ACT Government

CONSERVATION EFFECTIVENESS MONITORING PROGRAM: AN OVERVIEW

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Front cover (clockwise from left): Monitoring woodland flora; backpack electro fishing and strategic burning for grassland restoration. All Photographs: Conservation Research

CONTENTS

SUMMARY

The Conservation Effectiveness Monitoring Program (CEMP) is an overarching ecosystem condition monitoring framework for the ACT conservation estate. Monitoring is an integral part of evaluating the effectiveness of management actions in achieving nature conservation objectives. There are also many legislative, policy and management requirements for the ACT Government to monitor condition of biodiversity in nature reserves.

CEMP aims to create a coordinated, systematic, and robust biodiversity monitoring program that will allow us to detect changes in ecosystem condition within reserves, evaluate the effectiveness of management actions in achieving conservation outcomes and provide evidence to support land management decisions. A key component of the program is to develop monitoring plans for the eight identified ecosystem units within the ACT reserve system.

This document gives a brief summary of the purpose of CEMP and the rationale behind the adaptive management approach central to the CEMP framework. Its intent is to provide a background as to how and why the CEMP framework was developed including the choice to use ecosystem units to monitor changes in condition over time. Within this document the selection of indicators and metrics within an ecosystem is explained, in addition to a detailed summary of the symbology and classification used to report condition of indicators within ecosystem monitoring plans. The aim is to provide managers, contributors and other users with an easy to use resource that enables interpretation of symbology and summaries found in each of the CEMP ecosystem monitoring plans.

The CEMP reporting framework enables an assessment of the efficacy of management actions, identification of knowledge gaps and the prioritisation of future research. Through consolidating information on ecosystem condition and increasing accessibility of this information across ACT Government, CEMP aims to provide a data-rich decision support tool to inform strategic planning and assist management in conserving ecological values within the ACT reserve system.

1. INTRODUCTION

1.1 BACKGROUND

In Australia and internationally, natural resource agencies are increasingly embedding monitoring programs into reserve management to enable efficient evaluation of enhancement programs and actions (Parks Victoria, 2014b; Parks Victoria 2014a; Parks and Wildlife Service Tasmania 2014; WWF 2005; Hockings et al. 2013; Metsahallitus 2012; Gilliagan et al. 2005). Efficient and correctly established monitoring programs may also be used as a strong decision support tool (Lindenmayer and Likens 2010; Westgate et al. 2012), assist with ensuring effective resource allocation to programs (Hockings et al. 2006; Fancy et al. 2009), help improve park management planning (Vos et al. 1999; Hockings et al. 2006; Fancy et al. 2009) and may provide information suitable for engagement and education of stakeholders, thereby promoting appreciation of biodiversity values and fostering a conservation ethos in the broader community (Stevenson and Seddon, 2014).

Nature reserves, encompassing over half of the land area in the Australian Capital Territory (ACT), were established to protect the rich biodiversity values of the region and are managed by the ACT Government's Parks and Conservation Service (PCS). A 2011 investigation by the Commissioner for Sustainability and Environment into the Canberra Nature Park recommended that a nature reserve monitoring strategy be developed to ensure that threats to reserves were quickly identified, and that information was readily available to ensure better decision making in reserve management. For the purpose of this document, reserve areas refer to areas listed under the Territory Plan as national park, nature reserve, or wilderness area. They include Bimberi Wilderness Area, Canberra Nature Park (CNP), Googong Foreshores (GF), Jerrabomberra Wetlands (JW), Lower Cotter Catchment (LCC), Molonglo River Nature Park (MRNP), Mulligan's Flat Nature Reserve (MF), the Murrumbidgee River Corridor (MRC), Namadgi National Park (NNP), Tidbinbilla Nature Reserve (TNR) and all biodiversity offsets areas.

Stevenson and Seddon (2014) reviewed the extent and type of current monitoring programs across ACT reserves, and provided recommendations to improve the quality and sharing of information collected from these programs so that data may contribute meaningfully to reserve management. Stevenson and Seddon (2014) showed that while monitoring was taking place in ACT reserves, much of the data from these programs was not being collated and presented to reserve managers in a suitable format to inform decision making (Hockings et al. 2004). Additionally, monitoring of conservation outcomes and management actions were rarely linked; most management programs were evaluated by reporting on management actions as opposed to reporting changes in reserve condition or conservation outcomes. Other issues included a lack of coordination across monitoring programs (including the absence of formalised data collection, storage protocols and procedures), leading to an inconsistency of sampling methods between agencies; little integration of management actions and monitoring programs (including volunteer programs) and a large focus on mandated monitoring (such as threatened species monitoring conducted to meet legislative requirements) often providing little insight into the status of biodiversity more broadly. Such mandated monitoring is rarely driven by specific well formulated questions relevant to management with rigorous experimental design, therefore is usually ineffective for informing any meaningful management action (Lindenmayer & Likens, 2010).

Noting the presence of these issues in current monitoring, Stevenson and Seddon (2014) summarised the following important principles of effective monitoring and evaluation programs:

1. Management questions should inform research and monitoring. These questions need to be adaptive and may change over time;
2. Monitoring programs must include or be linked to evaluating conservation outcomes;
3. Conceptual models should be developed to build an understanding of ecosystem processes and relationships and to define critical assumptions;
4. All stakeholders must be engaged in the monitoring program to ensure acceptance;
5. Dedicated, on-going funding is required for biodiversity monitoring and evaluation;
6. Consistent and explicit monitoring protocols need to be developed and a program leader needs to oversee their implementation to maintain data integrity;
7. The monitoring program should use data from current monitoring programs where appropriate;
8. Systems must be developed to ensure the monitoring program is embedded as a land management decision support tool.

Adoption of these principles into a holistic monitoring program would enable a strong paradigm shift from mandate and reactive monitoring into an active adaptive management framework. In response to these findings, the ACT Government commenced the development of an overarching condition monitoring program for ACT nature reserves. The Conservation Effectiveness Monitoring Program (CEMP) was initiated to address the recommendations by the Commissioner for Sustainability and Environment (2011) and to incorporate improvements highlighted in the review by Stevenson & Seddon (2014). The overarching goals of the CEMP program were to:

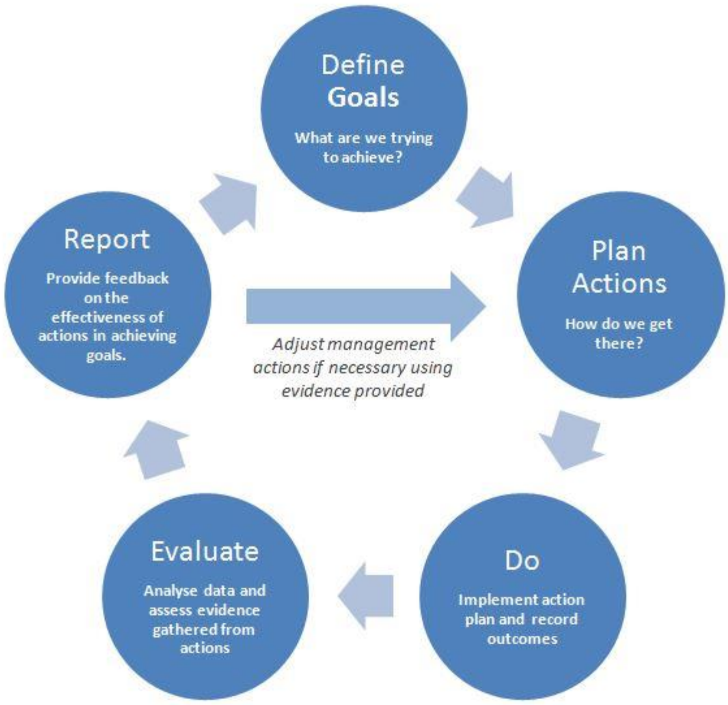
- Detect and report change in the condition of reserve ecosystems and the level of stress imposed by threatening processes;
- Evaluate the effectiveness of management actions at protecting and enhancing ecological values and reducing the impact of threats;
- Provide information to support evidence-based decision making;
- Identify knowledge gaps and areas requiring further targeted research and monitoring;
- Encourage ACT Government staff, community groups and research institutions to contribute towards biodiversity monitoring and research in nature reserves in the ACT.

The program would act as an important tool for evaluating the effectiveness of management actions in achieving conservation outcomes (Possingham et al. 2012); provide information to support land management decisions through evidence based assessment (Lindenmayer and Gibbons 2012) and help address the monitoring requirements of policy and management. A further desired outcome of the program was to develop a coordinated, systematic, and robust biodiversity monitoring program that enabled detection of early signs of change to reserve condition. In this way, the CEMP framework could provide the vital feedback linkages currently absent between management programs and monitoring to generate positive conservation outcomes (Reid et al. 2013).

1.2 THE ADAPTIVE MANAGEMENT CYCLE

An active adaptive management approach ensures management actions are constantly improved through an ongoing learning cycle that encourages research and investigation into best management practice (Allen, 2007; Hockings, et al., 2006). The stages of a typical adaptive management cycle involve recognition of what the desired achievement is (**Goal**), a plan on how this goal may be achieved (**Plan**), actions to carry out the plan (**Do**), a review or assessment on whether the actions achieved the goal (**Evaluate**), communication of this review to other stakeholders (**Report**) and then a decision to either adjust management actions (make a new **Plan**) or even adjust primary goals if necessary (Figure 1).

Figure 1. The stages of the adaptive management cycle as applicable to CEMP



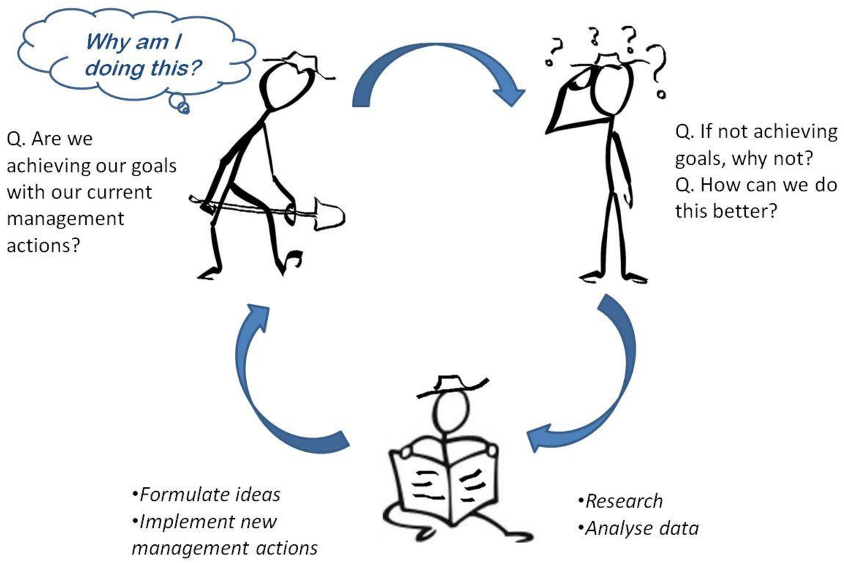
Monitoring the effectiveness of management actions in achieving the stated **goals** is a key component of any adaptive management process (Hockings, et al., 2006). Protecting and conserving natural and ecological values, as defined in management and operational plans for ACT reserves, is the core business of the Environment Division of the ACT Government, Environment and Sustainable Development Directorate. While the Parks and Conservation Service (PCS) is the land management agency, the overarching **goals** are driven by statutory obligations that align with legislative requirements. Action **plans** (for example, action plans for a threatened species or the boarder Reserve Operational Plans (ROPs)) align with these **goals** and form the basis of reserve Plans of Management (POM).

During the first stage of the CEMP program, a framework was developed to enable the systematic evaluation of the effectiveness of reserve management in the ACT. The framework was based on the adaptive management framework, where qualitative and quantitative information drawn from current monitoring programs (the **Do** phase of the cycle) could be used to track progress toward achieving conservation **goals**. Using monitoring data, the framework could evaluate ecosystem condition and the effectiveness of reserve management programs in maintaining and/or enhancing natural values (the **Evaluate** phase). The outcomes of this process would then provide information, recommendations and feedback (the **Report** phase) to support adaptive, evidence-based decision making into the future (completion of the cycle back to the **Plan** phase) (Figure 1).

In this way CEMP aims to provided the **evaluation** and **reporting** capability for adaptive management by filling the currently missing links between the on the ground actions (the **Do** phase) and the **goal** setting and planning phases, for example by feeding into ROPs (the **Plan** phase) or helping to redefine strategic objectives. The review by Stevenson and Seddon (2014) showed that in the **Do** phase of the cycle, many current monitoring programs in ACT reserves only monitor trends in values of interest over time, with little or no data collected on possible causal agents and response to variations in management. There was also a lack of research questions and appropriate frameworks to focus monitoring efforts. CEMP aims to initiate the progression towards a more experimental approach to monitoring in the ACT through encouraging the simultaneous monitoring of probable causal agents, selecting monitoring sites that represent the variation in different management regimes and monitoring control sites in addition to sites where management actions are implemented (i.e. “active” adaptive management).

The information provided by the CEMP allows adaptation of management objectives and actions as the knowledge base increases, assisting in identifying research priorities and knowledge gaps and may assist in improving budgeting allocations over time to ensure resources are directed to priority programs and in ways that lead to improvements in the conservation values (Figure 2).

Figure 2. On-the-ground management and learning through doing in an adaptive management framework.



Biodiversity condition ↔ management and monitoring

How effective are our management programs in conserving our ecosystems?

2. AN ECOSYSTEM APPROACH

2.1 USING ECOSYSTEM UNITS IN THE CEMP FRAMEWORK

The review by Stevenson and Seddon (2014) highlighted the need to coordinate monitoring programs around explicit management questions derived from a conceptual understanding of the ecology of ACT ecosystems. The review recommended a framework for collecting and collating monitoring information using ecosystem units. The ecosystem units were broadly based on native vegetation formations identified by Keith (2004) in addition to management context. The combination of a management and ecosystems approach has the benefit of linking reserves with the broader landscape to promote a nil-tenure approach to natural resource monitoring, in addition to enabling a more targeted assessment of values, threats and processes specific to each ecosystem. Furthermore, this method provides increased synergies with statutory reporting requirements such as threatened species action plans (Stevenson and Seddon 2014).

Stevenson and Seddon (2014) identified eight ecosystems that were represented in ACT nature reserves. Most ecosystems were separated into either 'lowland' or 'upland' monitoring units to recognise the differing management needs and threats to the fragmented lowland communities of Canberra Nature Park compared to the more intact upland communities of Namadgi National Park, the Lower Cotter Catchment and Tidbinbilla Nature reserve. The following eight ecosystems are used in the CEMP program:

1. Lowland native grasslands
2. Lowland woodlands
3. Lowland forests
4. Aquatic and riparian ecosystems
5. Upland native grasslands
6. Upland woodlands
7. Upland forests
8. Upland bogs and fens

The CEMP project aims to development individual monitoring plans for these eight ecosystem monitoring units.

2.2 UNDERSTANDING ECOSYSTEM INTERACTIONS

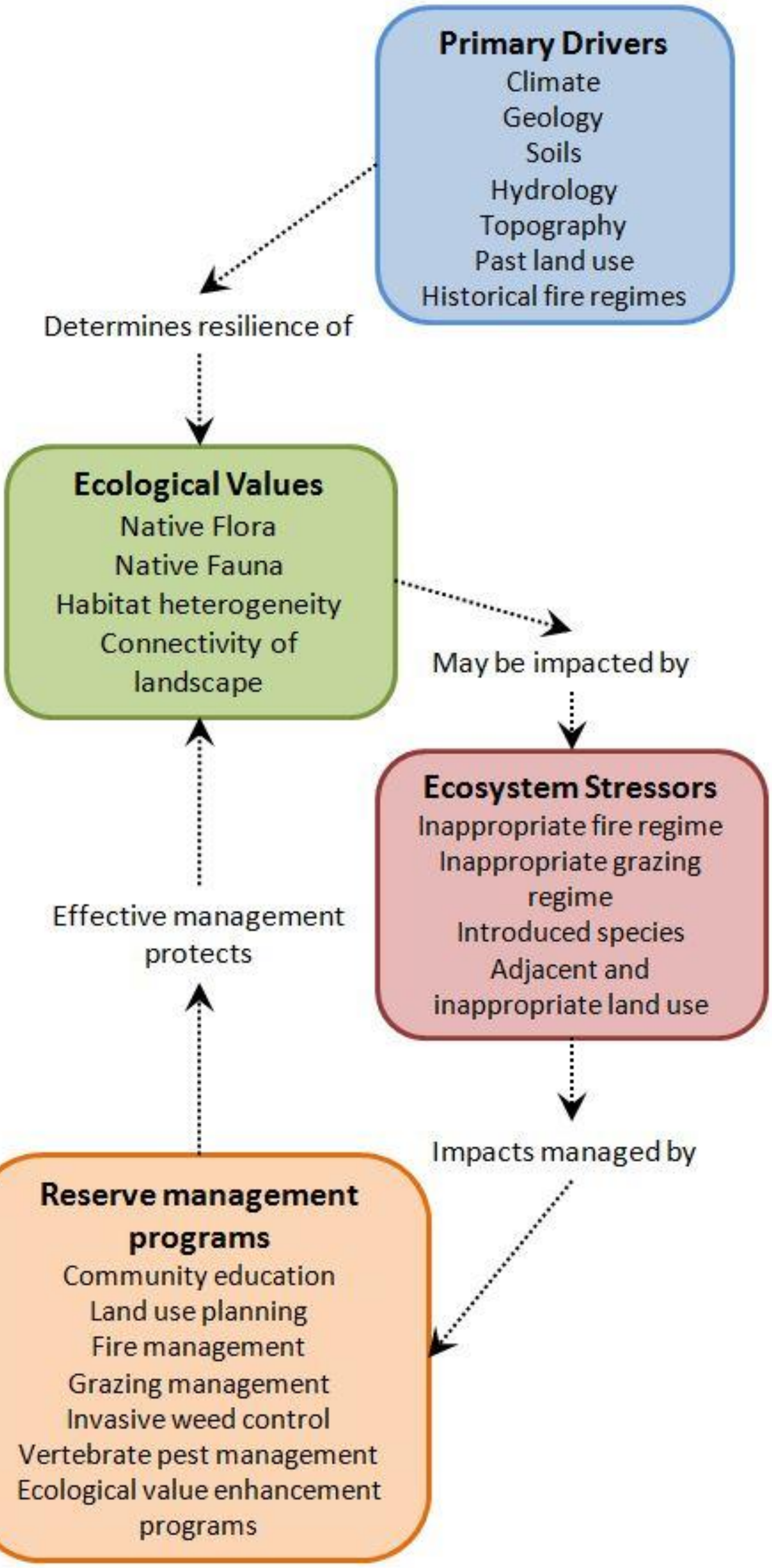
Monitoring ecosystem condition requires an understanding of the complex relationships and interactions between organisms and their environment. For each ecosystem, a conceptual model is created using an expert reference group. The conceptual model aims to demonstrate the current understanding of how the ecosystem functions and to identify the key influences that can potentially drive change in reserve condition. This includes defining key values, threats and interactions within each ecosystem.

For each ecosystem unit, CEMP incorporates a conceptual model of how primary drivers, ecological values, stressors and management programs interact and influence ecosystem condition within ACT nature reserves.

Key ecosystem influences, as derived from expert discussions, could be grouped into one of four categories: primary drivers, ecological values, ecosystem stressors and reserve management programs (Figure 3).

1. **Primary drivers:** These are the natural ecological drivers or historical processes that determine the distribution, composition and structure of ecosystems. In many cases they are the processes maintaining ecosystems in their natural states. Measures of primary drivers may include elements of landscape dynamics or climatic variation.
2. **Ecological values:** These are the biological and physical environmental characteristics contained within ACT nature reserves that the ACT Government identifies as core values for conservation and key for healthy ecosystem function. In the CEMP reporting, ecological values are used to derive the ecosystem condition indicators and metrics. Ecological values typically include native flora and fauna, habitat and connectivity of the landscape.
3. **Ecosystem stressors:** These are the threatening processes in ecosystems that are suspected to elicit change in the condition of the ecological values of the ecosystem. Protection and conservation of ecological values requires the identification and management of threat agents and processes that may impact and stress ecological values. Most management actions aim at reducing the level of stress posed by threatening processes. Specific ecosystem stressors may include pressures such as weeds, pest animals, inappropriate fire regimes, grazing, urban development, recreation, disease, and climate change.
4. **Reserve management programs:** These are the land management actions that aim to eliminate or reduce the impact of ecosystem stressors on ecological values. They can be reactive, such as pest management, or proactive, such as land use planning and community education programs.

Figure 3. A cyclic model showing the interactions between primary drivers, ecological values, ecosystem stressors and reserve management programs in a CEMP ecosystem unit.



3. MONITORING ECOSYSTEM CONDITION

3.1 SELECTING INDICATORS TO MONITOR ECOSYSTEM CONDITION

Indicators are being increasingly used by management agencies to provide information about changes in condition of protected areas. Measurement and monitoring of all ecosystem components is impossible, therefore indicators are often used as "measurable surrogates", providing a low cost and time efficient method for monitoring ecosystem health and the influence of disturbance over time (Carignan and Villard 2002; Fancy et al. 2009; Lindenmayer 1999; Niemi and McDonald 2004; Noss 1990; Noss 1999). Given the limited resources available for a detailed monitoring program in the ACT, the use of indicators is a resource efficient method of monitoring ecosystem condition over the longer term.

Within CEMP ecosystem monitoring plans, indicators are used to capture current knowledge about the relevant ecosystem and to provide a measurement of ecosystem condition. In biodiversity assessment, indicators may take many forms, and include entities such as species, ecosystems or processes. Two types of indicators are used in the CEMP monitoring plans; ecosystem condition indicators and ecosystem stressors. Ecosystem condition indicators report on the state of ecological values within an ecosystem, while ecosystem stressor indicators identify threats and effectiveness of management programs at reducing these threats. The combined use of these two types of indicators enables assessment of effectiveness of management actions aimed at reducing threatening processes and maintaining or enhancing reserve condition.

Ensuring indicators used in monitoring programs are representative of ecosystem condition is challenging (Dale and Beyeler 2001; Fancy et al. 2009; Noss 1999). In selecting indicators, the ecological values, threatening processes and what ecosystem functions play a key role in ecosystem health need to be identified for each ecosystem unit (see section 2.1). Indicator selection can then be informed and validated by expert opinion, peer-review literature or management experience. The indicators used in the CEMP monitoring plans are selected by members of an expert reference group associated with each ecosystem. Expert reference groups comprise of researchers, ecologists, land managers and community group representatives.

During a workshop, the expert reference group for each ecosystem unit propose a list of indicators which are then assessed for suitability against the following criteria:

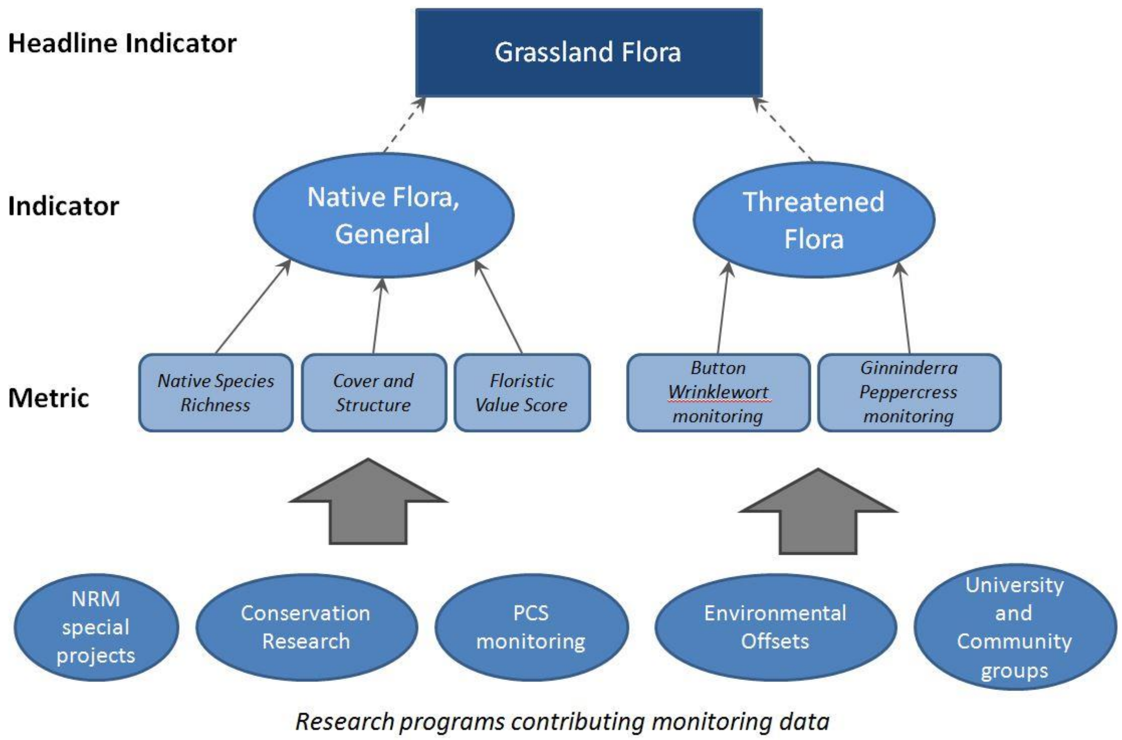
1. Can the indicator be accurately measured quantitatively?
2. Is the indicator ecologically responsive and sensitive to change?
3. Can the influence of natural processes on the indicator be separated from that of management actions (i.e. Can we determine the mechanism of change)?
4. Is the indicator informative to land managers, so that changes to management actions may affect desired conservation outcomes?
5. Is measuring the indicator logistically feasible, cost effective and within current resource availability?
6. Does the indicator meet a management need to capture current knowledge and/or fulfil statutory monitoring requirements?

The sensitivity of an indicator is not always known prior to monitoring; knowledge of how well an indicator detects change in ecosystem condition often emerges over time. In light of this, CEMP evaluates and reviews the contribution of both indicators and metrics each reporting cycle.

Following the expert reference group workshop and choice of indicators for each ecosystem, a four-tiered structure is used to help further define selected indicators and determine how they can be measured to assess ecosystem condition. The four components of the indicator structure developed (Figure 4) are:

1. **Indicator type**: Two types of indicators are used – ecosystem condition indicators and ecosystem stressor indicators.
2. **Headline Indicator**: Each indicator belongs to a headline indicator, which enables the grouping of indicators into broad categories. Examples of a headline indicator may be flora or fauna.
3. **Indicators:** Indicators are monitored and assessed in each ecosystem to provide an indication of change in condition. Examples of indicators might be a threatened ecological community or introduced predators.
4. **Metrics**: Metrics are used as the data sources to measure the condition of each indicator. There may be more than one metric contributing to each indicator.

Figure 4. A diagram showing the upwards flow of information from monitoring and research programs that contribute data to metrics, which in turn inform indicators for ecosystem condition assessment. The example shown is for two ecosystem condition indicators in the Lowland Native Grassland Ecosystem unit; Native Flora (General) and Threatened Flora, which are grouped together under the Grassland Flora headline indicator.



3.2 CLASSIFICATION OF METRIC ATTRIBUTES

Metrics are the 'measurable entities' that are used to provide data to inform indicator condition in CEMP. For example, the condition of the indicator 'Native Flora (general)' in the Lowland Native Grassland Ecosystem Monitoring Plan may be measured in various ways, such as by assessing native species richness, cover and structure of major functional groups or the floristic value score of grasslands. These are just some of the ways to 'measure' grassland flora health. Similarly, the indicator of 'Threatened Flora' may be measured by choosing some representative species and assessing changes in abundance and distribution in response to management actions (Figure 4).

For each ecosystem unit, CEMP initially used information from pre-existing monitoring programs that had data on metrics which could be aligned with chosen indicators. The use of existing monitoring programs enabled an assessment of the amount and quality of pre-existing quantitative data, in addition to a preliminary assessment as to where current knowledge gaps and data deficiencies were. For each ecosystem unit plan, additional, new metrics were suggested where data gaps were strongly apparent.

Once indicators and associated metrics were decided upon for each ecosystem unit, CEMP conducted an analysis of available data for each metric to determine its' condition within the ecosystem. In order to provide accurate information with repeatable measurements so that metric condition (and therefore indicator and ecosystem condition) could be tracked over time and compared between reporting cycles, metrics were required to have a clear, concise and repeatable method for measurement and analysis of data. To ensure this, metrics were defined using a number of different attributes (Table 1).

The first step was to define in detail what data populated each metric and how they would be assessed. This was termed the 'metric assessment' (Table 1) and examples included changes in abundance, richness or area or distribution.

To capture how important each metric was to informing the relevant indicator and thus ecosystem condition, metrics were ranked against five criteria and given a rating or "class" associated with its ranking; either "core", "mandate" or "minor" (Table 1). To determine the metric rating we considered whether:

1. There is a large risk to the ecological value represented by the metric, indicator and/or ecosystem function associated with incorrect /absent management strategies;
2. The cost of managing and monitoring the metric is acceptable and achievable;
3. There exists a long term data set that forms solid baseline data from which future research questions can be effectively derived;
4. There is uncertainty surrounding the best management practice for the ecological value represented by the metric;
5. The species or community impacted is threatened (therefore must be monitored under statutory obligations) or is little known.

Table 1. Metric attributes and associated definitions.

Metric Attribute	Definition
Metric name and associated indicator or stressor	The metric name and number. The metric number indicates whether the metric contributes data towards a condition (C) indicator or a stressor (S).
Summary and condition report	A summary of the findings for the condition, trend and data confidence for the metric applicable to the current CEMP report.
Metric Assessment	The method by which the metric is assessed, such as increase in area, richness, abundance or diversity over time.
Class	The three classes include core (usually long-term monitoring programs or key ecosystem function), mandate (usually a threatened species monitored through statutory requirements) or a minor metric.
Category	The ACT monitoring category; whether the indicator or stressor is monitored under a statutory obligations under the *Nature Conservation Act 2014* or the *Environment Protection and Biodiversity Conservation Act 1999* or is a non-statutory monitoring program.
Primary Drivers	Primary natural drivers such as climate and land use history, which are identified as interacting with the indicator as shown in the conceptual model relevant to the ecosystem.
Associated condition indicators	Related ecosystem condition indicators identified as interacting with the metric as shown in the conceptual model relevant to the ecosystem.
Associated stressors	Related ecosystem stressors identified as interacting with the metric as found by the conceptual model relevant to the ecosystem.
Rationale	An explanation of the rationale behind the inclusion of the metric e.g. statutory monitoring, high priority for management.
Projects contributing to metric	Which projects and/or organisations (within ACT government or otherwise) have monitoring programs that contribute data to inform the metric.
Periodicity	How often the data will contribute to CEMP reporting.
Baseline	The data used as the reference or baseline condition of the indicator or stressor e.g. the first survey or control plots.
Reference Condition	The original (modelled or data-derived) condition of the indicator prior to large scale modern anthropogenic disturbance. A detailed description is given section 3.3 of this document.
Target Condition	When maintenance or restoration of reference condition cannot be feasibly achieved, the target condition is used to provide a meaningful goal for management actions to aim towards over the medium term (10+ years).
Trigger point(s) for management	A pre-defined point for management intervention. For example, if population decline of a threatened species is found to be greater than 30% over two years, then a particular response may be triggered.
Qualitative input	Identified any expert opinion, observational data or other qualitative input that informs the metric. Source of expertise is identified.
Future research questions, management directions, knowledge gaps and recommendations:	A practical outcome of the assessment including data gaps, priorities for management or information/data needs relating to the indicator or stressor.

Metrics meeting three or more of the first four criteria are classed as “core” metrics. Most metrics that are placed in the “core” category included those with consistent methods and long-term datasets. Metrics that meet condition five are classed as “mandate” while all others are placed in the “minor” category.

Each metric was assigned an ACT monitoring category to indicate whether it was monitored under statutory requirements. The primary drivers associated with each metric were identified, as were other condition indicators and stressors that would interact with each metric and associated indicator. The rationale behind the inclusion of the metric was explained, contributing projects (including the use of expert advice) were identified and how often the metric would be assessed (periodicity) was listed (Table 1). Four important metric attributes were the baseline, reference condition, target condition and trigger points, and these are explained in more detail in section 3.3 below. The final attribute for each metric was the recommendations on future research priorities and management directions as an outcome of the metric condition assessment (see section 4).

3.3 WHO PROVIDES DATA TO INFORM CEMP METRICS?

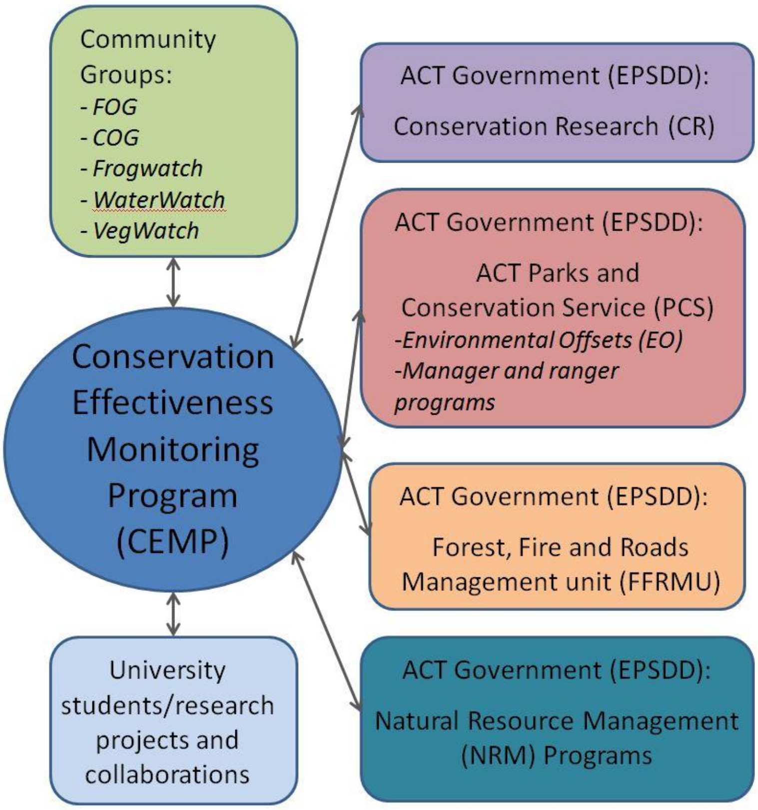
As metrics may be informed by a number of different monitoring programs or research projects, for the purpose of assessing the quality and relevance of data, monitoring and research programs contributing to each metric are defined by different attributes (Table 2). These include location of study sites, duration of program, methods used and sampling design as well as information including the program name, primary contact position, data storage, reporting schedules and specific research questions to inform users of CEMP reports of the origins of data informing the metrics. These data appear in the appendix of each ecosystem monitoring plan.

Information to inform CEMP metrics and associated indicators is collected from Government and non-Government monitoring programs, research projects and surveys. CEMP draws on data collected during monitoring and research programs conducted by ACT Government as well as relevant external research and monitoring conducted by universities and community groups (Figure 5). This provides an opportunity to coordinate and integrate monitoring efforts across government, research institutions and community groups, and to capture the best information available to support adaptive, evidence-based decision making.

Table 2: Attributes of contributing programs and corresponding definitions.

Program Attribute	Definition
Program name and affiliated projects	The name of the monitoring program/research project and the organisation or group from which it is run, in addition to any affiliated projects.
Sites	Locations from which data is collected.
Measured attributes	The variables within the metric that are measured representing numerical or categorical data that could be used in analyses.
Monitors action or asset	Whether or not the monitoring is focused on recording only changes in the entity that is directly managed (action) and/or monitors the ecological asset or value to be conserved.
Management/research questions (project specific)	Specified management questions that the research project or monitoring is aimed at answering.
Type of monitoring:	Defined as one or more of four types of monitoring: opportunistic/ad-hoc, qualitative surveys, mandate monitoring or research project.
Temporal scale:	The length of time the monitoring or research program has run, or is intended to run, defined as one of three categories: long (> 10 years), medium (5-10 years) or short (<5 years) term.
Monitoring period:	The period of time over which the monitoring has taken place (for example from 2008-current day), with any missed sampling periods identified.
Sampling intervals	How often the monitoring takes place, for example, annually during October, or biannually during summer and spring.
Sampling methods:	What sampling methods are used, and if sampling methods have changed over the monitoring period. For example transects, spotlighting, trapping, point observation.
Data type	The data that is collected, for example presence/absence, number of individuals, qualitative.
Spatial data available	Spatial locations of research and monitoring plots should be available on ArcGIS Online "Research and Monitoring plots" file (CR administration), where applicable.
Confidence in data	A three-tiered system (Low, Moderate or High; see section 4.1 of this document) measuring the rigour of data collected by the monitoring program or research project.
Data storage and availability	The location that the data is stored in (either ACT Government or external), when data becomes available (if cyclic) and any prior agreements with external parties to access the data.
Reporting schedule	When reports/up-to-date data are to be available from the project or monitoring program, including if not immediately available or if cyclic.
Contact	The primary contact for the monitoring program or project, including ACT Government department, external organisation and position.

Figure 5: Framework to show contributors to data sources collated by CEMP. Information from programs feed into CEMP, which in turn provides feedback on management actions and future research priorities.



3.4 BASELINES, REFERENCE CONDITION, TARGET CONDITION AND TRIGGER POINTS

Key attributes of metrics are the **baseline, reference condition** and where applicable, **target condition** and associated **trigger points**.

The **baseline** refers to the initial condition from which any change in condition, including an increasing, stable or declining trend, can be measured. For many metrics the results from the first survey are used as a baseline, or alternatively the first data contributing to CEMP are used. This is particularly the case where large changes in methods used have taken place that compromised the ability to use historical data to compare changes over time. For research projects with a robust experimental design, data from control plots were are as a baseline.

The **reference condition** is defined as the ideal condition of the metric reflecting a relatively intact ecosystem. Reference conditions are sometimes called 'benchmarks' and relate to the natural range of variability of an ecosystem. Depending on the scale at which data was collected for the metric, reference condition is defined in one of three ways. The three data scales identified in CEMP are:

1) **Spatial data collected at the landscape scale (e.g. extent, connectivity):** To establish the reference condition for spatial metrics assessed at a landscape scale CEMP used the known or estimated (modelled) distribution prior to recent modern anthropogenic changes to the landscape. For example, the reference condition for Natural Temperate Grassland (NTG) extent would be the distribution of NTG prior to clearing and development of the area associated with European settlement. The connectivity of the metric at a landscape scale could also be assessed and compared to the level of connectivity in the intact or pre-modified condition.

2) **Data collected at the plot or site scale (e.g. species assemblage or structural attributes): F**or metrics sampled at the plot or site scale, such as species assemblages, richness, or biodiversity surrogates such as habitat and vegetation structural attributes. For these metrics we selected local sites which were most representative of an "intact" community (i.e. minimal disturbance by recent modern anthropogenic changes) and measured the metric at those sites (Gibbons & Freudenberger 2006). We then took either the average measurement or create a range (typically ± 1 SE) to establish reference condition for that metric. The use of a range rather than an absolute value for the reference condition allowed for natural variability between sites in addition to accommodating climatic and seasonal variations.

3) **Data collected on single species populations (e.g. threatened species):** The third and final way of establishing reference condition is for single species data, which usually applies to mandate monitoring of threatened species or monitoring of vertebrate pests. For native species data CEMP uses the IUCN Red List category for the species in the ACT as the current condition compared to the reference condition. IUCN ratings take into account abundance, geographic extent and number of populations of the species. (IUCN 2008). For vertebrate pests and introduced species, the reference condition is zero.

The **target condition** is established for metrics where the reference condition is, in all practical terms, beyond the ability of management to achieve, and represents medium-term goals for management to work towards. For example, the return of NTG to its pre-modern anthropogenic change extent of 15,000 ha may be the reference condition for a metric measuring NTG extent, but is an unrealistic target for management. A more achievable goal may be to increase the quality of 5% of native pasture to NTG status over 10 years and avoid any net loss of extent from current levels. The target condition for metrics are established with extensive consultation with managers, and can be adjusted over time as increased knowledge of the ecosystem is available and better adaptive management outcomes are obtained.

Trigger points are used in some metrics to define recognisable points (thresholds) above or below which a change in management should be triggered. For example, when the estimated population density of a threatened species falls below a certain number (e.g. <500 animals) a pre-determined management response may be initiated. Trigger points enable adjustment to management actions prior to poor condition being reached, with an upper or lower trigger point used where appropriate. For metrics without substantial data sets or expert knowledge, the definition of a meaningful trigger point is difficult to allocate. In the first CEMP report for each ecosystem unit, the trigger points for some metrics are defined as 'To Be Advised' (TBA) until further knowledge is gained that can assist in the establishment of meaningful trigger points and associated management response.

4. ASSESSING ECOSYSTEM CONDITION

4.1 DEFINING ‘CONDITION’

For the purpose of the CEMP program, monitoring ecological condition refers to the measuring of the biodiversity values within the ecosystem (Keith and Gorrod 2006). This may include metrics that measure structure, function or composition of the ecosystem at various scales (Noss 1990). To monitor ecosystem condition CEMP measures changes in select indicators and associated metrics within an ecosystem. The first step of assessing the condition of metrics (and consequently related indicators) involves the review of information from current monitoring programs as per each metric assessment definition (Table 1). The condition of each metric/indicator is a relative state; it is assessed and defined relative to the ‘baseline’ and against the ‘reference condition’ and ‘target condition’ over time (see section 3.3 of this document).

Three elements of condition are assessed to determine the overall condition grading for each metric. **Condition/state** is the current condition of the metric relative to the prescribed reference condition; **condition trend** is the current condition compared to the baseline condition (i.e. whether condition is improving, stable or declining over time) and **data confidence** refers to how confident we are in the accuracy of the data informing condition/state and trend. These three elements of overall condition are defined as follows:

1) **Condition/state**: In this assessment the term ‘condition’ refers to the health of ecological values, while the term ‘state’ refers to the status of ecological stressors. The condition or state of a metric is assessed relative to an identified acceptable condition or state (the reference condition or target condition).

   Specific criteria for ranking condition or state have been established for different data types. The scaling of condition for spatial metrics was adapted from McIvor and McIntyre (2002) and condition assessments for population metrics used listing categories in the IUCN Red List (IUCN 2008).

   Condition/state of a metric or indicator may be one of four levels as follows:

   a. <u>Good condition</u> refers to a situation where the condition of ecosystem values and processes are close to or above the reference condition and where the negative impacts of threatening processes are limited or successfully controlled by management actions. The quantitative assessment of ‘good’ condition in CEMP reporting is defined as equal to or above 75% of reference condition for spatial data, equal to or above reference condition for plot data, and for individual species data the population meets criteria for not being listed in the IUCN Red List and is stable.

   b. <u>Good with some concerns</u> indicates overall condition of the metric/indicator is good, but there are some sites or attributes that need improvement or do not meet the ‘good condition’ criteria and condition is therefore below reference condition. The quantitative assessment of ‘good with some concerns’ condition in CEMP reporting is defined as being greater than 60% but less than 75% of reference condition for spatial data, within one statistical range of variability (e.g. standard deviation or standard error) from reference condition (defined for each metric) for plot data, and for individual species data the population meets criteria for not being listed in the IUCN Red List, but is declining and/or is uncommon and data deficient.

c. Moderate condition indicates that values within the ecosystem are showing signs of degradation and management actions need to be implemented as a priority to restore condition and to prevent further loss of condition. The quantitative assessment of 'moderate' condition in CEMP reporting is defined as being between greater than 45% but less than 60% of reference condition for spatial data, within two statistical ranges of variability from reference condition for plot data, and for individual species data the population meets criteria for being listed as Vulnerable in the IUCN Red List.

d. Poor condition indicates the indicator is not managed or management has been ineffective, placing a significant threat on the ecosystem values. Changes to management should be of high priority; in some cases data deficiency on threatening process will lead to a poor rating. The quantitative assessment of 'poor' condition in CEMP reporting is defined as being between less than 45% of reference condition for spatial data, outside of two statistical ranges of variability from reference condition for plot data, and for individual species data the population meets criteria for being listed as Endangered or Critically Endangered in the IUCN Red List.

The scaling system used for condition assessment of metrics and associated indicators in CEMP is based on a "traffic -light" system adapted from the US State of the Parks Report (see https://www.nps.gov/stateoftheparks), and the Queensland National Parks key park values rating system (http://www.npsr.qld.gov.au). The Queensland National Parks key park values rating system identifies a four tiered colour-coded indicator system adapted from the IUCN World Heritage Outlook (2014) (see http://www.worldheritageoutlook.iucn.org). In this system, 'good' condition/state is denoted using dark green, light green denotes generally good condition with some concerns, amber denotes moderate condition while red is used to show very poor condition of metrics/indicators (Figure 6).

2) **Condition trend:** Condition trend is the direction of change in condition over time, which may be one of three states: positive, negative or stable. Current condition of an ecosystem is assessed and compared to a previously determined state ('baseline'). In the CEMP program condition trend is indicated by a directional arrow located within the colour-coded symbol. Up arrows indicate an increase in condition over time as shown by the data, while a downwards arrow indicates a decrease in condition. A sideways arrow is used to indicate that the condition of the metric/indicator is stable (Figure 6).

3) **Data confidence**: The data confidence rating evaluates the ability to draw both statistical and causal inference from the data, reflecting the robustness of sampling methods used and therefore is an indication of the accuracy of and ability to be confident in the condition/state and trend rating given to each metric. The data confidence rating may be one of four ratings:

a. High: This confidence level is given when data is sourced from monitoring and/or research that used proven field methods and robust sampling designs, such as the use of many sites (replication), randomisation of site locations and the use of control plots.

b. Medium: This rating is given where monitoring has taken place over a long period of time, but may have inconsistencies in methods over this period, a change of study sites or minimum experimental design underpinning the methods used (e.g. many mandate monitoring programs) and with some, but limited, replication and randomisation.

c. Low: This rating was given where study sites are severely limited (minimal replication), no experimental design was used, there may have been large changes to the field methods used or study sites (inconsistency of methods), no randomisation and/or unproven sampling methods were used.

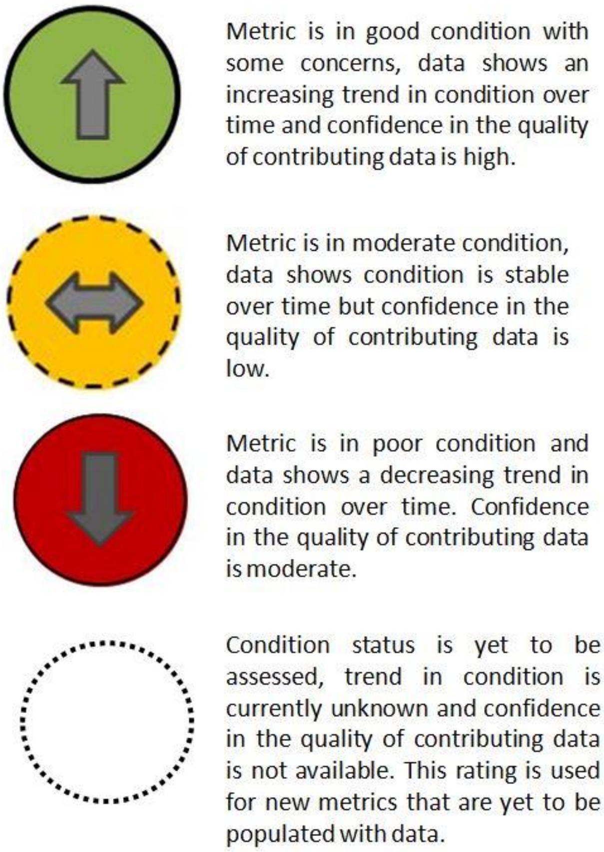
d. Unknown: Data confidence is unknown due to no information on data type. This category is often used for new metrics, where a data confidence rating will be assigned in the next reporting cycle. (Figure 6).

Figure 6. Levels and corresponding symbology for condition/state, condition trend and data confidence used in the CEMP program.

Condition/State		Condition Trend		Data Confidence	
	Indicator is in good condition	⇧	Condition of the indicator is improving		Confidence in condition assessment is high
	Indicator is in good condition with some concerns	⇔	Condition of the indicator is stable		Confidence in condition assessment is moderate
	Indicator is in moderate condition with a number of concerns	⇩	Condition of the indicator is declining		Confidence in condition assessment is low
	Indicator is in poor condition with many significant concerns		(Blank) Trend in the condition of the indicator is unknown		Confidence in condition assessment is not available

Examples of combinations of symbols used for reporting overall condition are shown in Figure 7. These represent the combined assessment of condition/state, condition trend and data confidence.

Figure 7. Examples of overall condition assessment symbology for metrics and indicators used in the CEMP reporting framework.



When each contributing metric has been assessed for condition/state, the outcomes are 'rolled-up' to inform the condition/state of the relevant indicator. The process of 'rolling-up' of metric data to get the overall condition/state grading follows an averaging process. Each condition/state is given a numeric value as follows: 'Good'=4, 'Good with some concerns'=3, 'Moderate'=2 and 'Poor'=1. As the number of metrics informing indicator condition/state varies between indicators, the total sum of all the metric conditions is calculated then averaged by the number of contributing metrics. For example, an indicator with four metrics with conditions 'Good' (4), 'Good with some concerns' (3), 'Moderate' (2) and 'Good with some concerns' (3) respectively, would lead to an indicator condition/state of 4+3+2+3=12/4=3, which gives an indicator condition assessment of 'Good with some concerns'. In a case of the final value containing a half (e.g. 2.5), a conservative approach is taken and the indicator condition/state is rounded down to the lower grading (e.g. 2.5 is lowered to 2= 'Moderate'). Examples of metric condition/state combinations and the 'rolled-up' overall indicator condition/state are shown in Figure 8.

Figure 8. 'Rolling-up' the data - table showing various combinations of metric conditions and outcomes for the condition of the relevant indication they inform, following an averaging process.

	Metric 1	Metric 2	Metric 3	Metric 4	Overall Indicator Grading
1	Good	Good with some concerns	Moderate	Good with some concerns	Good with some concerns
2	Good with some concerns	Poor	Moderate	Good	Moderate
3	Moderate	Good with some concerns	Poor		Moderate
4	Poor	Moderate	Moderate	Poor	Poor
5	Good	Good with some concerns			Good with some concerns
6	Good	Good	Moderate		Good with some concerns
7	Moderate	Moderate	Good with some concerns		Moderate

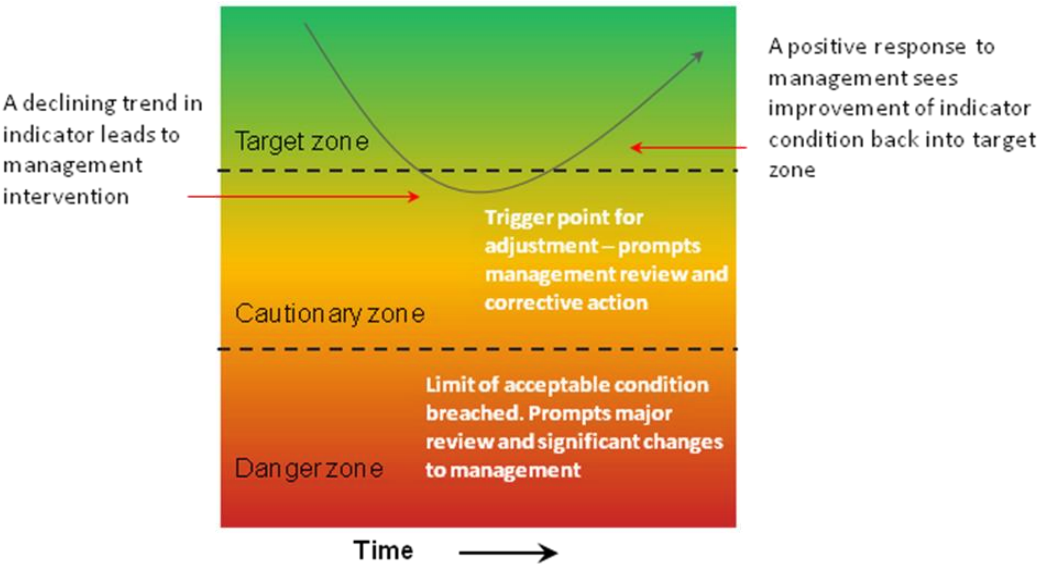
The same process of averaging used to assess indicator condition/state is repeated for condition trend ('Improving'=3, 'Stable'=2 or 'Declining'=1) and data confidence ('High'=3, 'Moderate'=2 and 'Low'=1). These two assessments are then combined with the condition/state of the indicator to inform the overall indicator condition.

4.2 COMBINING CONDITION ASSESSMENT WITH REFERENCE CONDITION AND TARGET CONDITION

CEMP modified the principles of ‘Target zones’, ‘Cautionary zones’ and unacceptable ‘Danger zones’ presented in Jones (2009) to tie together results of condition assessment with reference/target condition and trigger points. This method provides the ability to identify quantifiable thresholds in condition that ‘trigger’ a review of management actions when breached, thus enabling management to act prior to poor condition being reached (Figure 9).

For example, if indicator condition is within the target zone defined for that indicator (such as ‘good’ condition/state with a stable or improving trend – see section 4.1 of this document), management actions are adequate and the desired outcomes are being achieved. However, if the condition of the indicator is declining, its condition may soon pass a defined trigger point into the ‘Cautionary zone’. Such an outcome would initiate changes to management actions (Figure 9) that may be reviewed in the next CEMP reporting cycle. For example, for a particular species, a trigger point may be a population that is a given amount above the minimum viable population for that species. The actual minimum viable population represents the limit of acceptable condition beyond which the indicator enters the ‘Danger zone’ and requires immediate review and significant changes to be made to management (Figure 9). One current issue is that trigger points for many metrics are either unknown or based on expert opinion due to lack of data. Part of the CEMP process is to highlight research and knowledge gaps so that trigger points for each metric can eventually be derived from data and sound knowledge of the ecosystem.

Figure 9. The conceptual relationship between the condition/state of an indicator, its reference condition or target condition and trigger points that lead to a change in management actions. Adapted from Jones (2009).



5. REPORTING OUTCOMES, EVALUATION AND OTHER CONSIDERATIONS

The CEMP's primary role is to consolidate information on ecosystem condition, thereby providing a data-rich decision support tool to inform management actions. It is important therefore, that a reporting mechanism relevant to the temporal scale of both the indicators and current management programs be established. To meet this need, the CEMP program aims to hold annual update workshops with reserve managers in addition to formal reporting cycles, with ecosystem condition reports for each ecosystem unit produced once every three years. The purpose of CEMP ecosystem reports will be primarily to help inform management actions in conserving ecological values within the ACT reserve system, however, this timeframe will also compliment other existing ACT Government commitments for reporting on biodiversity conservation outcomes that inform strategic planning and policy development such as State of the Environment reporting (SOE), Reserve Operational Plans (ROP), State of the Forests reporting (SOF), the Biodiversity Research and Monitoring Program (BRAMP) and ACT Government Nature Conservation Strategy reporting (NCS).

The structure of the CEMP reporting framework, including the use of assessment summaries and symbology to represent indicator condition (see Section 4 of this document), aims to be both informative and user-friendly. The CEMP ecosystem reports also include graphs and relevant summaries of the data behind each condition assessment for transparency of reporting and providing access to data (including links to data sets) for those readers that require more detailed information. Publishing ecosystem reports online via an intranet Hub would allow an increase in accessibility to general staff and should be considered. It is hoped that through such a reporting structure, the CEMP program will achieve higher visibility generally and encourage greater collaboration between ecologists, planners and managers through linking research prioritisation, strategic planning and management actions. The CEMP reports may also be used to recognise and promote partnerships with citizen science and external organisations that have contributed monitoring data, or may wish to contribute in the future.

A review of monitoring in ACT reserves by Stevenson and Seddon (2014) revealed that monitoring generally did not record conservation gains in response to management actions, and that consequently many current monitoring programs were "data rich but information poor" (Lindenmayer and Likens, 2010). Monitoring programs that fail to provide useful information that links management and conservation outcomes will be highlighted in the CEMP report for each ecosystem unit, with the view to re-evaluating and/or re-designing such monitoring programs through the addition of question driven monitoring with robust experimental design. In many cases this may mean adding value to current "mandate" monitoring through supplementary research projects in order to address specific management questions. By addressing such limitations, there will be a shift towards monitoring uncertainty around management efficacy and a greater focus on ensuring monitoring remains relevant to conservation goals (including overarching policy requirements) and management priorities.

A further aim of CEMP is to identify gaps in our current knowledge pertaining to the management of ecosystem units, therefore it is important that the CEMP reporting framework contains a section that highlights these gaps and prioritises future research that addresses them. In addition to providing a mechanism for feeding in new projects to address knowledge gaps, a future research section within each ecosystem report aids in adjusting priority questions as new information emerges (adaptive management) and incorporating new conservation ideas that may have strong community and political support. This includes the ability to accommodate short term research projects, often associated with opportunistic funding, into the reporting framework.

Another issue with current monitoring programs, as identified by Stevenson and Seddon (2014), is that data is not always collected in a consistent manner over time or across organisations. Changes to study sites, field methods or the scale of data collection poses difficulties for latter data analysis and undermines confidence in results. Turnover in personnel responsible for monitoring programs and rapid changes in technology may result in inconsistent sampling methods over time, threatening data quality and consistency. The systematic approach of the CEMP framework enables the standardisation of protocols that are important for maintaining data integrity. CEMP project officers have liaised extensively to assist with achieving consistency between projects in monitoring of metrics, field methods used for data collection and to ensure management implications are considered in new programs.

CEMP also requires an ability to adapt as our knowledge base increases and new technologies become available (e.g. LIDAR, remote sensing, Collector app.). The ability of the CEMP program to incorporate multiple research projects into metrics provides a mechanism for bringing in new data collection techniques. Additional methods can be incorporated into the CEMP program to compliment standardised data whilst ensuring consistency between reporting cycles. The need to ensure data integrity across the CEMP program, in addition to promoting increased accessibility of information across agencies, has led to the idea of a centralised database for maintaining integrity of data for contributing metrics.

Other protected area management agencies in Australia have found a key element to ensure the long-term accessibility and participation in monitoring programs is the involvement of rangers and field staff (Parks and Wildlife Service, 2013). It is critically important that staff managing reserves feel involved, are able to contribute knowledge to the CEMP program (e.g. suggest areas of management uncertainty or future monitoring sites), understand its value in assisting management and consequently maintain a vested interest in collecting accurate monitoring records. Funding and logistical requirements for the CEMP program need to consider existing time demands on field staff, in addition to establishing robust protocols for the transfer of relevant skills in order to manage the high turnover of field personnel and to ensure information flow is retained on monitoring programs.

Finally, the efficacy of management actions, in terms of both achieving management goals and cost effectiveness, needs to be established. The CEMP assessment of ecosystem condition may be combined with budgeting to generate an assessment of the cost-effectiveness of management actions. A cost/benefit analysis (CBA) could consider the ecological risk vs. management cost when there is uncertainty of best practice and to assist in the prioritisation of management actions. Where monitoring data shows no measurable improvement in the ecosystem values and/or a CBA indicates management is not cost effective at achieving conservation goals, alternate management options should be considered.

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