture of existing monitoring commitments of RLP projects is not currently available (see Section 3.1), there can be little doubt that this will necessarily entail a high degree of diversity with respect to purposes and methods.

Through consultation conducted during the current project, we have identified two broad categories of RLP projects in relation to ecological monitoring:

- a. RLP projects already committed to existing monitoring protocols (e.g. projects following existing condition assessment methods, historical sampling methodologies etc.); and
- b. RLP projects seeking guidance on appropriate monitoring protocols or willing to adopt new, standardised protocols.

For the first group, monitoring data might still be standardised at the stage of data collection (see next section) but will require thorough accompanying metadata for this to be incorporated in subsequent analyses and aggregated reporting under the RLP LTMF. For the second group, there is an opportunity to recommend standardised monitoring protocols. This will also enable such standardised protocols to be tested and adapted for increased endorsement in future NRM programs.

Despite the intrinsic diversity of monitoring requirements across RLP projects, relevant ecological outcomes mainly concern responses of either species, communities or ecosystems (or all of these). There has been considerable investment in the collaborative development of robust, standardised ecological monitoring protocols in Australia in recent years, especially under the Terrestrial Ecosystem Research Network (TERN; <u>www.tern.org.au</u>). We therefore advocate using these methods as the basis for standardised monitoring of ecological targets under the RLP LTMF to facilitate

aggregated data analyses and reporting and evaluation of outcomes at scales greater than that of individual projects. Adoption of these protocols further enables the use of rich existing supporting materials (e.g. detailed survey manuals and data entry Apps), as well as enhancing national ecological surveillance monitoring and evaluation capacity both within the RLP LTMF (e.g. via comparisons with existing survey data) and more broadly (i.e. via contributions from the RLP LTMF to national data repositories).

We recognise that there is an inherent need for many RLP projects to adopt more specific, individualised monitoring techniques to address localised or target-specific evaluation questions, such as those associated with particular threatened species or certain ecological processes. While there will undoubtedly be opportunities over the RLP program to develop, collate and share such target-specific monitoring methods, these are not considered further in the current proposal beyond inclusion of their potential development in the operational road map provided in Chapter 8.

We propose the development of a modular approach to standardised monitoring at a project-level be recommended under the RLP LTMF, involving a series of protocols that can be utilised (and adapted) by RLP projects as required in relation to a particular NRM system of concern. In addition to protocols for monitoring ecological targets, accompanying protocols for monitoring threats, as well as natural drivers, will also be required for a comprehensive picture of NRM systems under the RLP LTMF. For the most part, we anticipate that interventions conducted as part of RLP projects are already being monitored and reported on as services via quarterly and annual output reports submitted to MERIT. Nevertheless, standardised protocols for monitoring interventions (e.g. condition of fencing) may still be needed.

The major modules of standardised monitoring protocols we are initially recommending for the RLP LTMF are:

- habitat condition monitoring
- fauna surveillance

We also provide some guidelines regarding monitoring of targeted threatened species.

5.2.1 Habitat condition monitoring

Habitat condition monitoring is highly relevant to evaluating the RLP program across all four ecological Outcomes. For threatened ecological communities, habitat condition is at the heart of the RLP program logic while for Ramsar sites, habitat condition monitoring can inform assessments of both change in ecological character and threats. Changes in natural heritage Outstanding Universal Values in World Heritage sites, and threats to these associated with invasive plant species, can also be investigated via habitat condition monitoring. Furthermore, habitat condition is likely to be an important aspect to understanding trajectories of threatened species. For species of threatened flora, survey protocols conducted under habitat condition monitoring (e.g. identification, recording and collection of vascular plant species, point intercept surveys) may also directly inform assessments of target species.

Extensive standardised survey protocols for monitoring habitat condition have been developed following significant consultation and reviews of existing monitoring methodologies by TERN AusPlots for rangelands, forests and woodlands (White et al. 2012; Wood et al. 2014; Wundke et al. 2015; Sparrow et al. 2016). We recommend these protocols, each of which is accompanied by a detailed manual, be promoted for use under the RLP LTMF with the proviso that the range of indicators measured, as well as sampling design, will depend on a project's specific context.

Indicators

A range of habitat condition indicators have been carefully described in the various AusPlots survey protocols (Table 9), all with detailed methods and data sheets provided in relevant manuals (White et al. 2012; Wood et al. 2014; Wundke et al. 2015; Sparrow et al. 2016). We recommend that RLP projects seeking to adopt standardised methods select methods from these protocols appropriate to their particular context. As per proposals made in the Discussion Paper developed in the first stage of this project (Capon et al. 2018), we also recommend the inclusion of several additional indicators including those associated with propagule availability and ecoacoustics (Table 9)

It should be noted that additional indicators will be required for monitoring habitat condition in Ramsar sites in relation to hydrology and water quality, but standardised measures to record many of these (e.g. soil moisture, inundation) could be added relatively easily to AusPlots survey methods with respect to soil description at a plot level. We recommend that protocols for these be developed in collaboration with ongoing development of long-term ecological monitoring and evaluation of wetlands being developed on behalf of the Commonwealth Environmental Water Office as well as the States. Table 9. Indicators of habitat condition proposed for the RLP LTMF. These include indicators described under AusPlots Condition, AusPlots Rangelands and AusPlots Forest protocols as well as several additional measures specific to the RLP outcomes. N.B. time estimates are based on those suggested in AusPlots manuals as well as the experiences of the authors.

Measure	Description	Estimated time per plot	Importance for evaluating RLP outcomes
Source: AusPlot Condition prot	ocols (Wundke et al. 2015) – 1 ha plot with 4 x 100 m point intercept transects and 5 x 100 m line trans	sects	
Growth stage / age class of vegetation	Condition point intercept survey over 4 x 100 m transects + visual assessment	1-2 hours	High
Litter depth	Condition point intercept survey over 4 x 100 m transects + litter depth gauge		High
Fire extent	Condition point intercept survey over 4 x 100 m transects + visual assessment, measurement of fire scar height		High
Factors affecting vegetation health	Condition point intercept survey over 4 x 100 m transects + visual assessment		High
Cover and quantity of coarse woody debris	Measurement of coarse woody debris diameter, length and decay class over 5 x 100 m transects	2-3 hours	High
Source: AusPlot Rangelands (W marked)	white et al. 2012) – 1 ha plot with ten transects (5E/W and 5 N/S). Nine points (four corners, edge midp	oints and centre are	
Cover of individual plant species	Cover measures are determined using point intercept transects where cover measures are made at 1 m intervals, starting at 0m. Ten 100 m transects (5E/W and 5 N/S orientation) are completed using a staff fitted with a laser pointer and densitometer. All plants below 1.5 m height that are intersected by the laser pointer are identified and recorded together with their height (see below).	3-6 hours	High
Cover of substrate types (bare soil, litter, rocks, biological crusts, coarse woody debris) (i.e. below 1.5 m)	Growth form cover measures are made using the point transects above where substrate type is determined by the feature intersected by the laser pointer.		High
Height of mid and lower vegetation strata	The uppermost height of any plant intercepted by the laser pointer along transects is recorded together with the species and growth form data. Voucher specimens are collected as required.		High

Measure	Description	Estimated time per plot	Importance for evaluating RLP outcomes
Canopy cover	Canopy cover is estimated using the densitometer to quantify any canopy intercepts and each point along transects. Canopy species are recorded are points where canopy was present but not intersected compared to open sky.		High
Basal area of individual tree and shrub species	A basal wedge is used to estimate the basal area (cross-sectional area) of trees and shrubs at breast height (1.3 m) from nine sampling points in the 1 ha plot. This means that basal area is determined from an area greater than the plot size itself. If there are no trees or shrubs that meet height requirements the basal wedge is not used. At each sampling point the basal wedge is used to determine the basal area for each species.	20 minutes	High
Total basal area	The total basal area is the sum of the individual species basal area measures for the nine sampling points. This provides an approximation of the basal area of the vegetation community.		High
Dominant species (top 3) in each stratum of vegetation (upper, middle and ground)	The dominant species are determined to provide an indication of the structural aspects of the community. For each of three strata the dominant species are identified. For the upper stratum only trees are included (i.e. no shrubs, grasses etc.), for the middle layer all low trees, shrubs, grass trees, tall grasses are included (i.e. no low grasses, forbs, rushes etc.), for the ground layer only grasses, forbs, low shrubs, lichens, ferns are included (i.e. no trees, tall shrubs).	5 minutes	High
Leaf area index (LAI)	The LAI is determined using a LAI-2200 instrument that calculates the canopy light intercepts. This is used in plots where there is canopy cover (vegetation > 2 m in height). Avoid taking measurements in direct sunlight. LAI measurements are taken at 50 points along N/S transects (10 points per transects, i.e. one every 10 m).	20 minutes	High
Plot homogeneity	This measure refers to how homogeneous the plot being sampled is to the surrounding landscape. A visual estimate is made of the minimum distance from the plot centre point to a vegetation community that is different to the one being sampled.	5 minutes	High
Erosion description (erosion types, erosion state, erosion extent) (plot level)	An erosion description is an important part of assessing the soils and landscape. Erosion can be described by the type, state and extent using a series of predetermined codes. Type refers to wind, water, mass movement etc., state refers to active, stabilised to partly stabilised erosion while extent refers to the magnitude ranging from not apparent (X), none to very severe (scores of 0-4). Measures and categories fully described in the Australian Soil and Land Survey Field Handbook (2009; also referred to as the Yellow Book).	2-3 hours	Moderate
Microrelief (plot level)	This refers to the relief of the land up to a few metres above the plane of the land. Categories used are Gilgai, Hummocky, Biotic, Other with assessments also being made as to the proportion of Gilgai as well as the specific components sampled.		Moderate

Measure	Description	Estimated time per plot	Importance for evaluating RLP outcomes
Drainage (plot level)	A brief statement is made about soils and plot drainage likely to occur. Codes (1-6) are used to refer to areas on a continuum from areas that are very poorly drained to those that are rapidly drained.		High
Disturbance (plot level)	Disturbance measures relate to the assessment of grazing, logging, cultivation etc. on the site. There are eight categories used with 0 referring to natural sizes with no disturbance, 1 are sites with grazing (Light, Medium or Heavy) by hoofed animals. Categories 2 & 3 refer to the extent of clearing (either limited, e.g. selective logging, or extensive respectively). Categories 4-7 are those that have been completed cleared but have varying levels of cultivation and irrigation. Category 8 refers to sites that are highly disturbed (e.g. quarries, mine sites, roads).		High
Soil surface condition (plot level)	Refers to the condition when the soils are dry. These are full described in the Yellow Book and include 15 different classifications (e.g. cracking, loose, firm, trampled, saline, recently cultivated etc.)		High
Soil core observations	A soil core is one of the methods used to make soil observations within the plot. Five are sampled in the SW corner $(25 \times 25 \text{ m})$ and a further four are positions randomly throughout the 1 ha plot to sample the full range of vegetation cover classes. Core positions close to trees need to record the distance to these trees. Cores are made to a depth of 30 cm and 500g soil samples are collected for each 10 cm depth increment. Bagged samples are photographed <i>in situ</i> before being dried and forwarded to the National Soil Archive.	2-3 hours	Low
Soil bulk density	The soil bulk density is useful in the determination of carbon content, but only indicative values are obtained at AusPlot sites. Samples are taken from the 0-10 cm layer as well as 10-20 cm and 20-30 cm. Care must be taken not to disturb the soil within each core before packaging for processing.		Low
Soil metagenomics	A small sample (200 g) of soil is taken after clearing the soil surface of any vegetation (leaf litter etc.) or animal material (e.g. scats) at each of the nine soil observation locations. Samples are stored with silica and labelled with plot information. Analyses by the University of Adelaide identify organisms from genetic material retained in the soils and provide an indication of their abundance.		Low
Source: AusPlot Forests (Wood Large Tree Survey Module. Sub	s et al. 2014) – 1 ha plots with corners marked. $20x20$ m subplots also marked with droppers. Importar plots monitored in sequence from 1-25.	nt modules in this man	nual are the
Number of stems of individual tree species	In each 20x20 m sub-plot tag and measure all stems > 10cm DBH (1.3 m). Identify all tagged individuals to species level and assign a 6 letter code (first three letters of Genus followed by first three letters of Species). X and Y coordinates of each tree on the sub-plot from origin is also	3-6 hours	High

Measure	Description	Estimated time per plot	Importance for evaluating RLP outcomes
	recorded. Living trees on the plot are numbered sequentially. Voucher specimens of species that cannot be identified in the field are taken.		
Diameter at breast height (DBH) of individual tree stems of each species	The DBH is measured at 1.3m height for all trees > 10 cm. If DBH cannot be measured at this height (e.g. burl, branching trunk etc.) the point of measurement is recorded.		High
Alive and growth stages of each tree species	Trees tagged are recorded as Alive (A), Dead (D) or Resprouting (R). Growth stages are subjectively observed using standard forestry codes. Tree may be regarded as regenerating, regrowth, mature, senescing or dead (various stages of decay). Trees can also be assigned to different crown classes e.g. emergent, dominant etc.		High
Mode of death of dead trees	The manner in which a tree died may be determined from repeated visits to sites. A number of codes are provided for listing the mode of death in the 'forests manual' and are assigned to three categories, the physical mechanism of mortality, the number of trees killed, and whether the tree was the killer or killed.		High
Height and bole height of individual trees	Tree height refers to the height of the tree from the base of the trunk to the height of the tallest part of the canopy. Bole height refers to the height from the base of the trunk to the height of the first major green branch (i.e. supporting living foliage) from the trunk. Should be recorded for all trees on the plot. Height is best measured using a vertex hypsometer.		High
Shrub biomass	Determined by measuring the height (nearest cm), life-form and density of 20 shrubs (5 individuals in each 7 m sub-transect) closest to the transect. Shrubs over 1.3 m in height also have their DBH measured.		High
Fuel load	Fuel measurements are taken along a single diagonal transect in each of four 20x20 m sub-plots. Key fuel parameters to record include fuel height, grass height, woody fuel, shrub biomass, fine fuel. Measurements are taken at 18 points along transects. Woody fuel is quantified by counting the number of items in four size classes in a nested hierarchical approach.	TBD	High
Litterfall	Measured using four litterfall traps of 0.75 x 0.75 m dimension.	1-2 hours	High
Temperature and humidity	Measured using iButton data loggers deployed on the 1 ha plot. Two temperature loggers and one humidity logger deployed at each site.		High

Measure	Description	Estimated time per plot	Importance for evaluating RLP outcomes
Litter decomposition	Measured by placing 15 mesh bags (each with 10g of dried leaf litter previously collected from the site) as well as 6 control bags (with a $10x10$ cm calico cloth) at the centre of the plot. Bags are weighed and recorded before deploying on site.		Moderate
Additional proposed condition r	neasures (N.B. some associated preliminary sampling protocols provided in RLP LTMF Stage 1 Discu	ssion Paper – Capon e	et al. 2018)
Canopy seed bank	Canopy seeds are important for providing material for requirement into the community. Canopy seed banks can be recorded by collecting seeds falling from the canopy in the similar approach to the litterfall mentioned above	Can be conducted with floristics survey above	High
Soil seed bank composition	The composition of the soil seed bank is important to determine the potential for recruitment. Seeds within the soil can be measured from 25 points in each 1 ha plot (intersections of the 5 E/W and 5 N/S transects). Seeds within the top 10 cm of soil can be estimated by taking 5 soil cores at each point and splitting this into 5 cm fractions. Once dried seeds are germinated to identify plant species but also to estimate recruitment potential (i.e. seed viability).	Soil samples can be collected as part of soil survey above + time for germination trials	Moderate
Propagule arrival	Propagule arrival can affect the species richness and composition of ecological communities. Arrival can take various forms depending on the mode of dispersal (i.e. wind, water, animal). Litterfall traps can be used to assess propagules being dispersed by birds and or wind, where seeds recovered are compared against potential parent plant sources.	< 1 hour to install propagule traps and collect on subsequent occasions, + time for germination trials	Moderate
Reproductive capacity of individual plants species	Flowering and fruiting are important phenological stages in a plant's life history. The timing of these events may be important for dispersal of seeds and delivery of seeds into soil seed banks. Phenological phases of plants on survey plots can be recorded during each survey session with the extent of flowering and fruiting placed into categories to reflect intensity of these events.	Can be conducted with floristics survey above	High
Resprouting / epicormic growth*	Eucalypts are resistant to fire and have various strategies to cope with fire. Certain traits allow species to recover post-fire and species can have different resprouting patterns (e.g. basal or epicormic) (Clarke et al. 2013, Pausas and Keeley 2017). The nature of any resprouting post-fire can be assessed for all trees on transects within the 1 ha plot to assess recovery and make possible inferences about fire intensity based on the position of new foliage on trunks, branches.	Can be conducted with floristics survey above	High
Hollow-bearing tree status*	Hollow-bearing trees (HBTs) are an important habitat element providing refuge and nesting sites for a large number of Australian fauna. The availability of hollows (number of trees with hollows	Can be conducted with floristics survey above	High

Measure	Description	Estimated time per plot	Importance for evaluating RLP outcomes
	present, number of hollows / trees, hollow typology) and the impact on known HBTs can be made along transects within the 1 ha plot.		
General soundscape metrics	Acoustic recorders (one per site) can be set to record events at specific periods. This can include periods in the early morning to record the avian dawn chorus as well as in the evening to record invertebrates as well as birds (e.g. cicadas). Recordings are then subsampled to analyse the soundscape diversity among sites.	<i>l hour to install recorders and collect on subsequent occasions + processing time</i>	Moderate

* New indicators added due to recent bushfires.

Sampling design

Standard plot sizes for field sampling under AusPlots survey protocols are 100 m x 100 m, i.e. one hectare (White et al. 2012; Wood et al. 2014; Wundke et al. 2015; Sparrow et al. 2016). It is recognised that the size and shape of plots may need to be altered according to the specific landscape context of projects, e.g. due to restrictions imposed by the extent of habitat patches themselves or because of accessibility or logistical concerns, such as in densely forested habitats. Guidance regarding changes to plot size and shape are provided in relevant AusPlots manuals, as is advice concerning the suitable positioning of plots.

The number and location of plots surveyed under individual RLP projects adopting standardised monitoring protocols would similarly be dependent on the particular context and complexity of the system of interest. To investigate responses to interventions at a local scale, however, previous studies have recommended at least five to ten replicate plots per treatment (i.e. with interventions) in addition to a similar number of control plots (i.e. without interventions; Williams 2010). To enable change detection in relation to interventions, monitoring data is ideally collected following a BACI (Before After Control Impact) design, with sampling conducted in replicate sites with and without interventions, before and after these occur. In many cases, however, there may not be any suitable reference sites available to monitor target species, habitats and ecosystems. In such cases, sampling may instead be conducted along gradients of threat and/or intervention type or intensity.

Timing of sampling, including the season and interval between sampling events, will also need to vary amongst projects in relation to the short and longer-term temporal dynamics of the system of interest, e.g. seasonal variation etc. Previous studies have suggested intervals of three to five years are likely to be appropriate for monitoring habitat condition in many terrestrial systems including grasslands and shrublands (Williams 2010). More dynamic systems, such as many wetlands, however, are likely to require more frequent or flexible monitoring in relation to fluctuating conditions. In relation to the RLP LTMF, we recommend plot-scale condition sampling be conducted at least every 2.5 to 5 years.

5.2.2 Fauna surveillance

Fauna surveillance is clearly of direct relevance to monitoring outcomes associated with RLP projects targeting threatened fauna species but may also contribute to evaluation of projects addressing other RLP Outcomes. For example, ecological character of many Ramsar sites is closely associated with the presence, diversity and breeding of waterbirds. Similarly, fauna surveillance can also inform assessments of pest fauna species. Consequently, regular fauna surveillance will be desirable for the evaluation of many RLP projects.

A draft vertebrate fauna survey protocols manual has been developed by AusPlots to accompany survey methods for Rangelands plots (Table 10; O'Neill et al. 2017). We recommend that these methods are endorsed and further developed under the RLP LTMF. As per habitat condition monitoring, however, we recognise that the fauna surveillance modules appropriate to each RLP project, as well as sampling design, will need to be determined in relation to the specific context of particular projects, but conducted in conjunction as far as possible. Furthermore, these protocols only pertain to terrestrial vertebrates so would not be applicable to any RLP projects targeting aquatic fauna or invertebrates.

Table 10. Fauna (terrestrial vertebrates) surveillance modules described in AusPlots Fauna Survey Protocols (O'Neill et al. 2017).

Module	Description	Estimated time per plot	Importance for evaluating RLP outcomes
Trapping module	Set and check traps over 5-7 nights	2-4 hours	High
Camera observations	Camera traps set to record over 5-7 nights	15 minutes for set up and pack down + image processing time	High
Measure, mark and release module	Record of key morphological measurements for captured individuals	variable	Moderate
Tissue specimen module	Obtain tissue samples for future DNA analyses if determined necessary based on guidelines provided in protocols manual	Variable	Low
Whole animal vouchering module	Collection of whole specimens for vouchering if determined necessary based on guidelines provided in protocols manual	< 15 minutes per individual	Low
Observations module	Active fauna search of plot	1 hour	High
Birds module	Active bird search of plot and 2 ha surrounding area	2 x 20 minutes (am & pm)	High
Bats module	Ecoacoustic recorders set for at least one night.	15 minutes for set up and pack down + data processing time	High

5.2.3 Monitoring of target species

Sampling designs for monitoring specific threatened species of fauna and flora will need to be tailored to meet the requirements for the particular target species. Resources are available for many threatened species that describe appropriate methodologies and survey techniques for rare, cryptic and highly mobile threatened species, e.g. Regent Honeyeater (Clarke et al. 2003, Crates et al. 2017, 2019) and

Australasian Bittern (O'Donnell et al. 2013, O'Donnell and Williams 2015, Williams et al. 2019). In general, however, monitoring of target sites at a project level should include enough replicate sites to provide independence of the data recorded. As such, fixed sampling sites should be spatially discrete with monitoring efforts to detect the target species at these sites needing to be standardised and replicated over time. A sufficiently large sample of sites should be surveyed to provide enough power required to detect changes in the populations surveyed. Non-detections of target species (i.e. absence or 0 counts) should also be recorded.

Assessment of threatened species' trajectories under the RLP program more broadly will benefit from alignment with the approach developed by the Threatened Species Index (TSX; <u>https://tsx.org.au</u>). This index is designed to report on species trends over time so is particularly pertinent to evaluating the threatened species outcome under the RLP program. Currently, this index has been calculated for birds and is also being developed for mammals and plants. In general, contribution of monitoring data from RLP projects to the TSX will be facilitated by sampling the abundance (or an indication of this) of a species on two or more years using the same methods from the same location.

Essential sampling design considerations, as informed by the TSX data requirements, include:

- survey sites selected are specific locations recorded with high precision (including any details for the datum / projection);
- survey sites above are repeatedly surveyed through time. At least two surveys over at least two different years are required to report on any trends;
- survey timing and frequency may be species-specific (e.g. if a migratory species) and are best guided by best practice for target species. At least one survey each year at all survey sites is required;
- use of standardised/ fixed survey methods to detect and record the target species through time; and
- clear definition of the target species variable of interest (e.g. individuals, calls, nests), how many were recorded (i.e. count), the areas that was covered in the survey (i.e. quadrat size, transect area), and the magnitude of effort (e.g. time to complete a survey).

5.3 Data collection

To enable aggregated analyses, evaluation and reporting of ecological monitoring data that can incorporate data from both existing, on-going monitoring programs as well as additional targeted monitoring (i.e. RLP project groups 1 and 2 outlined in Section 5.2 above), the following processes will be required:

- a recommended process for data collection from RLP projects using standardised monitoring protocols (i.e. as per recommendations in Section 5.2); and
- consistent reporting of selected standardised metrics across all RLP projects regardless of the monitoring approaches being used (i.e. to enable incorporation of data from other existing and historic monitoring programs).

Data entry for standardised monitoring

We suggest data entry for targeted terrestrial monitoring occur via the data entry App that has already been developed by TERN AusPlots to support the implementation of recommended habitat condition monitoring. While this App might be sufficient for immediate use in the case of many RLP projects, a more tailored App could be developed relatively quickly to incorporate some additional key indicators (e.g. measures of fire effects, hydrological indicators for wetlands) and with an overall modular design so that it can be built upon into the future.

Standardised data entry for non-standardised monitoring

For RLP projects not adopting recommended sampling protocols, modular data entry templates could be designed and provided to enable the contribution of non-standardised monitoring data to aggregated analyses, reporting and evaluation under the RLP LTMF. To account for the inherent flexibility of this data, thorough accompanying metadata will be essential. Raw ecological monitoring data should also be contributed for potential use in analyses, evaluation and reporting. Again, clear metadata will be critical.

5.3.1 Metadata

To ensure appropriate analysis, evaluation and reporting of available ecological monitoring data, accompanying metadata must specify information regarding the data's:

- spatial context (i.e. location, area, resolution of data);
- temporal context (i.e. date and duration of data collection);
- ecological context (e.g. ecosystem type, vegetation community);
- management context (e.g. known interventions conducted at site).
- collection context (e.g. who collected the data, the methods used for data collection, including the overall sampling design, the data custodians and funders etc)

Reference to available baseline data and/or historical monitoring data should also be included where available. Clear metadata will be required for entire datasets but also with respect to individual data points within each dataset where these involve complex data structures. Precise information regarding the spatial location and sampling time of each data point will be required as well as information

regarding units of measurement and certainty, e.g. were data points visually estimated, measured via instruments; were species identifications verified? Information regarding the plot type in relation to sampling design (e.g. control, treatment type etc.) will also be critical. To enable rapid aggregation and analysis of data, we recommend that the type of indicator (i.e. extent, magnitude, condition and/or social) also be provided.

5.3.2 Habitat condition data entry template

Williams (2010) examined commonalities across different approaches to habitat condition assessment, identifying a suite of indicators that are typically recorded by such protocols even where these utilise different sampling methods (Table 11). In addition to condition metrics commonly monitored in the field, consistent remotely sensed condition metrics will also be useful for data analyses and evaluation. For the RLP LTMF, these may be provided by local data providers or collected by a program level team.

Attribute	Indicators	Importance for evaluating RLP outcomes
Plot-level attributes collected vi		
Large trees (hollows)	High	
Native species cover and richness of 4 or 5 life forms: - trees - shrubs - perennial grasses - forbs - other	Percent cover and species richness of each life form. Percent cover and richness of weed species can also be determined from this.	High
Full plant species listing	Percent cover and richness of weed species can be determined from this. If this is not available, dominant species in each stratum (i.e. canopy, mid-storey, groundcover) should be provided along with separate weed assessment.	High
Weeds	Percent cover and richness of weeds.	Moderate
Woody perennial plant recruitment	Number of stems of woody plant recruits	High
Coarse woody debris	Number and length of logs over a certain diameter	High
Organic litter cover	Percent cover and depth	High

Table 11. Core habitat condition indicators common amongst most major Australian habitat assessment protocols (adapted from Williams 2010)

Landscape-level attributes collected via analysis of remote sensing data (e.g. aerial photos, satellite imagery etc.)

Patch characteristics	Patch size and shape, neighbourhood context, connectivity, distance to permanent water	Moderate
Fire history	May require field validation	High

5.3.3 Species data entry template

To contribute to calculations conducted using the approach of the Threatened Species Index (TSX; <u>https://tsx.org.au</u>), metadata accompanying monitoring data on threatened species' trajectories must specify:

- what count data represents (e.g. individuals, nests etc.) and how it was calculated (e.g. average count, first per month, maximum count per year, rate etc.)
- records of non-detections of taxa (i.e. absence or 0 counts);
- the extent (i.e. sampling area) for which counts were obtained;
- the timing of sampling (i.e. year, but preferably month and date as well);
- the specific location (latitude and longitude) of fixed sampling sites with specified datum / projection; and
- details regarding survey methods (effort, survey duration, etc.; Table 12).

Table 12. Example of data that that might be provided for use in calculating the TSX (Adapted from Science for Policy Research Findings Factsheet, Project 3.1, Threatened Species Recover Hub, NESP: Threatened Species Index data usage factsheet (PDF, 1.3MB).

SITE ID	GPS coordinates of site (WGS84)		Species name (subspecies)	Search type description	Units of measurement	1970 counts	1980 counts	2017 counts
16093	-36.31880487	144.9278026	Malleefowl	fixed route search	proxy: breeding pairs	9	8	
12885	-28.5877954	153.1466674	Northern Rufous Scrub-bird	500m area search	sample: abundance (counts)	0.5	0.25	
14300	-38.22420633	146.3744546	Swift Parrot	Swift Parrot search	sample: abundance (counts)	3.5	6	

The Threatened Species Index meta-data protocols also enable capture of the level of standardisation achieved by projects, whereby those project sampling with greater consistency over time receive a higher score (Table 13; TSX 2019).

Table 13. TSX scores for the use of standardised approaches in threatened species monitoring (Source: TSX 2019). The higher the score the better the degree of standardisation, NULL values have no standardisation defined.

TSX Score	Score Description
6	Pre-defined sites/plots surveyed repeatedly through time using a single standardised method
	and effort across the whole monitoring program
5	Pre-defined sites/plots surveyed repeatedly through time with methods and effort
	standardised within site units, but not across program - i.e. sites surveyed have different
	survey effort/methods
4	Pre-defined sites/plots surveyed repeatedly through time with varying methods and effort
3	Data collection using standardised methods and effort but surveys not site-based (i.e.
	surveys spatially ad-hoc). Post-hoc site grouping possible - e.g. a lot of fixed area/time
	searches conducted within a region but not at pre-defined sites
2	Data collection using standardised methods and effort but surveys not site-based (i.e.
	surveys spatially ad-hoc). Post-hoc site grouping not possible
1	Non-standardised methods/effort, surveys not site-based

The submission of data to the TSX portal is also submitted to a series of quality control checks before being accepted. If data files do not conform to the required standards then parties submitting files are encouraged to resolve any issues identified by the system (e.g. missing fields, etc.) prior to submitting the data (E. Bayraktarov *pers. comm.*).

5.3.4 Supplementary data

Supplementary data obtained from other sources, including remotely sensed data and other monitoring programs, will be required to support appropriate data analyses and evaluation of RLP outcomes. As well as landscape-level patch characteristics (Table 11), weather data (e.g. rainfall, temperature, humidity etc.) are likely to be particularly critical. These may be provided by RLP project service providers or collected by a RLP LTMF program level team.

5.4. Data management

We recommend all ecological data collected under the RLP program, either by RLP project service providers or by a RLP LTMF program level team, is submitted to an enduring repository for structured long-term ecological data where these data can be stored and shared to support robust evaluation and reporting (see also section 7.1). An example of such existing capacity is TERN's data repository, AEKOS (<u>Advanced Ecological Knowledge and Observation System</u>), where data can be stored via the pre-established ShaRED data submission tool (<u>https://www.tern.org.au/SHaRED-Data-Submission-</u>

pg32958.html). TERN have also developed thorough metadata principles for sharing ecological data that may be applicable. Data can be safely stored and accessed from AEKOS by a variety of users for subsequent data analyses, reporting and evaluation.

5.5 Data analyses

Appropriate data analyses will strongly depend on the availability and quality of data provided by RLP projects. As discussed in Capon et al. (2018), monitoring data may be analysed directly or used to calculate various composite indicators (e.g. species diversity indices) or indicators of emergent properties (e.g. connectivity measurements). Analyses of both simple and composite indicators can then be conducted at multiple scales (e.g. catchment, State etc.) and/or aggregated with respect to particular targets (e.g. specific threatened species, threatened ecological communities etc.) or, overall, to describe patterns, infer processes and inform responses to relevant KEQs (Table 8). A combination of univariate and multivariate analyses will enable description of patterns for each populated indicator as follows:

- temporal trajectories;
- spatial trends; and
- combined temporal and spatial trends (e.g. differences in indicator trajectories in different regions)

Statistical relationships between temporal trajectories and spatial trends of different elements can also be explored to infer processes. In particular, ecological responses following NRM interventions can be expected to be strongly influenced by key weather variables (e.g. rainfall). Where data are available from multiple replicate treatment plots and control plots (i.e. as recommended in Section 5.2), a range of statistical hypothesis tests will also be possible as will the development of predictive quantitative models. Selection of appropriate methods will depend on data availability.

5.6 Evaluation

A diversity of data sources and data analyses will enable the KEQ's developed for the RLP program to be addressed across a range of hierarchical levels, i.e. project-level, target-level, area-based, program level (Table 14; Section 4.2). In general, however, evaluation of ecological outcomes of NRM investment and interventions are likely to involve the following steps:

- detection of change, i.e. has a response occurred and, if so, what kind of response?
- identification of drivers of change, i.e. what caused this response?
- assessment of change, i.e. is the response what was expected/desired? and

• determine implications of assessment, i.e. do we need to act in relation to this response?

Change detection necessarily requires baselines (or references) against which indicator trajectories can be evaluated while assessment of that change can be either value-driven (i.e. was it good or bad?) or knowledge-based, i.e. is this what we thought would happen? For change assessment, the desirability of outcomes must be determined in relation to various goals or objectives, i.e. (benchmarks) while expected outcomes reflect current understanding of a system as represented by conceptual models. The ability to reliably detect changes in the RLP targets for various projects will also be dependent on assessments of the statistical power (Southwell et al. 2019).

5.6.1 Baseline assessment

Evaluation of ecological monitoring data against baselines (or references) will enable assessment of ecological change in either time and/or space and, where the sampling design justifies this, may additionally permit the identification and quantification of drivers of any changes detected. In this context, such drivers of change may include known (or unknown) threats and NRM interventions as well as other natural drivers (e.g. topography), as captured by conceptual models representing current ecological understanding. Because the proposed RLP LTMF involves evaluation of ecological outcomes across multiple hierarchical levels (i.e. project-level, target-level, area-based and progam-level), relevant baselines will also be required for each of these.

Baselines for evaluating changes in ecological targets with respect to both habitat condition and species' trajectories may include historic data or data concerning selected reference sites (e.g. ecologically comparable control sites not subject to NRM interventions or threats). At a project-scale, monitoring data would ideally be collected following a BACI (Before After Control Impact) design, with sampling conducted before and after interventions in replicate treatment and control sites. Where suitable reference or control sites are not available, however, ecological changes may instead be evaluated along gradients of threat and/or intervention type or intensity or alternatively assessed mainly in relation to benchmarks.

Appropriate baselines for use in evaluation over each hierarchical level under the RLP LTMF can be compiled from a range of sources including RLP project plans, relevant conservation advice and management plans, supplementary data and expert assessments (Table 14). We recommend this compilation is conducted by the RLP MERI team.

5.6.2 Benchmark assessment

Ecological responses can also be assessed in relation to conservation, restoration and management objectives and goals to evaluate whether or not observed ecological changes were expected and/or desirable (and with what degree of certainty and for whom). Such objectives may be drawn from goals associated with specific management plans or policies (e.g. threatened species recovery plans, Ramsar site ecological character descriptions etc.; Table 15). Evaluation of threatened species responses, for example, may be conducted in relation to expert trajectory assessments developed under the Threatened Species Strategy

(https://www.environment.gov.au/biodiversity/threatened/publications/strategy-home).

To enable effective and transparent evaluation, relevant conservation, restoration and management objectives should entail the definition of specific, measurable and defensible benchmarks. In many cases, existing management objectives may not be sufficiently nuanced to enable such evaluation. Furthermore, climate change and associated recent disturbances (e.g. drought, bushfires), necessitate a thorough recapitulation of conservation objectives in most, if not all, cases. Consequently, definition of clear benchmarks for conservation and restoration of many species and ecosystems targeted under the RLP program is likely to be necessary to guide robust ecological monitoring and evaluation into the future. In particular, benchmark development is likely to be required for hierarchical levels greater than that of project or targets, e.g. area-based, program or national levels.

Benchmarks should be based on clearly enunciated evaluation questions (e.g. Tables 8, 14 and 15) and closely associated with conceptual models representing current ecological understanding as well as human values associated with this (Table 15). Because of the diversity of knowledge and values encompassed by the RLP program, we strongly recommend urgent collaborative development of relevant benchmarks for each Outcome across multiple hierarchical levels to enable transparent and robust evaluation of ecological outcomes into the future (Table 15).

KEQ ID	Generic evaluation question			Data	sources			Evaluation type	Relevant baseline(s)/benchmark(s)	Results			
		Conservation advice / management plans	RLP project plans	RLP Outputs reporting	RLP project Outcomes reports	RLP project data	Supplementary data						
Descriptive	Descriptive evaluation questions:												
Threats								1	1				
DE_TH1	What are the key threats of concern?	*	*		*	*	*	descriptive	N.A.	Threats database			
DE_TH2	What are the key threats being addressed by the RLP program? (N.B. In addressing this question, key threats not being addressed by the RLP program should also be identified.)	*	*		*	*		descriptive; benchmark assessment	RLP project plans	Threats database; assessment score			
DE_TH3	What are the extent and magnitude of each key threat i) nationally and ii) with respect to RLP projects and targets?	*	*	*	*	*	*	descriptive	N.A.	Threats database; threat maps			
DE_TH4	Have key threats expanded/contracted, intensified/reduced or changed in their importance i) nationally and ii) with respect to RLP projects?			*	*	*	*	change detection	RLP project threat baselines; threats database	Threats database; threats maps; threat trajectory plots			
DE_TH5	Have any new actual or potential threats emerged?			*	*	*	*	change detection	RLP project threat baselines; threats database	Threats database; threats maps; threat trajectory plots			
Interventi	ons												
DE_IN1	Which NRM interventions have been implemented under the RLP program?	*		*	*	*		descriptive; benchmark assessment	RLP project plans	NRM interventions data base; assessment score			

Table 14. Potential data sources, baselines and analyses to address each RLP KEQ identified in Section 4.2.

KEQ ID	Generic evaluation question			Data	sources		-	Evaluation type	Relevant baseline(s)/benchmark(s)	Results
		Conservation advice / management plans	RLP project plans	RLP Outputs reporting	RLP project Outcomes reports	RLP project data	Supplementary data			
	(N.B. In addressing this question, priority actions not being implemented by the RLP program should also be identified.)									
DE_IN2	To what extent and magnitude has each priority action been implemented i) nationally and ii) with respect to RLP projects and targets? (N.B. In addressing this question with respect to RLP targets, the implementation of actions should be considered in the immediate vicinity of targets as well as in their broader landscape of influence.)			*	*	*		descriptive	RLP project plans; relevant conservation advice / management plans	NRM interventions data base; NRM interventions maps; NRM interventions trajectory plots
Targets								-		
DE_T1	Which ecological targets have been addressed under the RLP program?(N.B. In addressing this question, priority ecological targets not being implemented by the RLP program should also be identified.)		*	*	*	*		descriptive; benchmark assessment	RLP project plans; relevant conservation advice / management plans	Ecological targets database; assessment score
DE_T2	Has the condition of ecological targets addressed under the RLP program changed (i.e. improved or declined) i) nationally and ii) respect to RLP projects?		*	*	*	*	*	benchmark assessment	RLP project plans; relevant conservation advice / management plans	Ecological targets database; ecological target condition trajectories; assessment score
DE_T3	To what extent and magnitude has the condition of ecological targets addressed under the RLP program		*	*	*	*	*	benchmark assessment	RLP project plans; relevant conservation	Ecological targets database; ecological target condition

KEQ ID	Generic evaluation question			Data	sources			Evaluation type	Relevant baseline(s)/benchmark(s)	Results
		Conservation advice / management plans	RLP project plans	RLP Outputs reporting	RLP project Outcomes reports	RLP project data	Supplementary data			
	changed (i.e. improved or declined) i) nationally and ii) with respect to RLP projects and targets?								advice / management plans	trajectories; assessment score
Mechanis	tic evaluation questions									
ME_1	Have NRM interventions implemented under the RLP program had their desired/expected primary response?		*	*	*	*	*	mechanistic evaluation and benchmark assessment	RLP project plans; relevant conservation advice / management plans; existing scientific models	Models of relationships between interventions and responses; assessment score
ME_2	Have NRM interventions implemented under the RLP program influenced the extent, magnitude and/or other attributes of key threats?		*	*	*	*	*	mechanistic evaluation	Existing scientific models	Models of relationships between interventions and responses
ME_3	Have NRM interventions implemented under the RLP program influenced condition of ecological targets addressed by RLP projects?		*	*	*	*	*	mechanistic evaluation and benchmark assessment	RLP project plans; relevant conservation advice / management plans; existing scientific models	Models of relationships between interventions and responses
ME_4	What other drivers have affected threats to ecological targets addressed by RLP projects and ecological responses to these?		*	*	*	*	*	mechanistic evaluation	Existing scientific models	Models of relationships between other drivers and responses

KEQ ID	Generic evaluation question			Data	sources	_		Evaluation type	Relevant baseline(s)/benchmark(s)	Results
		Conservation advice / management plans	RLP project plans	RLP Outputs reporting	RLP project Outcomes reports	RLP project data	Supplementary data			
ME_5	What other drivers have affected the condition of ecological targets addressed by RLP projects?		*	*	*	*	*	mechanistic evaluation	Existing scientific models	Models of relationships between other drivers and responses
Knowledg	e generation									
KG_1	What datasets have been generated by the RLP program?		*	*	*	*		descriptive	N.A.	NRM knowledge bank
KG_2	Has the RLP program increased our understanding of priority ecological targets and threats to these?				*	*		change detection	RLP project plans; relevant conservation advice / management plans	NRM knowledge bank
KG_3	Has the RLP program increased our knowledge of best practice NRM?				*	*		change detection	RLP project plans; relevant conservation advice / management plans	NRM knowledge bank
KG_4	What is the best practice NRM for the future?				*	*		descriptive	N.A.	NRM knowledge bank; adaptive management guidelines
RLP Outcome	From RLP program	Existing benchmarks	Additional benchmarking required							
---	--	--	--							
Outcome 1. Ramsar sites	Compilation of project- level benchmarks from relevant RLP project plans and outcomes reports in MERIT	Limits of acceptable change in site-based ecological character descriptions Restoration objectives in site-based management plans	Revision of ecological character descriptions to include consistent, defensible limits or acceptable change and/or management goals Area-based and RLP program-level benchmarking							
Outcome 2. Threatened Species		Expert-developed trajectories used in <i>Threatened Species</i> Strategy Targets in State-based threatened species strategies, e.g. NSW Saving Our Species (State of NSW and Office of Environment and Heritage 2018) Threatened Species Index (<u>www.tsx.org.au</u>) Recovery objectives in species-based management plans	Updates to expert-developed trajectories used in <i>Threatened Species Strategy</i>							
Outcome 3. World Heritage sites		Descriptions of the natural heritage Outstanding Universal Value of World Heritage sites	RLP program-level benchmarking							
Outcome 4. Threatened Ecological Communities		Ecological community condition benchmarks (e.g. BioCondition benchmarks: <u>https://www.qld.gov.au/environment/plants-animals/biodiversity/benchmarks</u>) Restoration objectives in site-based management plans	Application of consistent approach to defining defensible restoration objectives Area-based and RLP program-level benchmarking							

Table 15. Potential sources of benchmarks for assessing ecological outcomes of the RLP program

5.7 Reporting

Reporting from the proposed descriptive evaluation pathway outlined in this chapter will depend on the outputs of each previous stage. However, it is envisaged that the proposed LTMF will enable the generation of both descriptive reports (i.e. results of data analyses) and assessment reports (i.e. addressing proposed KEQs; Tables 8 and 14) across multiple hierarchical levels of aggregation, i.e. target-based, area-based and at the level of the RLP program. Where relevant data is available, descriptive reports may include a range of maps and plots illustrating patterns in NRM system components over space and/or time as well as relationships between indicators. Where appropriate, reports may also include findings of statistical models describing relationships between various indicators (e.g. interventions and threats).

Baseline assessments will generate assessment reports regarding the occurrence, direction and magnitude of change detected in relevant indicators. Benchmark assessments will enable generation of 'assessment scores' in relation to KEQs (Table 14). In their simplest form, these assessment scores might just be a tick, cross or line to indicate a positive, negative or neutral response. Traffic light reporting or assignation of 'grades' may also be possible but will rely on the clear definition of benchmarks to identify appropriate cut-off points.

To efficiently generate timely, relevant and consistent reports, we recommend the development of an online platform to coordinate data analyses, evaluation and reporting on monitoring data collected under the RLP program. Our proposed system, Latimer, is outlined in Chapter 7. However, evaluation reports might also be generated independently following the descriptive or mechanistic (see Chapter 6) evaluation pathways outlined here.

Targeted monitoring via RLP MER networks

6.1 Introduction

In this chapter, we present proposals for targeted monitoring across RLP MER networks to be implemented in addition to, but capitalising on, RLP project monitoring already being conducted or proposed by service providers. The purpose of these proposed RLP MER networks is to enable monitoring, data analyses, evaluation and reporting with respect to selected priority RLP KEQs (Table 8) using robust standardised methods for data collection, analysis and assessment. Overall, these RLP MER networks are designed to specifically address critical mechanistic evaluation questions regarding NRM interventions to guide future investment and inform adaptive management.

More specifically, the aims of the RLP MER networks proposed here are:

- to establish and test standardised protocols for improved monitoring and evaluation of national NRM investments;
- to evaluate and report on ecological outcomes and effectiveness of selected NRM interventions conducted under the RLP program;
- to generate and compile data concerning ecological indicators, baselines and benchmarks in relation to priority NRM KEQs;
- to enable scientifically robust evaluation of targeted priority KEQs related to RLP in current phase and into the future;
- to enhance ecological understanding and knowledge of NRM systems; and
- to support relevant knowledge and practice networks.

To develop suitable proposals for targeted MER networks under the RLP program, we used the RLP project database generated in Stage 2 of this project (Chapter 3) to identify potential clusters of RLP projects focusing on common targets, threats or interventions. We propose that these RLP project clusters, or portions of these, provide the basis for developing broader MER networks, akin to CSIRO's proposed Platform for Ecological Restoration Research Infrastructure (PERRI) networks (Prober et al. 2018). Such project clusters could enable the establishment of large, distributed experiments within which specific ecological outcomes, as well as responses to particular NRM interventions, can be investigated in a scientifically robust manner. This would likely require additional investment on behalf of the Department to enable sufficient data collection (e.g. addition of replicate and/or control sites) within existing RLP project areas and in other locations if required.

Here, we present preliminary proposals for several potential RLP MER networks based on RLP project clusters associated with threatened species as well as those associated with priority NRM interventions and threats. We provide a rationale for each proposed MER network and an overview of possible RLP project clusters identified for each. We also suggest some priority mechanistic evaluation questions that might be rigorously addressed through monitoring and evaluation associated with each proposed network. Where required, we additionally highlight specific sampling concerns, however, we propose that the main steps of monitoring, data collection, data management, data analyses, evaluation and reporting associated with each of these proposed MER networks follow relevant aspects (i.e. standardised monitoring protocols) of the LTMF outlined in Chapter 5.

6.2 Threatened species MER network(s)

6.2.1 Rationale

Threatened species are a key focus of the RLP program with 74 RLP projects addressing monitoring requirements for 84 fauna and 38 flora species. Amongst these, numerous species are targeted by multiple projects, affording opportunities to establish MER networks under the RLP program that can address KEQs related to NRM interventions which aim to improve the trajectory of these threatened species in a robust scientific manner.

Ten threatened fauna species are associated with four or more RLP projects as a primary investment while only five threatened flora species are the primary investment targets of three or more RLP projects (Table 4). While all of these species could be investigated via MER networks, here, we suggest the establishment of two potential networks, one targeting the critically endangered Regent Honeyeater (*Anthochaera phrygia*) and the other focused on the endangered Australasian Bittern (*Botaurus poiciloptilus*). The Regent Honeyeater is a primary investment target of six RLP projects while the Australasian Bittern is targeted by five RLP projects (Figures 8 and 9).

We selected these species over others such as the Malleefowl and Swift Parrot which, despite being the focus of multiple RLP projects, already have considerable effort dedicated to their monitoring under ongoing national programs. For example, the National Malleefowl Recovery Team have an existing database and program for coordinating monitoring efforts across four states (see http://www.nationalmalleefowl.com.au/the-national-malleefowl-monitoring-database.html) in line with the actions identified in the National Malleefowl Recovery Plan.

6.2.2 Evaluation questions

The purpose of the proposed threatened species MER networks within the RLP LTMF is to enable reporting on and evaluation of the trajectories of specific threatened species and factors affecting these, especially in relation to priority threats and NRM interventions. While knowledge generated by MER networks would contribute to addressing broader KEQs proposed for the RLP LTMF (Table 8), specific evaluation questions could also be developed (Table 16) in relation to the particular context of each species, its priority threats and the NRM interventions being conducted under the RLP program in relation to these (Figures 8 and 9).

KEQs for threatened species MER networks	Potential indicators	Examples of species-specific evaluation questions
What are the population level responses of threatened species to threats managed through a suite of interventions?	 Abundance of target population/s within the study area Occupancy of sites within the study area Distribution of species at local scales within the landscape (e.g. number of metapopulations) Reproductive success of the target population Population growth rates of the target population 	Does habitat improvement and revegetation contribute to increases in Regent Honeyeater populations? Has habitat improvement (i.e. condition) resulted in greater occupancy by Regent Honeyeater?
What are the species level responses of threatened species to threats managed through interventions across space and time?	 Abundance of the target species from multiple sites Occupancy of the target species from multiple sites Distribution of the species at larger landscape and regional scales Average growth rates in the species throughout the distribution 	Does habitat improvement and revegetation at the landscape scale contribute to increases in Regent Honeyeater populations? Has landscape-level improvement in environmental flows led to an increased occupancy of wetlands by Australasian Bittern?
What are the secondary responses to threat interventions that could lead to positive outcomes for threatened species? For example, managing weeds at project sites may improve the condition of the habitat by increasing the number of foraging niches available.	 Improvement in habitat condition Increased awareness of the requirements for a threatened species Reduction in the extent / number of pest species Reduction in the frequency and magnitude of disturbance factors (e.g. humans, fire, flood) 	Has increased awareness about the plight of Regent Honeyeater / Australasian Bittern resulted in a greater reporting rate by citizen scientists?

Table 16. Potential KEQs for proposed threatened species MER networks.



Figure 8. Primary investment RLP projects for the Regent Honeyeater that highlight the range of threats being addressed and interventions being used to achieve RLP outcomes for threatened species.



Figure 9. Primary investment RLP projects for the Australasian Bittern that highlight the range of threats being addressed and interventions being used to achieve RLP outcomes for threatened species.

6.2.3 Sampling design

For the two target species identified here, the sampling design required to evaluate trajectories of the species will be closely tied to the number of RLP projects currently targeting these species. The proposed design assumes that all RLP project service providers engaged in monitoring of one of these target species will be part of the MER network. Therefore, for the Regent Honeyeater and Australasian Bittern, there are six and five primary projects respectively. Expanding this primary network to RLP projects that list these species as secondary targets would result in six and eight projects in each cluster respectively.

The next step would be to explore the spatial coverage of existing project locations and identify possible gaps throughout the species' distributions where on-ground monitoring may be required to further expand the network. At present, each RLP project cluster is contained within a larger distribution footprint for these species based on records from the Atlas of Living Australia (ALA; Figures 10 and 11). Importantly, RLP projects targeting these species, especially those for the Regent Honeyeater, are in known hotspots based on previous records from ALA (Figures 10 and 11). There are also opportunities, however, to locate additional sites as part of MER networks to target areas at a national level which are not currently part of the RLP program, particularly for Australasian Bittern.

Additional locations could be included in any RLP MER networks using a planned phased approach (Burns et al. 2018) following initial evaluation and analysis of data from foundational RLP project clusters. Inclusion of additional projects may require additional investment to support the expanded monitoring and evaluation. However, expansion of these RLP MER networks would likely be required to ensure that data collected would have the power to report on changes in population trajectories (Robinson et al. 2018).

At a program level, not all RLP projects in each cluster identified here address all of the threats associated with the target species (Figures 8 and 9). The most efficient sampling design would be to assess threats and interventions across projects that are already monitoring responses to interventions of these target species (either directly or indirectly) and extend this to those existing projects that have not captured this in their protocols for inclusion via additional, targeted monitoring efforts. Alternatively, a specific (possibly novel, i.e. not currently an area of investigation through the RLP) research question regarding responses of target species to either threats and/or interventions could be determined and communicated to all RLP project partners for inclusion in future services (e.g. see Table 16).



Figure 10. Representation of RLP projects with the Regent Honeyeater identified as the primary investment overlaid with the distribution map for the species based on ALA records with data for 'year' and 'location'.



Figure 11. Representation of RLP projects with the Australasian Bittern identified as the primary investment overlaid with the distribution map for the species based on ALA records with data for 'year' and 'location'.

Species-specific sampling considerations

Regent Honeyeater

The Regent Honeyeater is a widely distributed species with low numbers that displays seasonal aggregation during breeding (Clarke et al. 2003, Crates et al. 2017). At present, the RLP projects that have identified Regent Honeyeater as a primary investment target adopt a range of survey approaches. These include the collection of baseline woodland bird data, fixed duration radial point counts with call playback, as well as standardised 2 ha searches. The number of sites surveyed ranged from 10 (Clarke et al. 2003) to 321 (Crates et al. 2017), but it should be noted that Clarke et al. (2003) highlighted that a greater number of sites (up to 133) would be required to detect any change in the populations of Regent Honeyeater with enough power. Furthermore, where the research question was associated with assessing the breeding performance of the species the number of sites was more than doubled (Crates et al. 2019) using an adaptive sampling methodology that surveyed additional sites near those where the species had been detected during initial survey efforts.

A key metric for evaluating trends in this species would be to assess the occupancy of sites surveyed over time where these are able to account for any variation in the detectability of the species. For a MER network established to monitor the Regent Honeyeater, it would be preferable to have standardised survey methodologies across all projects that have prioritised this species. However, the TSX team have suggested that this is not critical if individual projects adopt a consistent methodology across their sites for the life of the project.

Australasian Bittern

The Australasian Bittern is a cryptic species associated with wetlands with a patchy but widespread distribution across southern Australia. The inclusion of wetlands that are known to, or could potentially, support populations of the Australasian Bittern will be important in designing a MER network that is in line with the strategy currently being used in Western Australia (DBCA 2018). At these wetlands, research suggests that completing call counts, either with autonomous recorders or by observers, during the breeding season are well suited to monitoring this species and should therefore be a key element of survey methods (O'Donnell et al. 2013, DBCA 2018, Williams et al. 2019).

Current RLP projects focused on the Australasian Bittern are spatially restricted to a small portion of the species' range in South Australia and Victoria (Figure 10). There are opportunities to expand these efforts by linking with ongoing monitoring efforts in Western Australia (see DBCA 2018), but also to other locations where the species has had historically higher reporting rates (Figure 10). The number of locations surveyed at each wetland will be a function of the wetland size as well as accessibility. Williams et al. (2019) used a randomised survey strategy at sites that were spaced at least 400 m apart, with the knowledge that bittern calls could be heard from as far as 4 km away. For the RLP projects

currently underway, acoustic monitoring is recommended as a key survey methodology but also 20minute 2 ha searches. Active wading searches that flush birds from the wetlands have also been used in Western Australian monitoring efforts in the past (DBCA 2018).

6.3 NRM Interventions MER network(s)

6.3.1 Rationale

Interventions associated with active and passive revegetation, e.g. planting/seeding, fencing, pest control, pathogen control and weed control, represent a major investment under the RLP program across all four environmental outcomes (Figure 4). Forty-one projects are implementing, or plan to, actions classified under the intervention sub-category of revegetation while 92 projects include weed control as an intervention (76 of which also list weeds as a threat). The exact nature of actions being implemented, as well as associated threats, targets and ecological contexts (e.g. habitat/community types), vary considerably across these project clusters (Appendix 3 and 4). RLP projects implementing weed control interventions, for example, are targeting a diverse range of weed species (or vegetation types) using a range of different methods (Appendix 4). In many cases, however, expected outcomes regarding primary responses of these broad intervention categories are likely to be comparable. For example, revegetation via planting or seeding may be conducted to promote the abundance or extent of seedlings while weed control seeks to remove or limit the cover and extent of exotic plant species, usually with the expectation that this will result in beneficial secondary responses, e.g. increased native plant diversity. However, there is surprisingly little empirical evidence to support common assumptions underpinning many NRM interventions (e.g. Doerr et al. 2017). Consequently, establishment of intervention-focused MER networks under the RLP program represents a unique opportunity to test these assumptions and evaluate the efficacy of key NRM interventions under a range of conditions and with respect to a diversity of targets and threats.

6.3.2 Evaluation questions

The purpose of the proposed NRM intervention MER networks within the RLP LTMF is to enable reporting on and evaluation of the ecological outcomes of common NRM interventions being conducted under the RLP program. These outcomes could concern responses of priority threats to interventions as well as responses of target species and/or communities. As per the proposed threatened species MER networks, data generated by these intervention-focused networks could inform KEQs proposed for the RLP LTMF more broadly (Table 8) as well as addressing more specific evaluation questions that would need to be developed in relation to the selected RLP project clusters (Table 17).

KEQs for NRM intervention MER networks	Potential indicators
What are primary responses of key revegetation interventions? [and to what extent, where, when, differences between types of interventions, differences between types of habitats/targets, threats etc.]	Seedling survivalSeedling condition metrics (e.g. growth rates)
What are primary responses of key weed control interventions? [and to what extent, where, when, differences between types of interventions, differences between types of habitats/targets, threats etc.]	 Weed cover Weed propagule abundance (e.g. seed banks, propagule arrival)
What are secondary responses of RLP habitats / targets to key revegetation interventions? [and to what extent, where, when, differences between types of interventions, differences between types of threats, differences between types of habitats / targets etc.]	 Plant community composition (species richness, abundance) Habitat condition relevant to ecosystem type Ecosystem function (e.g. litter and flammability) Extent and abundance of introduced species
What are secondary responses of RLP habitats / targets to key weed control interventions? [and to what extent, where, when, differences between types of interventions, differences between types of threats, differences between types of habitats / targets etc.]	Propagule pressure of introduced speciesHabitat use

Table 17. Potential KEQs for proposed NRM intervention MER networks.

6.3.3 Sampling design

Intervention-focused MER networks could examine common NRM interventions (e.g. revegetation, weed control, fencing) either individually or collectively. We have identified potential RLP project clusters that could individually comprise revegetation (Appendix 3) and weed control (Appendix 4) MER networks, or be combined to support a broader intervention-focused distributed experiment (Table 18). The overall sampling design and that at each location would strongly depend on the range of RLP projects and locations included in final project clusters associated with each network but would require replicate sampling locations (i.e. RLP project study areas) as well as replicate intervention 'treatment' and control sites within each location (see Section 5.2). As outlined in the Discussion paper arising from Stage 1 of this project (Capon et al. 2018), it would not be necessary for every intervention type, or relevant action, to be implemented as an experimental 'treatment' at every location included in the MER network as long as each location had sufficient numbers of replicate plots and associated control sites for interventions relevant to that location. It would also be desirable for any MER network established to include a range of ecological community / habitat types subjected to each treatment combination.

Table 18. RLP projects, across all four ecological Outcomes, conducting interventions associated with revegetation through planting or seeding, fencing and/or weed control that could be part of proposed NRM intervention MER network(s).

RLP Project	NRM Intervention type		ı type	Ecological community*	
	Planting / seeding	Weed control	Fencing		
RLP-MU56-P1				Mabi Forest and/or Littoral Rainforest	
RLP-MU52-P3	1			Ormeau Bottle Tree	
RLP-MU07-P6	1	1	1	Forests and woodlands - unspecified	
RLP-MU30-P4		1	1	Eucalyptus and Melaleucas	
RLP-MU25-P4				Brown stringybark	
RLP-MU28-P2	1		1	Grasslands - unspecified	
RLP-MU13-P12			1	Coastal saltmarsh	
RLP-MU24-P3		1	1	Coastal saltmarsh	
RLP-MU18-P1	1	1	1	unspecified	
RLP-MU44-P1	1		1	Native vegetation	
RLP-MU19-P6	1			Native vegetation	
RLP-MU27-P2	1			unspecified	
RLP-MU35-P2			1	unspecified	
RLP-MU37-P1	1	1	1	unspecified	
RLP-MU56-P2				unspecified	
RLP-MU09-P1	1	1		Native vegetation	
RLP-MU28-P1	1			unspecified	
RLP-MU29-P1	1	1		unspecified	
RLP-MU52-P1		1	1	unspecified	
RLP-MU13-P2			1	unspecified	
RLP-MU26-P2				unspecified	
RLP-MU33-P6				unspecified	
RLP-MU38-P1	1	1		unspecified	
RLP-MU31-P1				unspecified	
RLP-MU37-P2		1	1	unspecified	
RLP-MU29-P4	1			Mountain Plum Pine; native vegetation	
RLP-MU22-P1	1	1	1	Buloke ; stringybark woodland	
RLP-MU26-P3	1		1	Grey Box (Eucalyptus microcarpa) Grassy Woodlands	
RLP-MU17-P1	1			Narrow-leaved Mallee Woodland	
RLP-MU32-P1	1			Buloke ; stringybark woodland	
RLP-MU33-P5			1	Matchstick Banksia	
RLP-MU35-P4			1	Banksia woodland	
RLP-MU02-P1	1			White Box-Yellow Box-Blakely's Red Gum Grassy Woodland	
RLP-MU07-P3	1			White Box-Yellow Box-Blakely's Red Gum Grassy Woodland	
RLP-MU25-P1				Banksia woodland; Sheoak and Sweet Bursaria	
RLP-MU27-P3	1			Buloke	
RLP-MU05-P3				Grey Box (Eucalyptus microcarpa) Grassy Woodlands	
RLP-MU16-P2	1			Eyre Peninsula Blue Gum (Eucalyptus petiolaris) Woodland	
RLP-MU33-P1				Eucalypt Woodlands of the W.A. Wheatbelt	

6.4 RLP threat MER network - Fire

6.4.1 Rationale

Fires are an ecological process characteristic within Australian landscapes. However, while Australian ecosystems are resistant to the effects of fire and resilient enough to recover after fire (Lewis and Debuse 2012, Clarke et al. 2013, Pausas and Keeley 2014, Doherty et al. 2017), it remains important to assess how these systems change in response to fire (Guinto et al. 1999, Bradstock et al. 2005, Burgess et al. 2015, Denham et al. 2016). These responses are also likely to vary depending on the fire regime (frequency, intensity, magnitude) (Whelan 1995, Archibald et al. 2013), and whether these fires are planned or unplanned, i.e. wildfires / bushfires (Keeley 2009). The current catastrophic bushfires appear to be closely linked to the changing global climate with fire conditions exacerbated by extend drought, low rainfall, high fuel loads and elevated temperatures over the summer (NE&E, Dickman et al. 2020). Large-scale disturbance of the magnitude experienced with the current 2019/2020 bushfires is likely to become more widespread and frequent (Dickman et al. 2020). These large-scale intense bushfires can also have significant effects on habitats and their constituent species (Legge et al. 2008, Price et al. 2015, Bowman et al. 2016). There is potential capacity within the RLP program to contribute to our greater understanding of the changing circumstances surrounding fire as a landscape-level ecological process in Australia (Capon et al. 2020), and monitoring has been identified as an important conservation response (Dickman et al. 2020).

6.4.2 Evaluation questions

The purpose of the proposed fire MER network within the RLP LTMF is to enable reporting on and evaluation of responses by RLP outcomes to the threat faced by fire. Monitoring in relation to bushfires can include sites where monitoring has occurred prior to any fire so that post-fire responses can be evaluated, but novel sites in areas affected by fire can also be identified for targeted monitoring of these systems using standardised protocols. The questions posed to assess the threat from fire could consider the impact and response to unplanned bushfires but could equally consider the response to planned manipulation of fire regimes as part of RLP interventions (e.g. application of fire as a strategic intervention) (Table 19).

KEQs for fire MER networks	Potential indicators
What are the impacts of fire on targets and habitats at RLP sites?	 Abundance of target population/s within the study area Extent of habitat impact by fire (hectares) Heterogeneity of fire impacted sites and prevalence of fire refugia Mortality of key habitat features (e.g. hollow-bearing trees, species) Cover and quantity of coarse woody debris
What are the responses of threatened species, vegetation communities, and habitats to unplanned bushfire across space and time?	 Abundance of the target fauna / flora species from multiple sites Occupancy of the target species from multiple sites – assess rates of colonisation Proportion of plants showing resprouting / epicormic growth from multiple sites Vegetative cover following fire and assessments of native versus weed cover Habitat condition assessments and status Water quality and riparian condition Seedbank measures (canopy and soil), and propagule arrival Soundscape measures
What are the responses of threatened species, vegetation communities to planned fire across space and time?	 Abundance of the target fauna / flora species from multiple sites Occupancy of the target species from multiple sites – assess rates of colonisation Proportion of plants showing resprouting / epicormic growth from multiple sites Vegetative cover following fire and assessments of native versus weed cover
Have interventions implemented through RLP actions minimised the impact of unplanned bushfires on RLP outcomes?	 Changes in community composition Abundance of the target fauna / flora species from multiple sites Habitat condition assessments and status

Table 19. Potential KEQs for proposed fire MER networks.

6.4.3 Sampling design

We propose the development of a modular approach to standardised ecological monitoring at a sitelevel, involving a series of protocols that can be tailored as required in relation to the particular system of concern. With respect to terrestrial ecological components, these can be drawn from the TERN AusPlots monitoring protocols using sites that are 1 ha in size (White et al. 2012, Sparrow et al. 2016). Accompanying protocols for monitoring threats, as well as natural drivers, and any management interventions being conducted will also be required.

The major modules of standardised protocols for monitoring ecological responses following the bushfire crisis as detailed in Capon et al. (2020) are:

- Habitat condition monitoring
- Terrestrial fauna surveillance
- Aquatic ecosystem monitoring

The number and location of plots surveyed in particular areas will depend on the particular context and complexity of the system of interest. To investigate responses at a local scale, however, previous studies have recommended at least five to ten replicate plots per treatment combination in addition to a similar number of control plots where available (Williams 2010). With respect to ecological monitoring post-bushfires, this means that at least five replicate plots per ecosystem context (e.g. similarly burnt plots of a particular vegetation community in a specified region) are likely to be required to detect and evaluate responses as well as similar numbers of unburnt plots of the same habitat type where available. Where the effect of pre- and/or post-fire management interventions (e.g. replanting, weed control) are also of interest, replicate and control plots will similarly be required for each relevant treatment combination.

Ecological responses post-fires are also likely to exhibit some rapid changes with high sensitivity to natural drivers and other perturbations. Therefore, it may be pertinent in this context to conduct habitat condition monitoring on a more frequent basis at least initially. We recommend sampling be conducted initially on a seasonal basis for the first 1-2 years and at least annually after that for 5 years, beyond which less frequent sampling may be sufficient depending on early responses.

6.4.4 Potential contribution of the RLP LTMF to monitoring and evaluation of bushfire response

The proposed RLP LTMF may benefit monitoring and evaluation of post-fire ecological responses by contributing data from relevant RLP projects as well as through the sharing of expertise and infrastructure. There are 52 RLP projects that currently list fire as a threatening process in their project descriptions on the MERIT portal and the sites for these projects are widely distributed across Australia. Of these, the majority are projects targeting threatened species (Outcome 2, n = 34, 65.3 %) followed by threatened ecological communities (Outcome 4, n = 11, 21.2 %), with only a small number of projects associated with either Ramsar and World Heritage sites (n = 4 and 3 respectively, 7.7 % and 5.8 %) (Figure 12).

These projects identify a variety of intervention strategies to address fire, and also include the use of fire to control invasive species (e.g. buffel grass). At present it appears that slightly more than half of the current RLP projects include the explicit assessment of RLP Outcomes to fire and the use and/or monitoring of responses to either controlled burns or wildfire. The is also a considerable parallel effort

in developing fire management plans and raising awareness amongst communities about the ecological responses to fire and the need to identify appropriate fire regimes for specific habitats.

There is considerable potential to capitalise on existing RLP monitoring effort to coordinate an assessment of responses to the current bushfire crisis but it is likely that additional prioritisation and / or identification of new sites may be required to include sites in habitats / ecosystems that have burned more recently compared to those that are currently the focus of RLP efforts. This might only be possible once more detailed mapping of the current fires becomes available.



Figure 12. RLP project sites across Australia for projects that list 'fire' as a threat to the RLP Outcomes. RLP outcomes are identified for each of the four ecological program outcomes.

Long-term Ecological Monitoring, Reporting and Evaluation platform (Latimer)

7.1 Overview of proposed platform

This chapter lays out a high-level proposal for the development of an online platform (nicknamed *Latimer* (meaning 'interpreter' in Old English) – Long-Term Ecological Monitoring, Evaluation and Reporting platform) to coordinate data collection, analysis, evaluation and reporting. This proposal leverages Virtual Laboratory technology (also known around the world as Science Gateways, Virtual Research Environments, or more generally Platforms) to deliver a rich environment for cumulative assessments of the outcomes of the RLP program.

Latimer would draw together RLP data alongside key external datasets and connect these data with analytical tools and workflows (e.g. models) to support collaborative research and knowledge generation across institutional, jurisdictional and discipline boundaries. Latimer would provide the means for automating intricate, arduous, lengthy, manual or at best semi-automated processes that restrict the holistic cumulative assessment of RLP-collected information.

7.2 Platform objectives

The benefits and impact of the proposed platform will be both transformational and immediate and will allow for robust cumulative assessments of impacts of the broader RLP program in an efficient, timely manner. The key outcomes are expected to deliver the following benefits:

- a. a consistent approach to data collection across RLP projects through consistent and continuous collection, storage and access to baseline or templated data across project services;
- b. a consistent approach to reporting across RLP projects, targets, and outcomes. This will be executed through online analytical modules that provide immediate access to the required data (external or internal) and tools. The outputs of the workflows will include all provenance information to ensure transparency and repeatability;
- c. increased efficiency in operating standard workflows for particular threats or interventions and therefore greater clarity for guiding future investments;
- d. increased coordination and reliability of RLP impact assessments through established national standards and protocols;
- e. an enduring platform for monitoring and evaluation of future programs; and

f. increased collaboration through a user-friendly interface that can be tailored to specific end-user requirements based on the modular design of the analytical components.

7.3 Blueprint and prototype

We have developed a preliminary blueprint for the Latimer platform outlining the high-level workflow for users that would enable summaries and cross-project evaluations for outcomes of the RLP program (Figure 13). The blueprint details the workflows of four key search components outlined in Table 20 below.

Accompanying the blueprint is a visual prototype. This prototype is a representation of the potential design and concept of Latimer. There is no existing data that this prototype can utilise and therefore it is not a functional prototype. An interactive version of this prototype can be accessed through the link below. Static representations of this can be seen in Appendix 5 and 6.

Interactive prototype: <u>https://xd.adobe.com/view/463f58f9-ac8d-4b80-6d9f-cb8c1ff7af96-</u> 300e/?fullscreen&hints=off

The blueprint is designed based on a two initial user stories:

As an RLP Project Service Provider

I need to ...

- be able to store and visualise data collected throughout my project
- combine project collected data and national-scale spatial datasets with advanced analytical modules
- see my project in context with others in terms of location, targets and interventions
- search for similar projects and see up-to-date progress and outcomes

so that I can...

- continuously assess project impact towards key project targets (e.g. improve the population trajectory of the eastern bettong)
- contextualise my project alongside other RLP projects as well as other national systems to pinpoint areas for collaboration
- share my project data and outputs with other projects
- learn from other projects working with similar threats or interventions

As an **Evaluator of the RLP program**

I need to ...

- be able to search and view individual projects to assess progress against service targets
- be able to search for a particular target (e.g. Malleefowl species) and get an aggregated view of outcomes from all projects working on this target
- be able to search by a given area (e.g. Wet Tropics IBRA region or the state of Queensland) and get an aggregated view of outcomes from all projects working within this area
- be able to search by a given outcome (e.g. Threatened Species, Threatened Ecological Community, Ramsar, World Heritage site) and get an aggregated view of outcomes from all projects working within this overarching outcome
- be able to visualise information on the state of a given threat or the success of a particular intervention based on project collected data

so that I can...

- continuously assess overall program impacts towards key targets (e.g. is data from the program showing an improvement in the population trajectory of the eastern bettong)
- access summary reports on key Targets and Outcomes to assist in the prioritisation of future investments

Search by	Search by	Search by	Search by
PROJECT	TARGET	AREA	OUTCOME
Search by Project is the most	Search by Target allows for	Search by Area allows	Search by Outcome allows
straightforward search	stakeholders to assess	stakeholders to assess	stakeholders to assess
component that allows	cumulative RLP program	cumulative RLP program	cumulative impacts on the
stakeholders to filter projects	impacts on a given target (e.g.	impacts on a given area. The	four big RLP outcomes. The
based on a set of facets such	Malleefowl or Brigalow	system would allow users to	system would allow users to
as outcome, intervention type,	habitat). Again, stakeholders	draw or select an area (e.g.	select the outcome they are
threat type, target type, and/or	can filter targets by outcome,	state/territory boundaries,	interested in and summarise
human measures.	intervention type, threat type,	IBRA regions, bounding box,	all information working on
	target type, and/or human	buffer around a point)	that high-level outcome.
	measures.		

Table 20. High-level search components proposed for the Latimer platform

For each of the search components there are four information/reporting options (Table 21). The elements mentioned under these options are ideas of the kinds of information that can be summarised at each level - a thorough investigation of end user requirements would be gathered prior to system development to ensure information presented in these views are useful to all levels of stakeholders.



Figure 13. High-level draft system blueprint for the Latimer platform showing a user workflow

View Options	Search by PROJECT	Search by TARGET	Search by AREA	Search by OUTCOME
1. Metadata	includes the project organisation, location, duration, and a description of intended outputs.	includes a description of the target, a map with all RLP projects and site locations for primary and secondary investments, and a map from the ALA showing a target density map (where available).	includes a description of the area, a map with all RLP projects and site locations, a list of the top outcomes assessed within the area of interest.	this view will vary depending on the outcome selected, e.g. the Threatened Species outcome metadata may include a graph listing all threatened species and the number of projects working on them.
2. Services report (data from MERIT)	a table with a list of project services and progress against the service targets (this may either link to the MERIT system or could replicate the functionality of MERIT).	a table with a list of services implemented by all projects working on the target as a primary investment. Values will show the cumulative progress against the service targets across all relevant projects.	a table with a list of services implemented by all projects working within the area of interest. Values will show the cumulative progress against the service targets across all relevant projects.	a table with a list of services implemented by all projects working on that outcome. Values will show the cumulative progress against the service targets across all relevant projects.
3. Result dashboard	an interactive result dashboard page showing results from information collected throughout the project.	an interactive result dashboard page showing results from information collected across relevant projects working on the specified target.	an interactive result dashboard page showing results from information collected across relevant projects within the specified area.	an interactive result dashboard page showing results from information collected across relevant projects working on the selected outcome.
4. Report card	an overview of progress towards the project's KEQs and expected outcomes.	an aggregated overview of progress against KEQs and expected outcomes for a given Target (i.e. Malleefowl species)	an aggregated overview of progress against KEQs and expected outcomes within the specified area.	an aggregated overview of progress against KEQs for the selected outcome.

Table 21. Reporting options for each of the search components

7.4 Latimer system modules

7.4.1 Aggregation module

The Latimer platform will comprise a data aggregation module that enables rapid synthesis of perproject information at three levels; 1) Target, 2) Area, 3) Outcome. This aggregation layer would be responsible for tagging and sorting information so that it can be easily pulled together for a given search component e.g. show me the cumulative list and number of pest species caught in trapping services across all projects.

7.4.2 Analytics module

The platform will develop a series of modules that pull data from RLP projects, including services and outcomes reports from MERIT, raw data contributed by RLP projects (e.g. via TERN AEKOS) and external data collections such as spatial climate or vegetation layers, and feed this into a series of analytical tools. Results of these analytical modules would then be provided in relevant Result Dashboards and Report Cards (Table 21). What these analytical tools are, and what results they produce, will depend on the type of data available (from both RLP projects and supplementary sources) and also the types of services a RLP project is undertaking.

Given that each project undertakes a set of predefined services, the analytical modules would be developed to tie in with the data collected through the service activities. The actual statistical tests or models that make up these modules will heavily depend on the type of data that projects collect, and how consistent this is from project to project. Developing data collection standards and specifying minimum baseline variables to be collected (see sections 5.2 and 5.3 for examples) will increase the utility and impact of these analytical modules.

An example of this is outlined in Figure 14 below for two of the RLP Service Categories. The diagram shows three different projects undertaking the same service, fauna surveys on nesting birds and installing traps for feral cats. By collecting consistent baseline data, Latimer will be able to analyse and show results for each individual project, but also aggregate these data to visualise overall program trajectories for given interventions or targets. Developing templates for this baseline information would be one of the first steps in building the system.



Figure 14. Example of using templated data from two different RLP services to assess outcomes.

Road map for implementation

8.1 Overview

This chapter provides a suggested road map for implementing the proposed RLP LTMF presented here. We identify the key tasks required of major relevant actors in three broad phases (Table 22):

- a. Establishment (2020-21)
- b. Short-term (2021-22)
- c. Medium-term (2022-23)

8.2 Establishment of the RLP LTMF

To implement the framework proposed here, an initial establishment phase would be required. This would involve ascertaining the identities, roles and responsibilities of key actors in the framework (e.g. MERI team, RLP project service providers, steering committee etc.) and formalising key partnerships (e.g. with supplementary data providers). In particular, coordination of the involvement of RLP project service providers and their contribution to the proposed descriptive evaluation pathway and MER networks would need to be determined during this establishment phase. Additionally, the processes and infrastructure necessary to support the proposed framework, such as data collection Apps, project reporting templates and the Latimer platform, would need to be developed. A collaborative benchmarking process to inform evaluation of outcomes associated with Ramsar sites, World Heritage areas and threatened ecological communities would also be beneficial during this phase.

At the end of this initial phase, we would envisage that the overall structure of the proposed framework would be established in sufficient detail to enable short-term evaluation and reporting for the mid-program milestone.

8.3 Short-term implementation (2021-22)

Following establishment of the proposed framework, the next phase would involve data collection, analyses, evaluation and reporting in relation to mid-program outcomes. This could be conducted in such a way that analytical modules, results dashboards and report cards (e.g. in the Latimer platform) could be further developed and tested in conjunction with analyses and reporting so that future reporting milestones could be achieved utilising the capabilities of the Latimer platform.

The main outputs from this phase would include an operational Latimer platform and short-term evaluation reports for the program. A review and revision of the framework would also be appropriate at the end of this phase.

8.4 Medium-term implementation (2022-23)

The third phase would focus on evaluation of the current RLP program utilising the framework established in previous phases. A review and revision of the framework with respect to its longer-term use should also be conducted in this phase.

Table 22. Implementation schedule

What?	Who?	When?		
		2020-21	2021-22	2022-23
Establishment phase				
establish MERI team, steering committee etc.	Department			
finalise outcomes reporting and meta-data template(s) for mid-year RLP project reporting	MERI team			
formalise key partnerships, e.g. TERN, TSX	MERI team, Department			
finalise design and establish MER network(s)	MERI team, Department, RLP project service providers			
develop RLP monitoring App in conjunction with TERN	MERI team			
finalise design and develop first phase of Latimer platform	MERI team, Department, platform developers			
conduct collaborative benchmarking process for RLP Outcomes 1, 3 and 4	MERI team, Department, relevant stakeholders			
Short-term evaluation				
RLP project outcomes reporting and data collection (RLP project service providers)	RLP project service providers			
supplementary data collection (MERI team)	MERI team			
data screening (MERI team)	MERI team			
data analyses (MERI team)	MERI team			
design of evaluation report cards (MERI team)	MERI team			
development of analytical modules, results dashboards and report cards in Latimer platform (MERI team, platform developers)	MERI team, platform developers			
preparation of short-term RLP program evaluation report (MERI team)	MERI team			
review and revision of LTMF (MERI team)	MERI team			

What?	Who?	When?		
		2020-21	2021-22	2022-23
Medium-term evaluation				
RLP project outcomes reporting and data collection	RLP project service providers			
supplementary data collection	MERI team			
data screening	MERI team			
data analyses	MERI team			
preparation of medium-term RLP program evaluation report	MERI team			
review and revision of LTMF for ongoing delivery	MERI team, Department			

References

Anon (2020). Biodiversity in flames. *Nature Ecology & Evolution*, 4, 171. https://doi.org/10.1038/s41559-020-1119-4

Archibald, S., Lehmann, C.E.R., Gomez-Dans, J.L., & Bradstock, R.A. (2013). Defining pyromes and global syndromes of fire regimes. *Proceedings of the National Academy of Science*. 110, 6442-6447.

Bowman, D. M. J. S., Williamson, G. J., Prior, L. D., Murphy, B. P. & Poulter, B. (2016). The relative importance of intrinsic and extrinsic factors in the decline of obligate seeder forests. *Global Ecology and Biogeography*, 25, 1166-1172.

Bradstock, R.A., Bedward, M., Gill, A.M., & Cohn, J.S. (2005). Which mosaic? A landscape ecological approach for evaluating interactions between fire regimes, habitat and animals. *Wildlife Research*, 32, 409-423

Burgess, E.E., Moss, P., Haseler, M., & Maron, M. (2015). The influence of variable fire regime on woodland structure and composition. *International Journal of Wildland Fire*, 24, 59-69.

Burns, E.L., Tennant, P., Dickman, C.R., Gillespie, G., Green, P.T., Hoffmann, A., Keith, D.A., Lindenmayer, D.B., Metcalfe, D.J., Morgan, J.W., Russell-Smith, J., & Wardle, G.M. (2018). Making monitoring work: insights and lessons from Australia's Long-Term Ecological Research Network. *Australian Zoologist*, 39(4), 755-768.

Capon, S., Castley, G., Palmer, G., Schmidt, D., Linke, S., & O'Connor, R. (2018). *Regional Land Partnerships Long-term Monitoring Framework: Draft Discussion Paper*. Griffith University. 83pp.

Capon, S., Castley, G., Linke, S. & Palmer, G. (2020). *Post 2019-20 bushfire crisis proposal for long-term ecological monitoring and evaluation*. Griffith University. 23pp.

Capon, S.J. & Pettit, N.E. (2018). Turquoise is the new green: Restoring and enhancing riparian function in the Anthropocene. *Ecological Management & Restoration*, 19, 44-53.

Clarke, P.J., Lawes, M.J., Midgley, J.J., Lamont, B.B., Ojeda, F., Burrows, G.E., Enright, N.J. and Knox, K.J.E., (2013). Resprouting as a key functional trait: how buds, protection and resources drive persistence after fire. *New Phytologist*, 197(1), 19-35.

Clarke, R. H., Oliver, D. L., Boulton, R. L., Cassey, P., & Clarke, M. F. (2003). Assessing programs for monitoring threatened species–a tale of three honeyeaters (Meliphagidae). *Wildlife Research*, 30(5), 427-435.

Collins, L. (2020). Eucalypt forests dominated by epicormic resprouters are resilient to repeated canopy fires. *Journal of Ecology*, 108, 310-324.

Crates, R., Rayner, L., Stojanovic, D., Webb, M., Terauds, A., & Heinsohn, R. (2019). Contemporary breeding biology of critically endangered Regent Honeyeaters: implications for conservation. *Ibis*, 161(3), 521-532.

Crates, R., Terauds, A., Rayner, L., Stojanovic, D., Heinsohn, R., Ingwersen, D., & Webb, M. (2017). An occupancy approach to monitoring Regent Honeyeaters. *The Journal of Wildlife Management*, 81(4), 669-677.

Department of Biodiversity, Conservation and Attractions (2018). Australasian Bittern (*Botaurus poiciloptilus*) Western Australian Recovery Plan. Wildlife Management Program No. 64. Perth, WA: Department of Biodiversity, Conservation and Attractions.

Department of the Environment and Energy (2018). Regional Land Partnerships Evaluation Plan. Final Report. RMCG, June 2016. Last accessed 07 January 2019, <u>http://www.nrm.gov.au/system/files/resources/20a6df50-2e57-4549-98e2-f32318e18bb4/files/rlp-</u> evaluation-plan-2018.pdf

Department of the Environment and Energy (2019). *Threatened Species Strategy: Year three progress report*. Retrieved 5 December 2019, from https://www.environment.gov.au/biodiversity/threatened/publications/threatened-species-strategyyear-three-progress-report

Denham, A. J., Vincent, B. E., Clarke, P. J. & Auld, T. D. (2016). Responses of tree species to a severe fire indicate major structural change to Eucalyptus–Callitris forests. *Plant Ecology*, 217, 617-629.

Dickman, C., Driscoll, D., Garnett, S., Keith, D., Legge, S., Lindenmayer, D., Maron, M., Reside, A., Ritchie, E., Watson, J., Wintle, B., & Woinarski, J. (2020). After the catastrophe: a blueprint for a conservation response to large-scale ecological disaster. NESP, Threatened Species Recovery

Hub, January 2020. <u>http://www.nespthreatenedspecies.edu.au/publications-tools/report-after-the-</u> catastrophe-a-blueprint-for-a-conservation-response-to-large-scale-ecological-disas

Doerr, V.A.J., Davies, M.J., Doerr, E.D., Prober, S., Murphy, H., McGinness, H. & Hoffmann, B. (2017). *Knowledge Bank of Management Effectiveness: Technical guide*. CSIRO, Australia.

Doherty, M.D., Lavorel, S., Colloff, M.J., Williams, K.J., & Williams, R.J. (2017). Moving from autonomous to planned adaptation in the montane forests of southeastern Australia under changing fire regimes. *Austral Ecology*, 42 (3), 309-316.

Guinto, D. F., House, A. P. N., Xu, Z. H. & Saffigna, P. G. (1999). Impacts of repeated fuel reduction burning on tree growth, mortality and recruitment in mixed species eucalypt forests of southeast Queensland, Australia. *Forest Ecology and Management*, 115, 13-27.

Keeley, J. E. (2009). Fire intensity, fire severity and burn severity: a brief review and suggested usage. *International Journal of Wildland Fire*, 18, 116-126.

Legge, S., Murphy, S., Heathcote, J., Flaxman, E., Augusteyn, J. & Crossman, M. (2008). The short-term effects of an extensive and high-intensity fire on vertebrates in the tropical savannas of the central Kimberley, northern Australia. *Wildlife Research*, 35, 33-43.

Lewis, T. & Debuse, V. J. (2012). Resilience of a eucalypt forest woody understorey to long-term (34-55 years) repeated burning in subtropical Australia. *International Journal of Wildland Fire*, 21, 980-991.

O'Donnell, C. F., & Williams, E. M. (2015). Protocols for the inventory and monitoring of populations of the endangered Australasian Bittern (*Botaurus poiciloptilus*) in New Zealand. Publishing Team, Department of Conservation.

O'Donnell, C. F., Williams, E. M., & Cheyne, J. (2013). Close approaches and acoustic triangulation: techniques for mapping the distribution of booming Australasian Bittern (*Botaurus poiciloptilus*) on small wetlands. *Notornis*, 60(4), 279-284.

O'Neill, S., Sparrow, B., Thurgate, N. & Lowe A.J. (2017). *AusPlots Rangelands Vertebrate Fauna Survey Protocols Manual*, Version 0.3 University of Adelaide. 102pp.

Pausas, J.G. & Keeley, J.E. (2014). Evolutionary ecology of resprouting and seeding in fire-prone ecosystems. *New Phytologist*, 204, 55–65.

Pausas, J.G. & Keeley, J.E. (2017). Epicormic resprouting in fire-prone ecosystems. *Trends in Plant Science*, 22(12), 1008-1015.

Prober, S.M., Broadhurst, L., Boggs, G., Breed, M.F., Bush, D., Lynch, A.J.J. & Dickson, F. (2018). Discussion Paper: Achieving more with less – linking ecological restoration investments with ecological restoration research infrastructure. CSIRO, Australia.

Regional Land Partnerships Evaluation Plan | National Landcare Program (2019) Retrieved 9 January 2020, from http://www.nrm.gov.au/publications/regional-land-partnerships-evaluation-plan

Robinson, N.M., Scheele, B.C., Legge, S., Southwell, D.M., Carter, O., Lintermans, M., Radford, J.Q., Skroblin, A., Dickman, C.R., Koleck, J., Wayne, A.F., Kanowski, J., Gillespie, G.R., and Lindenmayer D.B. (2018). How to ensure threatened species monitoring leads to threatened species conservation. *Ecological Management & Restoration*, 19(3), 222-229.

Southwell, D.M., Einoder, L.D., Lahoz-Monfort, J.J., Fisher, A., Gillespie, G.R. & Wintle, B.A. (2019). Spatially explicit power analysis for detecting occupancy trends for multiple species. *Ecological Applications* 29(6) e01950. 1361-1373.

Sparrow, B., Christensen, R., Thurgate, N., O'Neill, S. & Lowe, A.J. (2016). *AusPlots Woodlands Protocols Manual*, Version 1. University of Adelaide. 34pp.

State of NSW and Office of Environment and Heritage (2018). Saving our Species Monitoring, Evaluation and Reporting: guidelines for conservation projects.

TSX (2019). Australian Threatened Species Index. Data dictionary to Threatened Bird Index Version 2.0 data. Aggregated for National Environmental Science Program Threatened Species Recovery Hub Project 3.1. Generated on 2019-11-29

Whelan, R.J. (1995). The Ecology of Fire. Cambridge, UK; Cambridge University Press.

White, A., Sparrow, B., Leitch, E., Foulkes, J., Flitton, R., Lowe, A.J. & Caddy-Retalic, S. (2012). *AusPlots Rangelands Survey Protocols Manual*, Version 1.2.9. The University of Adelaide Press. 86pp.

Williams, J. (2010). *Project 4: Assessments leading towards consistency in reporting on increasing native habitat and vegetation. 4b. Scientific Assessment of Vegetation Condition Protocols.* A report to Caring for our Country. NRM Insights.

Williams, E. M., Armstrong, D. P., & O'Donnell, C. F. (2019). Modelling variation in calling rates to develop a reliable monitoring method for the Australasian Bittern *Botaurus poiciloptilus*. *Ibis*, 161(2), 260-271.

Wood, S., Stephens, H., Foulkes, J., Ebsworth, E. & Bowman, D. (2014). *AusPlots Forests Survey Protocols Manual*, Version 1.6. University of Tasmania. 90pp.

Wundke, D., Sparrow, B., Thurgate. N., Christensen, R., O'Neill, S. & Lowe, A.J. (2015). *AusPlots Condition Protocols Manual*, Version 0.1 University of Adelaide. 37pp.

APPENDICES

Appendix 1. List of services being provided by RLP projects according to MERIT.

Service	Total # of projects	Total units of service	Direct association to ecological monitoring
Collecting, or synthesising baseline data	95		
Number of baseline data sets collected and/or synthesised		139	
Communication materials	99		
Number of communication materials published		658	
Community / stakeholder engagement	214		
Number of field days		60	
Number of training / workshop events		378	
Number of conferences / seminars		3	
Number of one-on-one technical advice interactions		176	
Number of on-ground trials / demonstrations		4	
Number of on-ground works		30	
Controlling access	59		
Number of structures installed		2	
Length (km) installed		55.4	
Area (ha) where access has been controlled		790	Yes
Area (ha) treated for pest animals – initial		363412	Yes
Area (ha) treated for pest animals - follow-up		1111806	Yes
Controlling pest animals	139		
Area (ha) treated for pest animals – initial		2011261.7	Yes
Area (ha) treated for pest animals - follow-up		6590381.7	Yes
Debris removal	10		
Area (ha) of debris removal		194	Yes
Developing farm/project/site management plan	64		
Number of farm/project/site plans developed		97	
Service	Total # of projects	Total units of service	Direct association to ecological monitoring
---	---------------------	------------------------	--
Area (ha) covered by plan		309	
Erosion management	4		
Area (ha) of erosion control		70	Yes
Length (km) of stream/coastline treated for erosion		0.6	Yes
Establishing and maintaining agreements	100		
Number of agreements		163	
Area (ha) covered by agreements		0	
Number of days maintaining agreements		97	
Establishing and maintaining feral-free enclosures	6		
Number of feral free enclosures		0	Yes
Area (ha) of feral-free enclosures		0	Yes
Number of days maintaining feral-free enclosures		0	Yes
Establishing and maintaining breeding program	12		
Number of breeding sites and/or populations		0	Yes
Number of days maintaining breeding programs		0	
Establishing monitoring regimes	88		
Number of monitoring regimes established		117	Yes
Number of days maintaining monitoring regimes		369	
Farm management survey	2		
Number of farm management surveys conducted		0	
Fauna survey	72		
Area surveyed (ha) (fauna)		9765	Yes
Number of fauna surveys conducted		233	Yes
Fire management actions	26		
Area (ha) treated by fire management action		0	Yes
Flora survey	59		

Service	Total # of projects	Total units of service	Direct association to ecological monitoring
Area surveyed (ha)		0	Yes
Number of surveys conducted		51	Yes
Habitat augmentation	22		
Area (ha) of augmentation		11.2	Yes
Number of structures or installations		6	Yes
Identifying the location of potential sites	54		
Number of potential sites identified		206	Yes
Improving hydrological regimes	10		
Number of treatments implemented to improve water management		5	
Improving land management practices	34		
Area (ha) covered by practice change		69945.5	
Managing disease	3		
Area (ha) treated for disease		0	Yes
Negotiating with the Community, Landholders, Farmers, Traditional Owner groups, Agriculture industry groups etc.	69		
Number of groups negotiated with		273	
Obtaining relevant approvals	27		
Number of relevant approvals obtained		34	
Pest animal survey	42		
Area (ha) surveyed for pest animals		39320	Yes
Number of pest animals surveys conducted		91	Yes
Plant survival survey	19		
Area (ha) surveyed for plant survival		60	Yes
Number of plant survival surveys conducted		2	Yes
Project planning and delivery of documents as required for the delivery of the Project Services and monitoring	116		
Number of planning and delivery documents for delivery of the project services and monitoring		275	

Service	Total # of projects	Total units of service	Direct association to ecological monitoring
Number of days project planning / preparation		1518	monitoring
Remediating riparian and aquatic area	12		
Area (ha) remediated		435.9	Yes
Length (km) remediated		0.2	Yes
Removing weeds	154		
Area (ha) treated for weeds – initial		59349.9	Yes
Area (ha) treated for weeds - follow-up		53843	Yes
Length (km) treated for weeds – initial		0	Yes
Length (km) treated for weeds – follow-up		28.5	Yes
Revegetating habitat	84		
Area (ha) of habitat revegetated		970.4	Yes
Area (ha) of revegetated habitat maintained		78	Yes
Number of days collecting seed		0	Yes
Number of days propagating plants		5	Yes
Site preparation	20		
Area (ha) of site preparation		649.2	
Number of days preparing site		16	
Skills and knowledge survey	50		
Number of skills and knowledge surveys conducted		43	
Soil Testing	2		
Number of soil tests conducted in targeted area		2	Yes
Undertaking emergency interventions to prevent extinctions	8		
Number of interventions		0	
Water quality survey	9		
Area (ha) surveyed for water quality		6400	Yes
Number of water quality surveys conducted		79	

Service	Total # of projects	Total units of service	Direct association to ecological monitoring
Weed distribution survey	38		
Area (ha) surveyed for weeds		450	Yes
Number of weed distribution surveys conducted		76	

Appendix 2. RLP project self-evaluation template for mid-project and final-project outcomes reporting.

_				
KEQ ID	Evaluation Question	Response / self-evaluation	Justification	Evidence
DE_TH1	What are the key threats of concern in this RLP project?	This information should be available from RLP project plans but may need to be reported in a	This information should be available from RLP project plans but may need to be reported in a	What sourc evaluation? responses t

N.B. It is proposed that this template is delivered as a dynamic form online via MERIT.

DE_TH1	What are the key threats of concern in this RLP project?	This information should be available from RLP project plans but may need to be reported in a	This information should be available from RLP project plans but may need to be reported in a	What sources of data support this evaluation? Refer to datasets referenced in responses to KEQs KG 1-5.
DE_TH2	What are the key threats being addressed by this RLP project?	more standardised manner, e.g.moreLists of threats classified into majorwithcategories and sub-categories usingthreaddrop-down menuthread	more standardised manner, e.g. with clear justifications for each threat considered	
DE_TH3	What are the extent and magnitude of each key threat with the project area?			
DE_TH4	Have key threats expanded/contracted, intensified/reduced or changed in their importance with respect to the RLP project area?	Response required for each threat listed in previous responses	Response required for each threat listed in previous responses	
DE_TH5	Have any new actual or potential threats emerged in the RLP project area?			
DE_IN1	Which NRM interventions have been implemented under this RLP project?	This information should be available from RLP project plans and services reports but may need to be reported in a more standardised manner, e.g. Lists of	This information should be available from RLP project plans but may need to be reported in a more standardised manner, e.g. with clear justifications for each	

KEQ ID	Evaluation Question	Response / self-evaluation	Justification	Evidence
		interventions classified into major categories and sub-categories using drop-down menu	<i>intervention considered and clear</i> <i>links made between interventions</i> <i>and threats.</i>	
DE_IN2	To what extent and magnitude has each priority action been implemented under this RLP project?	Response required for each action listed in previous responses	Response required for each action listed in previous responses	
DE_T1	Which ecological targets have been addressed under this RLP project?	This information should be available from RLP project plans but may need to be reported in a more standardised manner, e.g. Lists of targets classified into major categories and sub-categories using drop-down menu	This information should be available from RLP project plans but may need to be reported in a more standardised manner, e.g. with clear justifications for each target considered	
DE_T2	Has the condition of ecological targets addressed under this RLP program changed (i.e. improved, declined or stayed the same)?	Response required for each target listed in previous responses	What is the trend informing this assessment? What baseline/benchmark has been used?	
DE_T3	To what extent and magnitude has the condition of ecological targets addressed under this RLP project changed (i.e. improved or declined)?			
ME_1	Have NRM interventions implemented under this RLP			

KEQ ID	Evaluation Question	Response / self-evaluation	Justification	Evidence
	project had their desired/expected primary response?	Response required for each intervention listed in previous responses	What is the analysis informing this assessment? What conceptual model has informed this?	
ME_2	Have NRM interventions implemented under this RLP project influenced the extent, magnitude and/or other attributes of key threats?			
ME_3	Have NRM interventions implemented this RLP project influenced condition of ecological targets?			
ME_4	What other drivers have affected threats to ecological targets addressed by this RLP project and ecological responses to these?	<i>Response required for each threat listed in previous responses</i>	What is the analysis informing this assessment? What conceptual model has informed this?	
ME_5	What other drivers have affected the condition of ecological targets addressed by this RLP project?	<i>Response required for each target listed in previous responses</i>	What is the analysis informing this assessment? What conceptual model has informed this?	
KG_1	What datasets have been generated by the RLP program?	<i>List of datasets associated with threats, interventions and targets listed in previous responses</i>	N.A.	Raw +/- standardised datasets with accompanying meta-data

KEQ ID	Evaluation Question	Response / self-evaluation	Justification	Evidence
KG_2	Has the RLP program increased our understanding of priority ecological targets and threats to these?	Response required for each threat, intervention and target listed in previous responses	What is the analysis informing this assessment? What conceptual model has informed this?	
KG_3	Has the RLP program increased our knowledge of best practice NRM?			
KG_4	What is the best practice NRM for the future?			

Appendix 3. Summary of approach used to identify and classify RLP project clusters for revegetation.

Across all Outcomes, 79 projects mentioned interventions related to the category of "*Habitat improvement/regeneration*" (including sub-categories "*Debris removal (incl. marine debris removal)*", "*Improve water quality*", "*Erosion control*", "*Revegetation*", "*Reducing pollution*"). While some projects may be specific with respect to the type of habitat improvement/regeneration they are conducting, other projects remain quite general (N=106). As a project can have more than one intervention within these categories, in total 224 interventions relate to "Habitat improvement/regeneration" (Figure 15).



Figure 15. Number of interventions per intervention general category and sub-category

Within this category, a smaller selection of projects focus specifically on "*Revegetation*" interventions (N=41). These projects were studied together, and a scoring methodology was developed to determine specific clusters. Within these projects, some mentioned more than one "*Revegetation*" Intervention amounting to a total of 75 "*Revegetation*" interventions across all projects.

Descriptive analysis of "Revegetation" projects

The most frequent threat category related to "*Revegetation*" interventions is "*Habitat loss*" (N=23) (Figure 16). Within the "*Habitat loss*" category, some projects mention in particular "*Habitat fragmentation*" (N=7) and "*Land clearing*" (N=6).



Figure 16. Frequency of Threat categories under "Revegetation" interventions (multiple threats can be listed for one project)

The "*Revegetation*" interventions were then analysed in more detail. Some projects indicate whether the intervention is supporting a specific target plant species or habitat and/or a specific fauna species (Figure 17, 18). For 24 projects, "*Revegetation*" interventions target a specific plant species/habitat (Figure 17). For example, five projects explicitly focus their intervention on "Native vegetation" and three projects focus on "Buloke". For 15 projects, "*Revegetation*" interventions support a specific fauna species (Figure 18). Three projects for instance are restoring the habitat of the Regent Honeyeater through "*Revegetation*" interventions.



Figure 17. Frequency of target plant species or ecological communities for projects (projects can address more than one plant species or Ecological Community)



Figure 18. Frequency of fauna species targeted by the "Revegetation" intervention (projects can address more than one fauna species)

The specific actions listed under the "*Revegetation*" interventions were then further explored. When mentioned, these actions were separated into different types, illustrated in Figure 19. "*Planting/seeding*" (N=21), "*Fencing/Riparian protection*" (N=16) and "*Habitat patches and corridors/connectivity*" (N=15) were the most common "*Revegetation*" intervention types. One project can have more than one type of "*Revegetation*" intervention. Almost half of all projects did not specify the type of "*Revegetation*" intervention that would be conducted through the project (N=20).



Figure 19. Frequency of the types of "Revegetation" interventions (projects can conduct more than one type of intervention)

The different types of methods for collecting the data related to "Revegetation" intervention were then analysed using the Indicators and Baselines that had previously been associated to specific "*Revegetation*" interventions (Figure 20).



Figure 20. Frequency of data collection methods for "Revegetation" Interventions (projects can use more than one data collection method)

Project scoring and clustering

Following the project descriptive analysis, a set of criteria was established to create clusters of similar projects. The scoring categories are presented in Table 22.

Based on this scoring criteria, projects were each given a score. The following clusters were created based on the scores of each project:

- Cluster 1 =projects with a score ≥ 5
- Cluster 2 = projects with a score = 4
- Cluster 3 = projects with a score = 3
- Cluster 4 = projects with a score = 2

Table 23 provides this breakdown for each project indicating their project ID for easy identification.

Scoring Criteria	Description	Scoring
	One of the most common types of interventions is " <i>planting, seeding</i> " interventions.	If "Type of intervention" is " <i>Planting, seeding</i> " = 1
Type of intervention	One of the most common types of interventions is <i>"fencing/controlling access"</i> interventions.	If "Type of intervention" is "fencing/controlling access" = 1
	One of the most common types of interventions is " <i>habitat patches and</i> <i>corridors / connectivity</i> " interventions.	If "Type of intervention" is focusing on " <i>habitat patches and</i> <i>corridors / connectivity</i> " = 1
Data collection Method	Some projects mention explicitly whether they are doing a pre- and post-project comparison.	If project is doing a " <i>pre-post</i> comparison" = 1
	Some projects mention a specific methodology – the Index of Wetland Condition.	If project is using the Index of Wetland Condition = 1
Focus of intervention	Some projects mention a specific plant species of or ecological community that is being targeted by the " <i>Revegetation</i> " Intervention.	If " <i>Revegetation</i> " Intervention mentions a specific target plant species or ecological community = 1
	Some projects mention a specific fauna species that is being targeted by the <i>"Revegetation"</i> Intervention.	If " <i>Revegetation</i> " Intervention mentions a target fauna species = 1
Service metrics	Some projects provide area metrics in the Service section, indicating the area of habitat revegetated they aim to reach	If project has metrics information on services "28A Area (ha) of habitat revegetated = 1

Table 23. Scoring criteria for "Revegetation" projects

				/ /	/ /	/ /	/ /	/ /		
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	/	/ /					/			
2 010 141122 04		1					1	/		_
2 RLP-IVIUZZ-P1 2 PLD MUI07 D6		1	T	1	1	1	1		6	_
2 RLP-MU18-P1		1		1	1	1	1		5	E.
4 RIP-MU26-P3		1		1	1	1	1		5	JST
2 RIP-MI129-P4		-	1	1	1	1	1		5	GL
1 RLP-MU44-P1	1	1	1	1	1	-	-		5	
4 RLP-MU17-P1	1			1	1		1		4	\neg
2 RLP-MU19-P6	1			1	1		1		4	
2 RLP-MU27-P2	1			1		1	1		4	
2 RLP-MU28-P2	1	1		1	1				4	
2 RLP-MU30-P4		1		1	1	1			4	7
2 RLP-MU32-P1	1			1	1	1			4	E
2 RLP-MU33-P5		1			1	1	1		4	ISN
2 RLP-MU35-P2		1		1		1	1		4	ปี
4 RLP-MU35-P4		1		1	1		1		4	
1 RLP-MU37-P1	1	1		1			1		4	
2 RLP-MU56-P1			1	1	1	1			4	
2 RLP-MU56-P2			1	1		1	1		4	
4 RLP-MU02-P1	1			1	1				3	
4 RLP-MU07-P3	1			1	1				3	
1 RLP-MU09-P1	1			1	1				3	~
4 RLP-MU25-P1				1	1			1	3	ER
4 RLP-MU27-P3	1			1	1				3	JST
2 RLP-MU28-P1	1			1				1	3	CL
2 RLP-MU29-P1	1			1		1			3	
1 RLP-MU52-P1		1	1	1					3	
2 RLP-MU52-P3	1			1	1				3	
4 RLP-MU05-P3			1		1				2	
4 RLP-MU13-P12		1			1				2	
2 RLP-MU13-P2		1	1						2	_
4 KLP-MU16-P2	1	1		1	1			1	2	ER 4
		1			1	1		1	2	ISTE
					1	1	1		2	CLU
				1	1	1	1		2	-
2 RID-MI122 DC				1	T	1	1		2	
2 RLF-WU35-P0	1			1		1	T		2	
	1			1					2	
1 RIP-MII31-D1				1					1	
2 RIP-MII37-P2		1		-					1	
2 RLP-MU41-P5		-							0	
TOTAL	2	21 1	.6 8	3	24	15	15	; :	3	
	-	- 1		5	27	10	10		-	

Table 24. Scoring for each "Revegetation" project

Appendix 4. Summary of approach used to identify and classify RLP project clusters for weed control.

The threat of 'weeds' was identified in 68 of the projects across all outcomes. Of these, 54 projects addressed the threat of weeds with the intervention 'weed control' (Figure 21). Therefore, the project clusters focus on the projects using weed control as an intervention. 92 projects included 'weed control' as an intervention with the majority of these listing 'weeds' as a threat (76; Figure 22).

From these 92 projects, they were ranked to find projects undertaking similar weed control activities based on details from all areas of the project MERIT pages, including; 1) target weed species/type, 2) method of weed control, 3) output service area of weed control (ha) and 4) whether the project is collecting baseline weed data. The project primary investment and ecosystem type of where weed control activities are undertaken was also recorded.

1) Target weed species/vegetation type

From the 92 weed control projects, 46 included information on the target weed species or vegetation type (Figure 23). These were categorised and ranked to identify projects with similar targets. The total number of projects listing each target species were then used to create categories, favouring projects targeting the same weed species as other projects. A category number was then assigned to each project, with projects targeting more than one weed species receiving an accumulative score to a maximum of 3 units. The ranking scheme for target weed species is;

•	5+ projects	score 3
•	3-4 projects	score 2
•	1-2 projects	score 1
•	Unspecified target weed species	score 0

Using these categories, 40 projects received a rank of 3, five projects received a rank of 2, one project received a rank of 1, and 46 projects received a rank of 0. Among the most commonly targeted weed species are African boxthorn (n=10), Buffel grass (n=7), and Lantana (n=7) (Figure 23).

2) Method of weed control

The method of weed control was extracted from the project MERIT pages with 32 of the 92 projects identifying a specific method. These weed control methods were tallied across projects (Figure 24). The majority of projects with a stated weed control method were either 'mechanical' (10) or 'chemical' (14), therefore these were the focus of the ranking for method of control. The ranking of weed control method is;

-	Chemical	score 1
-	Mechanical	score 1
-	Other/unspecified control method	score 0

3) Output services

The output services on the project MERIT page include 4 weed control related services including; 1) Area (ha) treated for weeds – initial 2) Area (ha) treated for weeds - follow-up 3) Length (km) treated for weeds – initial 4) Length (km) treated for weeds – follow-up. From the 92 projects undertaking weed control, 80 projects included weed control service metric data (Figure 25). To rank the projects on weed treatment area, the area in hectares was categorised. The scoring for area of weed control in hectares is;

•	1000+	score 3
•	500-999	score 2
•	1-499	score 1
•	No service metric data	score 0

Using these scores 18 projects were within the highest category (1000+ ha), 9 projects in the 500-999 ha category, 51 in the 1-499 category, and 14 projects with no listed area (ha) of weed control (Figure 25).

4) Baseline weed data

The MERIT page for each of the 92 projects was analysed for whether the project will be collecting baseline weed data. This was scored with *yes* projects scoring 1, and *no* projects scoring 0 with 46 out of the 92 projects including baseline weed data.

Project ranking

These accumulative scores were added to each of the 92 weed control projects to give them a total score. Projects were then ranked on these scores to form 3 project clusters. The primary project cluster includes those with the highest scores (Figure 26; Table 24), followed by the secondary cluster (Figure 27; Table 25), and the final cluster includes projects with low or no scores (Figure 28; Table 26). The ecosystem type where weed control will be undertaken within of each of these projects was established from the primary investment for outcome 4 projects, the primary investment listed Ramsar site, or World Heritage site where possible for outcome 1 and 3 projects where a single TEC was listed. The weed control ecosystem type couldn't be determined for projects without a stated TEC, and where more than one TEC was listed as a secondary investment for outcome 2 projects.

Primary cluster

The primary cluster includes the weed control projects with scores of 7-10 including 22 projects (Figure 26; Table 24). These projects are a mixture of TS, TEC, Ramsar and WHA projects, all include baseline weed control data and are across a mixture of different ecosystems types where weed control is being undertaken including; grassland, shrubland. woodland, rainforest, and wetland (Table 24; Figure 30). All 22 projects stated target weed species or vegetation types, with the most common being African Boxthorn (6), Buffel Grass (4), and Lantana (4) (Figure 29). The method of weed removal for primary cluster projects are chemical (10) and mechanical (7), with 11 projects not stating removal methods (Figure 31). All of the 22 projects included weed control area (ha) measurements with most of the projects (12) falling in the highest category (1000+ ha). The largest area included in weed control activities is 40000 hectares (RLP-MU03-P1, Figure 32).

Secondary and Tertiary cluster

The secondary cluster includes 29 projects with weed control scores of 4, 5, and 6 (Figure 27; Table 25). The tertiary cluster includes the remaining 41 projects with weed control scores of 1, 2, or 3 (Figure 28; Table 26). The projects in these clusters include less information regarding weed control than the primary cluster, with many projects not stating a weed control method, no target weeds, and often no baseline data being collected (Table 25, Table 26).



Figure 21. Interventions associated with the threat 'weeds' across all outcomes, project n=54



Figure 22. Threats associated with the intervention 'weed control' across all outcomes, project n=92



Figure 23. The number of projects targeting each listed weed species or vegetation site from project MERIT pages for all projects undertaking the intervention 'weed control'



Figure 24. The number of projects using listed weed control methods from the project MERIT pages for all projects including the intervention 'weed control'



Figure 25. The number of projects in each scoring group for the total area (ha) of weed control to be undertaken, from the service metrics data in MERIT for all projects using the intervention weed control.





Figure 26. Primary cluster, including projects across all outcomes undertaking weed control, with the highest scores (score 7-10)

Figure 27. Secondary cluster, including projects across all outcomes undertaking weed control, with the next highest scores (score 4-6)



Figure 28. Tertiary cluster, including projects across all outcomes undertaking weed control, with the lowest scores (score 0-3)

Table 25. Primary weed control project cluster

RLP ID	Outcome	State	Primary Investment	Weed control score	weed control ecosystem	Target weed	Control method	Weed control baseline data	Initial area weed control (ha)
RLP-MU03-P1	3	NT	Kakadu National Park	10	shrubland	unspecified grassy weeds	chemical, mechanical	yes	40000
RLP-MU27-P1	1	Vic	Hattah-Kulkyne Lakes	10	unable to determine	noogoora burr, African boxthorn, bridal veil, olive, prickly pear	chemical, mechanical	yes	1860
RLP-MU22-P3	1	SA	The Coorong, And Lakes Alexandrina And Albert Wetland	9	wetland	Juncus acutus, African boxthorn	chemical	yes	35000
RLP-MU09-P3	3	NSW	Gondwana Rainforests of Australia	8	rainforest	Perennial grasses, Mexican Water Lily, Tropical Soda Apple	chemical, mechanical	yes	10
RLP-MU11-P3	3	NSW	Gondwana Rainforests of Australia	8	rainforest	lantana	chemical, mechanical	yes	335
RLP-MU14-P2	4	NSW	Coolibah - Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions	8	woodland	African boxthorn	not specified	yes	10000
RLP-MU15-P4	2	SA	Petrogale lateralis MacDonnell Ranges race (Warru, Black-footed Rock-wallaby (MacDonnell Ranges race)) [Vulnerable]	8	unable to determine	Buffel grass	burning	yes	1600
RLP-MU17-P1	4	SA	Kangaroo Island Narrow-leaved Mallee (Eucalyptus cneorifolia) Woodland	8	woodland	Bridal veil	not specified	yes	1100
RLP-MU24-P4	4	Vic	Alpine Sphagnum Bogs and Associated Fens	8	wetland	Willow, Soft rush	chemical, mechanical	yes	80
RLP-MU26-P3	4	Vic	Grey Box (<i>Eucalyptus microcarpa</i>) Grassy Woodlands and Derived Native Grasslands of South-eastern Australia	8	woodland, grassland	blackberry, Serrated Tussock, thistle, olive	not specified	yes	1449
RLP-MU27-P2	2	Vic	Leipoa ocellata (Malleefowl) [Vulnerable]	8	unable to determine	buffel grass, Boneseed, African boxthorn, bridal veil, prickly pear, wheel cactus, Hudson pear	not specified	yes	16522

			Pulaka Woodlands of the Diversion and Murroy			buffel grass, African boxthorn,	not		
RLP-MU27-P3	4	Vic	Darling Depression Bioregions	8	woodland	bridal veil, prickly pear, wheel cactus, Hudson pear, Athel Pine	specified	yes	1995
RLP-MU31-P4	4	Vic	Alpine Sphagnum Bogs and Associated Fens	8	wetland	Willow, Soft rush	chemical, mechanical	yes	120
RLP-MU36-P3	2	WA	Macrotis lagotis (Greater Bilby) [Vulnerable]	8	rainforest	gamber grass, grader grass, mesquite, Parkinsonia	not specified	yes	20010
RLP-MU36-P4	2	WA	Leipoa ocellata (Malleefowl) [Vulnerable]	8	unable to determine	Buffel grass	not specified	yes	1140
RLP-MU41-P2	1	Tas	Flood Plain Lower Ringarooma River	8	wetland	Willow, African boxthorn, blackberry	chemical	yes	480
RLP-MU48-P4	4	QLD	Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions	8	rainforest	Lantana, Unspecified aquatic weeds, Guinea grass	not specified	yes	2500
RLP-MU16-P1	4	SA	Subtropical and Temperate Coastal Saltmarsh	7	wetland	Sea spurge, Marram grass, Sea wheatgrass, Pyp grass, Beach daisy	not specified	yes	960
RLP-MU30-P1	1	Vic	Western Port	7	wetland	Cord grass	chemical, mechanical	yes	370
RLP-MU44-P1	1	QLD	Great Sandy Strait (Including Great Sandy Strait, Tin Can Bay and Tin Can Inlet)	7	wetland	lantana, asparagus, broad leaf pepper	chemical	yes	60
RLP-MU47-P2	4	QLD	The community of native species dependent on natural discharge of groundwater from the Great Artesian Basin	7	unable to determine	unspecified grassy weeds, unspecified woody weeds	not specified	yes	500
RLP-MU48-P1	1	QLD	Shoalwater And Corio Bays Area (Shoalwater Bay Training Area, In Part - Corio Bay)	7	unable to determine	Lantana, Guinea grass	not specified	yes	500



Figure 29. The number of projects targeting each target weed species for the clustered primary group of weed control projects across all outcomes.



Figure 30. The number of projects performing weed control activities in identified ecosystem types for the clustered primary group of weed control projects across all outcomes.



Figure 31. The number of projects using each identified weed control method for the clustered primary group of weed control projects across all outcomes.



Figure 32. The number of projects in each weed control area (ha) grouping from the service metric data on project MERIT pages for the clustered primary group of weed control projects across all outcomes.

Table 26. Secondary weed control project cluster

RLP ID	Outcome	State	Primary Investment	Weed control score	weed control ecosystem	Target weed	Control method	Weed control baseline data	Initial area weed control (ha)
RLP- MU04- P4	4	NSW	White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland	6	woodland, grassland	unspecified grassy weeds	not specified	yes	68
RLP- MU06- P6	3	NSW	The Greater Blue Mountains Area	6	unable to determine	African olive, Boneseed, Willow	not specified	yes	180.1
RLP- MU07- P1	1	NSW	Myall Lakes	6	rainforest	Bitou Bush, slash pine, lantana, asparagus, blackberry, noogoora burr	not specified	yes	25
RLP- MU08- P4	2	NSW	Pedionomus torquatus (Plains- wanderer) [Critically Endangered]	6	unable to determine	African boxthorn, Unspecified woody	not specified	yes	20
RLP- MU08- P6	1	NSW	NSW Central Murray State Forests	6	unable to determine	Blackberry, African boxthorn, Unspecified woody, Unspecified aquatic, Sweet briar	not specified	yes	50
RLP- MU10- P3	1	NSW	Gwydir Wetlands: Gingham And Lower Gwydir (Big Leather) Watercourses	6	unable to determine	water hyacinth, green cestrum, cats claw, madiera vine, lippia, Pecan Tree	not specified	yes	70
RLP- MU13- P7	2	NSW/	Rutidosis leptorrhynchoides (Button Wrinklewort)	6	unable to	Unspecified grassy weeds, African lovegrass, Chilean Needlegrass, Serrated Tussock	Minimise seed	Ves	5
RLP- MU15- P1	2	SA	Leipoa ocellata (Malleefowl) [Vulnerable]	6	unable to determine	Buffel grass	burning	yes	200

RLP- MU24- P3	1	Vic	Gippsland Lakes	6	wetland	Swamp Everlasting, Metallic Sun-orchid, Dwarf Kerrawang	not specified	yes	5
RLP- MU25- P2	2	Vic	<i>Botaurus poiciloptilus</i> (Australasian Bittern) [Endangered]	6	unable to determine	Unspecified woody, Bridal veil, Radiata Pine, Italian Buckthorn, Phalaris, Spiny Rush, Sicilian Sea Lavender, Coastal wattle	not specified	yes	11
RLP- MU28- P2	2	Vic	Pedionomus torquatus (Plains- wanderer) [Critically Endangered]	6	woodland	African boxthorn	not specified	yes	30
RLP- MU29- P2	4	Vic	Alpine Sphagnum Bogs and Associated Fens	6	wetland	Willow, Juncus acutus, Soft rush	not specified	yes	265
RLP- MU29- P4	2	Vic	<i>Burramys parvus</i> (Mountain Pygmy- possum) [Endangered]	6	wetland	Willow, Blackberry, Apple	not specified	yes	245
RLP- MU52- P3	2	QLD	<i>Brachychiton</i> sp. Ormeau (Ormeau bottle tree) [Critically Endangered]	6	rainforest	Unspecified grassy weeds, Lantana	not specified	yes	1
RLP- MU07- P8	2	NSW	Numenius madagascariensis (Eastern Curlew, Far Eastern Curlew) [Critically Endangered]	5	wetland	Juncus acutus	not specified	yes	11
RLP- MU21- P3	1	SA	Coongie Lakes	5	unable to determine	not specified	chemical	no	19100
RLP- MU31- P1	1	Vic	Corner Inlet	5	wetland	Cord grass	not specified	yes	326
RLP- MU03- P4	2	NT	Livistona mariae subsp. mariae (Central Australian Cabbage Palm, Red Cabbage Palm)	4	unable to determine	Buffel grass, Couch grass	not specified	yes	not specified

RLP- MU03- P5	2	NT	<i>Zyzomys pedunculatus</i> (Central rock rat, Antina)	4	unable to determine	Buffel grass	not specified	yes	not specified
RLP- MU07- P6	2	NSW	Anthochaera phrygia (Regent Honeyeater) [Critically Endangered]	4	unable to determine	African olive, Lantana	not specified	yes	not specified
RLP- MU11- P4	3	NSW	Lord Howe Island Group	4	unable to determine	not specified	chemical,mechanical	no	280
RLP- MU12- P5	2	NSW	Pedionomus torquatus (Plains- wanderer) [Critically Endangered]	4	unable to determine	African boxthorn	not specified	yes	not specified
RLP- MU16- P2	4	SA	Eyre Peninsula Blue Gum (<i>Eucalyptus petiolaris</i>) Woodland	4	unable to determine	not specified	not specified	no	1050
RLP- MU20- P3	2	SA	<i>Bettongia penicillata</i> (Brush-tailed Bettong, Woylie) [Endangered]	4	unable to determine	not specified	not specified	no	3000
RLP- MU22- P1	2	SA	Calyptorhynchus banksii graptogyne (Red-tailed Black-Cockatoo (south- eastern)) [Endangered]	4	woodland	not specified	not specified	no	1200
RLP- MU36- P2	3	WA	The Ningaloo Coast	4	unable to determine	Bridal veil	not specified	no	14500
RLP- MU37- P4	4	WA	Proteaceae Dominated Kwongkan Shrublands of the Southeast Coastal Floristic Province of Western Australia	4	shrubland	Unspecified woody	not specified	Ves	not specified
RLP- MU39- P4	4	WA	Banksia Woodlands of the Swan Coastal Plain ecological community	4	woodland	not specified	not specified	no	619.65
RLP- MU43- P4	4	QLD	Brigalow (<i>Acacia harpophylla</i> dominant and co-dominant)	4	Unable to determine	not specified	chemical,mechanical	no	100

RLP ID	Outcome	State	Primary Investment	Weed control score	weed control ecosystem	Target weed	Control method	Weed control baseline data	Initial area weed control (ha)
RLP- MU04-	2	NGW	The Greater Plue Mountains Area	2	woodland,	not specified	chomical	20	160
RLP- MU10- P4	3	NSW	Brigalow (<i>Acacia harpophylla</i> dominant	3	Unable to	not specified	fencing	no	500
RLP- MU11- P1	2	NSW	Dasyornis brachypterus (Eastern Bristlebird) [Endangered]	3	unable to determine	not specified	mechanical	no	60
RLP- MU13- P12	4	NSW	Subtropical and Temperate Coastal Saltmarsh	3	wetland	Juncus acutus	not specified	yes	not specified
RLP- MU13- P13	3	NSW	The Greater Blue Mountains Area	3	woodland, grassland	not specified	not specified	no	600
RLP- MU19- P4	4	SA	Iron-grass Natural Temperate Grassland of South Australia	3	grassland	not specified	not specified	no	500
RLP- MU25- P6	2	Vic	<i>Thinornis rubricollis rubricollis</i> (Hooded plover)	3	unable to determine	Beach Daisy	not specified	yes	not specified
RLP- MU29- P1	2	Vic	Anthochaera phrygia (Regent Honeyeater) [Critically Endangered]	3	unable to determine	not specified	not specified	no	890

Table 27. Tertiary weed control project cluster

RLP- MU39- P2	2	WA	Petrogale lateralis lateralis (Black- flanked Rock-wallaby, Moororong, Black-footed Rock Wallaby) [Endangered]	3	unable to determine	not specified	not specified	no	801
RLP- MU02- P1	4	АСТ	White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland	2	woodland, grassland	not specified	not specified	no	275
RLP- MU05- P7	2	NSW	Lathamus discolor (Swift Parrot) [Critically Endangered]	2	woodland, grassland	not specified	not specified	no	100
RLP- MU05- P8	2	NSW	Anthochaera phrygia (Regent Honeyeater) [Critically Endangered]	2	woodland, grassland	not specified	not specified	no	100
RLP- MU05- P9	2	NSW	<i>Leipoa ocellata</i> (Malleefowl) [Vulnerable]	2	unable to determine	not specified	not specified	no	100
RLP- MU06- P1	1	NSW	Towra Point Nature Reserve	2	rainforest	not specified	not specified	no	32.9
RLP- MU07- P3	4	NSW	White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland	2	woodland, grassland	not specified	not specified	no	14
RLP- MU07- P7	2	NSW	Botaurus poiciloptilus (Australasian Bittern) [Endangered]	2	unable to determine	not specified	not specified	no	10
RLP- MU09- P1	1	NSW	Little Llangothlin Nature Reserve	2	unable to determine	not specified	not specified	no	8
RLP- MU13- P10	1	NSW	Blue Lake	2	wetland	Mouse Ear Hawkweed	not specified	yes	not specified
RLP- MU16- P6	2	SA	Acacia whibleyana (Whibley's Wattle)	2	unable to determine	not specified	Pest control	no	50

RLP- MU18-	_		Botaurus poiciloptilus (Australasian	_	unable to		not		
P1	2	SA	Bittern) [Endangered]	2	determine	not specified	specified	no	34
RLP- MU26- P2	2	Vic	Burramys parvus (Mountain Pygmy- possum) [Endangered]	2	wetland	not specified	not specified	no	47
RLP- MU30- P4	2	Vic	Lichenostomus melanops cassidix (Helmeted Honeyeater, Yellow-tufted Honeyeater (Helmeted)) [Critically Endangered]	2	unable to determine	not specified	not specified	no	36
RLP- MU32- P1	2	Vic	Calyptorhynchus banksii graptogyne (Red-tailed Black-Cockatoo (south- eastern)) [Endangered]	2	woodland	not specified	not specified	no	455
RLP- MU32- P4	2	Vic	Leipoa ocellata (Malleefowl) [Vulnerable]	2	unable to determine	not specified	not specified	no	200
RLP- MU35- P1	1	WA	Peel-Yalgorup System	2	freshwater	not specified	not specified	no	477
RLP- MU35- P4	4	WA	Banksia Woodlands of the Swan Coastal Plain ecological community	2	woodland	not specified	not specified	no	145
RLP- MU37- P1	1	WA	Lake Warden System	2	unable to determine	not specified	not specified	no	38
RLP- MU38- P1	2	WA	Pseudocheirus occidentalis (Western Ringtail Possum, Ngwayir, Womp, Woder, Ngoor, Ngoolangit) [Vulnerable]	2	unable to determine	not specified	not specified	no	7.9
RLP- MU38- P2	1	WA	Toolibin Lake	2	unable to determine	not specified	not specified	no	133
RLP- MU45- P2	4	QLD	Littoral Rainforest and Coastal Vine Thickets of Eastern Australia	2	rainforest	not specified	not specified	no	30

RLP-			Elseva albaqula (White-throated		unable to		not		
P3	2	QLD	snapping turtle) [Critically Endangered]	2	determine	not specified	specified	no	10
RLP- MU49- P2	3	QLD	Great Barrier Reef	2	rainforest	not specified	not specified	no	30
RLP- MU52- P1	1	QLD	Moreton Bay	2	unable to determine	not specified	not specified	no	15
RLP- MU56- P1	2	QLD	Casuarius casuarius johnsonii (Southern Cassowary, Australian Cassowary, Double-wattled Cassowary) [Endangered]	2	unable to determine	not specified	not specified	no	50
RLP- MU56- P2	2	QLD	Petaurus gracilis (Mahogany Glider) [Endangered]	2	unable to determine	not specified	not specified	no	215
RLP- MU13- P9	2	NSW	<i>Macquaria australasica</i> (Macquarie Perch)	1	unable to determine	not specified	not specified	no	not specified
RLP- MU25- P1	4	Vic	Natural Temperate Grassland of the Victorian Volcanic Plain	1	grassland	not specified	not specified	no	not specified
RLP- MU05- P2	2	NSW	<i>Swainsona recta</i> (Small Purple-pea, Mountain Swainson-pea, Small Purple Pea) [Endangered]	0	woodland, grassland	not specified	not specified	no	not specified
RLP- MU33- P5	2	WA	Banksia cuneate (Matchstick Banksia)	0	unable to determine	not specified	not specified	no	not specified
RLP- MU34- P5	2	WA	Verticordia spicata subsp. squamosa (Scaly-leaved featherflower)	0	unable to determine	not specified	not specified	no	not specified
RLP- MU37- P2	2	WA	Pezoporus flaviventris (Western Ground Parrot, Kyloring) [Critically Endangered]	0	unable to determine	not specified	Fencing	no	not specified

Appendix 5.

<u>Search by Project Prototype</u> including A) a portal interface that includes faceted search elements to filter and find projects; B) project metadata tab; C) project result tab showing a summary of progress towards service targets reported by the project (information from MERIT); D) project result tab showing an interactive dashboard with information collected during the project; E) a project report card providing an overview of progress against the projects targets and expected outcomes.


Appendix 6.

Search by Target Prototype including A) a portal interface that includes faceted search elements to filter and find a particular target (Species X in this example); B) target metadata tab; C) target result tab showing a summary of progress towards service targets reported by projects working on Species X as either a primary or secondary investment priority (information from MERIT); D) target result tab showing an interactive dashboard with aggregated information collected across relevant projects enabling assessment of cross-project impacts for Species X; E) a target report card with an aggregated overview of progress against the given target(s) and/or outcome(s) for Species X.

