Nature Conservation Service: Biodiversity Conservation Appraisal System

A framework to measure and report on biodiversity outcome-based conservation achievements and management effectiveness

Department of Environment and Conservation

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MEASURABLE, DEFENSIBLE AND ACCOUNTABLE CONSERVATION OUTCOMES

[Inside front page]

PREFACE

The basis for this document comes from the need to improve quality of biodiversity conservation management and to increase managers' ability to measure and report on conservation outcomes and management effectiveness. This document is also intended to provide clarity on a biodiversity conservation business model that can better align priorities with an active adaptive management approach to assist in improving knowledge of biodiversity and related operational management needs.

Demonstrating biodiversity outcome-related achievements, and the difference management has made (or is making) in alleviating adverse pressures and enhancing ecological processes, has been constrained by the absence of frameworks for conceptualising biodiversity conservation management, and tools allowing for easy measurement and evaluation of the state and condition of biodiversity. As a consequence, conservation can be penalised in trade-offs against other quality of life objectives and support for conservation can be depleted. There is also a requirement for public conservation agencies to determine which conservation investments will reap the greatest benefits for society to ensure long term health of biodiversity. Many stakeholders want to know that public funds are being used effectively and efficiently. The challenge of demonstrating achievements is made more complex by insufficient knowledge of ecosystems, taxa and related processes, and how systems respond to disturbances.

In conventional conservation and land management practices, and in the absence of appropriate knowledge and management tools, there is a tendency for managers and other investors to assume that biodiversity benefits will naturally follow if funds, and other inputs, are directed at a general range of issues (pressures or threats usually). Due to a lack of specific scientific understanding, activities can be largely based on first principles of conservation science in combination with 'best guess' management. This type of approach may bring immediate outputs that can satisfy some investors and stakeholders, for a while. However, it is very difficult to show and demonstrate any long term benefits from an investment. Further, it usually lacks explicit conservation targets or a desired biodiversity outcome, which is clear and quantifiable description of the biodiversity state(s) and condition being aimed for through management intervention. A conventional approach because of its vagueness often lacks accountability for the state or condition of biodiversity. Ultimately, this type of investment model and management approach will struggle to adequately demonstrate achievements and return for public investment, despite working hard at producing reams of output activities and accounts on costs of activities. These problems in conservation management are common to all Australian conservation agencies, if not world wide, and are a major challenge for existing management regimes.

An ability to adequately measure or quantify conservation outcomes resulting from conservation management is critical in order to demonstrate to the public and governments that public conservation and land management agencies, like DEC, knows its business, is spending the public purse wisely and is making a positive difference to the State's biota. Achieving long term public support is a necessary preoccupation for all public conservation and environmental agencies; where budgets are in competition with other vital government services such as human health, education and policing.

Demonstrating achievements will also be rewarding and moral-boosting for DEC staff to see that they are making a difference; to the conservation of biodiversity - after all, this is why most people have chosen to be DEC employees. On the other hand, an inability to do so will inevitably lead to the continuing questioning of the benefits of significant investment of public funds in conservation management, and limited support for new initiatives or expansion of programs. Current around 80-85% of the Nature Conservation Service comprises activities aimed at alleviating pressures or threats to biodiversity. This includes programs aimed at recovery of threatened taxa and ecological communities.

Many of the concepts and models outlined in this document are based on relevant work by the NSW Parks and Wildlife Service (Stathis, 2006), Parks Victoria (State of the Parks, 2007), the New Zealand Department of Conservation (Stephens, T et al. 2002) and the World Conservation Union (WCU) (Hockings et al. 2006). The management effectiveness framework developed by the WCU (formally IUCN) is a circular management system which is further developed in this paper as the biodiversity conservation business model, a more detailed description of the IUCN framework that is tailored to suit systems which are currently used by the Department, and provides direction for the components of the framework that are not currently in place.

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SCOPE AND STRUCTURE

This document is in two parts:

Part I describes and defines a biodiversity conservation business model from which is derived a framework to measure and report on conservation achievements that relate to:

i. changes to attain a desired state and condition of biodiversity, particularly at an ecosystem level; and

ii. evaluating the effectiveness of management at alleviating adverse biophysical pressures on biodiversity.

Part II applies this conservation management model and framework through a case study of the North Kimberley Biodiversity Conservation Initiative.

This document does not deal with:

1. measuring and reporting on people's enjoyment of biodiversity, including cultural and spiritual relationships. These values are included in the business model, along side environmental issues, but suitable evaluation frameworks for these elements are not the principal focus of this paper.

2. design or development of an integrated information management system to underpin data collection, retrieval and analysis. These issues are currently being addressed by Natural Heritage Trust-funded projects, with guidance provided by data management specialists within DEC.

3. project monitoring that is measuring and monitoring on project activity milestones and expenditure; and

4. development of decision making tools to allow determination and selection of biodiversity conservation priorities.

PART I

1. Introduction

Evaluating and reporting on biodiversity conservation management effectiveness in achieving outcomes is becoming a priority for governments and private conservation organisations around the World. There is growing political and community expectation to be informed of the outcomes and impact of the significant public expenditure on biodiversity conservation; is it making a difference and what is the state and condition of the State's biodiversity? The public, who invest in biodiversity conservation through taxation, and the Government, have the right to know that ecosystems and species are being well-managed and where additional investment needs to occur (Stephens et al. 2002, Stem et al. 2005, Hockings et al. 2006).

Appropriate answers to these questions will lead to an increase in stakeholder confidence in public institutions and continuing support for their activities. Measuring and evaluating management effectiveness and biodiversity state and condition also demonstrates the effectiveness of the management agency and how well its strategies and programs are working. These metrics help to identify when management actions are likely to succeed or fail (Hartry 1999) and they can alert managers to potential problems, allowing timely implementation of remedial or proactive actions (Stephens et al. 2002). An ability to measure and evaluate the condition of natural systems and adapt to changing circumstances and surprises forms the basis for improved decision making and quality of management (Stem et al. 2005). Measurement and evaluation forms the rational basis for conservation management, and is the basis for wider ranging industry-centred management such as Environmental Management System ISO 14001 (Whitelaw 2004).

This paper draws on experiences in other parts of the world to propose a biodiversity conservation management appraisal system that will enable the Department of Environment and Conservation (DEC) to meaningfully;

1. measure and evaluate its management performance in delivering the Nature Conservation Service;
2. measure changes in the state and condition of natural systems and biodiversity as a result of management activity and natural variability; and
3. report on its conservation achievements to a range of internal and external stakeholders.

The paper is divided into two Parts. This first part is structured into four sections. Section 2 provides international and national context, while Section 3 expands on the reasons to measure conservation achievements and management effectiveness. It is this section which highlights the fundamental gap in monitoring and evaluation that currently exists, limiting the Department's ability to measure the management effectiveness of biodiversity conservation. In Section 4 the policy setting and drivers for biodiversity management actions in Western Australia are reviewed. The Nature Conservation Service business model including the strategic framework that aims to deliver biodiversity outcomes required by higher level policy and strategies, such as the State's biodiversity conservation strategy and the nine Nature Conservation Service regional plans, are also reviewed. Section 5 introduces the framework for measuring the effectiveness of biodiversity conservation management using the worldwide and Australia-wide adopted pressure-state-response model as a template for setting conservation targets, as well as a monitoring template. It also provides criteria for selection and discusses the use of bioindicators as a means to determine trends in the state and condition of biodiversity and related pressures acting on biodiversity. Finally, the concept of management thresholds is introduced. It is this aspect of management process which needs to be embedded in priority setting and implementation of management actions. A glossary that provides a list of terms and definitions used throughout the paper is presented at the end of Part 1. These are drawn from IUCN definitions provided by Hockings et al. 2006, and now being applied by NSW Parks and Wildlife Service (Stathis, 2004) and Parks Victoria (State of the Parks, 2007).

Part II applies the concepts and models outlined in Part I through a case study that aims to deliver biodiversity conservation at the landscape scale in the North Kimberley bioregion of Western Australia.

2. Australian and World Context

Developing and implementing a framework that measures the effectiveness of biodiversity management and provides the tools to be able to report on conservation achievements has been a key goal of The World Conservation Union (IUCN), UNESCO's World Heritage Centre, The Organization for Economic Cooperation and Development (OECD) Environment Directorate, The Convention on Biological Diversity and the World Bank since the mid-1990's (Hockings *et al*. 2000, 2006, Dumanski, J. and Pieri, C. 1997). All organisations share a common objective; to develop a framework that allows for the implementation of a program that measures and reports on management effectiveness.

A *Management Effectiveness Framework* developed by The World Conservation Union in 2000, and reviewed in 2006, has now been used for the evaluation of management in 75 cases in countries including the United Kingdom, the United States of America, Canada, New Zealand, Italy, India, Bhutan, South Africa and Tanzania (Hockings et al. 2006), and within Australia in New South Wales and Victoria (see Figure 1 for simplified framework and Hockings et al. 2006 for an explanation of this framework in detail). Its wide application is a demonstration that it provides the tools with sufficient robustness and flexibility for assessing management effectiveness in a large number of different ecological, social and economic settings. Indeed, The World Conservation Union is of the view that such an evaluation framework will soon be integral to good conservation management (Hockings et al. 2006). In Australia, the New South Wales Parks and Wildlife Service, within the Department of Environment and Climate Change, (Stathis et al. 2006) and Parks Victoria (State of the Parks 2007) have implemented conservation targets based on management effectiveness frameworks considered to be best practise by the World Conservation Union (Hockings et al. 2006).

Features of these systems include:

1. it will be auditable, demonstrating the Department's biodiversity conservation management performance;
2. it will need to have a common language and application to performance measures found outside of the organisation, including State of the Environment (SoE) reporting by the WA Environmental Protection Agency, the national Natural

Resource Management Monitoring Framework, regional natural resource management groups; and
3. it will be consistent with Internationally recognised best practice (Hockings et al. 2006) adopted by members of The World Conservation Union.

While the management effectiveness frameworks by the WCU, NSW and Victoria deal with park and reserve management, and mostly area management, they fail to consider management effectiveness of biodiversity conservation at a landscape and/or system-wide scale. A biodiversity conservation business management model is presented at Figure 2 below, which has been adapted from the WCU/IUCN management effectiveness model. For the purpose of this paper, Figure 2 specifically deals with biodiversity conservation. The intent of this framework is not to necessarily restrict biodiversity conservation to area management within conservation parks and reserves, but to allow consideration at landscape, ecosystem and species levels, and for system-wide threats, that occur irrespective of tenure. Nevertheless, the proposed model uses the broad principles applied in the various 'state of the parks' frameworks.

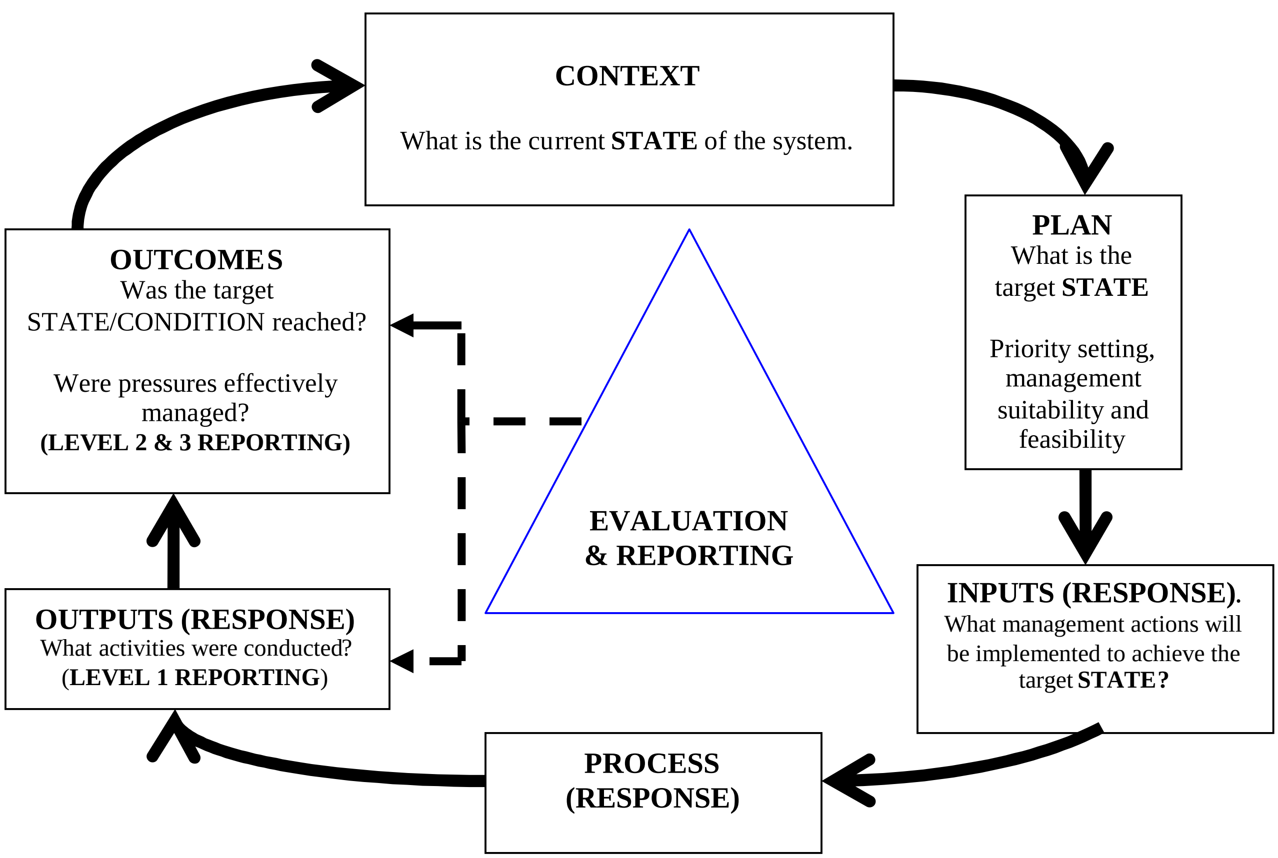

Figure 1: IUCN/WCU framework for evaluation of management effectiveness. This is a cyclical management framework, as is adaptive management. The central EVALUATION & REPORTING triangle comprises different levels of reporting and is expanded in Figure 2, 3 and Section 4 later in the document.

3. Why measure conservation achievements and management effectiveness?

It is important to quantify conservation achievements and to assess management effectiveness in achieving desirable outcomes in order to:

- measure and track trends in management progress towards specific biodiversity conservation goals

- validate management strategies and actions, i.e., are management actions delivering the desired outcomes;

- improve confidence of investors and to enhance political and community support for conservation and for DEC;

- report quantitatively to Government, statutory authorities and other stakeholders on outcomes;

- focus management attention on delivering conservation outcomes, not solely on activity and inputs

- improve management standards and planning for biodiversity, i.e. a better basis for prioritising projects and allocating of resources, and hence better targeting and more efficient use of resources; and designing and applying management intervention at the appropriate temporal and spatial scales;

- better coordinate the acquisition and application of biodiversity knowledge,

- improve communication between internal stakeholders and with external stakeholders; and

- define accountability for biodiversity outcomes and the means to achieve desirable goals.

At this point, it is important to recognise the difference between *conservation achievement and management effectiveness appraisal* with that of *project activity (performance) monitoring*. The latter is focused on monitoring and reporting on project expenditure and activity targets, or outputs, such as length of fencing erected or area burnt, while conservation achievement and management effectiveness attempts to answer two fundamental yet complex questions:

1. Are we achieving desired state(s) and condition of species, ecosystems and landscapes?; and
2. What difference are we making in alleviating adverse pressures, or threatening processes?

A principal difference between these levels of appraisal is that determining conservation achievements and management effectiveness is focused on outcomes and indicates the *why* and *where* activities should occur, while project performance is about determining *how* effort should be expended (Stephens, T et al. 2002). Amalgamating project performance outputs to determine the higher levels of interest in achieving desired state or alleviating pressures on biodiversity is generally not possible, or catered for under project reporting.

4. Biodiversity conservation business model

4.1 The Nature Conservation Service

The delivery of the Nature Conservation Service (formally known as the Nature Conservation Output) has progressively moved towards an outcome-based or value driven management approach, where actions are linked to expected biodiversity conservation-related outcomes. This has also been tied with work to better define priorities and targets for the Service, and adoption of an active adaptive management framework[1] for major projects and programs (see Section 3.4 and Figure 3). The development and implementation of a compendium of nine five-year Nature Conservation Service regional plans represents a significant step in this transition. The plans provide a framework to ensure that investment targets focus on the most important landscapes and biodiversity values and will achieve desirable measurable outcomes.

The aim of the plans is to improve the deliver of the Nature Conservation Service in DEC at a regional scale, through better integration and use of finite resources. Collectively, implementation of the plans aims to improve progress in the recovery of species and communities over 25 years, initially by slowing their rate of decline, involving;

- identifying and managing ecologically intact and functional landscapes and habitats (see the definitions and discussion in Walker and Salt (2006);
- creating and managing a network of conservation reserves; and
- continuously improving biodiversity conservation management by acquiring and applying knowledge gained through research and management experience..

Expected outcomes are:

1. shift in management approach from one that is largely input and activity-driven to one that is outcome-driven and fosters building institutional knowledge and technical capacity;
2. integration of effort (activities and function) across Divisions and Regions to reduce the impact of invasive species and other pressures on biodiversity through strategic and targeted effort in a cooperative manner;
3. cost-effective management and research at a regional scale that will maximize outcomes;
4. better informed decision making for the Nature Conservation Service, from the Corporate level downwards so activities and budgets are better aligned to direct biodiversity conservation management and research that will achieve agreed targets;

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[1] Active adaptive management aims to build corporate knowledge, accountability, ownership and provide testable hypothesis for management and policy issues. The ultimate goal of adaptive management is to learn and adapt to improve on management interventions or on-going projects. Discussed in section 3.4.

5. explicit (i.e. better defined and quantitatively described) Nature Conservation Service regional priorities, targets and budget information that will strengthen a Departmental and State business case for biodiversity conservation;
6. ability to measure and report on effectiveness of biodiversity management at a regional scale, and provide an enhanced audit function for the Nature Conservation Directorate; and
7. greater accountability of actions and for budgets.

The proposed State biodiversity conservation strategy provides the framework and many of the priorities for the Nature Conservation Service, of which the implementation of the Nature Conservation Service region plans will be a key part of its delivery.

4.2 Evolution of Management Effectiveness Evaluation – from linear to cyclical management frameworks.

The science underpinning biodiversity conservation has its roots in the population monitoring used in species status assessments that began in the late 1890's (Stem et al. 2005). This developing conservation science has supported a range of similar, linear management structures that have been used in species status assessments, environmental impact assessments, logical frameworks, state-of-the-environment monitoring, scorecards and rapid assessments over the last 100 years (Brooke 1998, Gotsch 1998, The Nature Conservancy 1999, Sayre et al. 2000). However, these conventional or traditional linear management structures are ineffective for biodiversity conservation because they do not allow for the identification of or predicting potential problems that may lead to a failure of management actions, nor do they allow for the incorporation of new information to future planning and management interventions (Holling 1978, Margoluis and Salafsky 1998, Hockings et al. 2006). Other major limitations of conventional management approaches is the tendency to foster closed decision making and limit feedback to improve management intervention and knowledge building. A secondary characteristic is limited accountability for outcomes, or target states, as opposed to activities or expenditure.

Biodiversity management effectiveness evaluation is a cyclical, rather than linear, framework that uses the principles of active adaptive management as the core project planning, design and evaluation procedure (see Table 1 for a comparison of the two management approaches). This is a contemporary "learning by doing approach", but in a systematic and purposeful way (Stem et al. 2005). Active adaptive management is recognised as world's best practise for biodiversity conservation (Hockings et al. 2006).

TRADITIONAL or CONVENTIONAL MANAGEMENT	ACTIVE ADAPTIVE MANAGEMENT
• Often 'closed' management decision making (single or small group of people unconnected making decisions), responding to past performance; • Usually focused on a single management approach to solve problems – generates risk averse, trial-by-error strategies using best guess information;	• Systematic and open approach to problem solving – used as a tool to learn about and alter the system; • Explicit goals and objectives, i.e. common understanding, peer reviewed; • Focuses on need to learn and the cost of ignorance; • Poses hypotheses that are testable –

• Focuses on inputs and costs of knowledge; • Unmonitored experience; • Doesn't normally improve knowledge, certainly limited corporate knowledge, and any knowledge generated usually isn't accessible; • Limited or no feedback loop into management system for improving quality of management; • Limited learning capabilities; • Highly inefficient.	leads to more than one approach being implemented; • Monitored experience; • Open review to improve approaches/strategies; • Generates corporate knowledge that is accessible; • Leads to structured reporting and communication to investors; • Reduces uncertainty; • Fosters learning (and team approaches).

Table 1: Comparison of characteristics between conventional (traditional) and contemporary (cyclical) approaches to biodiversity conservation management.

The development of management effectiveness reflects the development of ecological and conservation sciences. This is a process of continued improvement as new knowledge and techniques are developed. Some of the important stage in the development of this biodiversity management is summarised in Table 2.

Approach (and date of first use)	Typical strengths	Typical limitations
Status assessment – population monitoring (1890s)	Provides basic ecological information, shows change over time.	Expensive, time consuming, no causal data, observer differences.
Rapid assessment (1990s)	Relatively quick and inexpensive.	Scope, sample size and conclusions often limited.
State-of-the-environment (mid 1980s)	Give "general" health of ecosystems, allows multi-region and – country comparisons, politically effective.	Trends can not be explained.
National report cards (early 1990s)	Gives general sense of health of ecosystems, good communication tool, politically effective.	Very simplistic, no trends explained.
Scorecards (mid 1990s)	Assist management decision's, good communication tool.	Often no link between specific interventions and scores, data not causal.
Measuring effectiveness - environmental impact assessment (1970)	Ensures environmental impacts considered in development projects.	Narrow focus – limited attention to broader ecosystems, does not consider cumulative impacts, advocates mitigation of impacts rather than proactive alternatives.

Social impact assessment (mid 1970s)	Ensures social impacts considered in development projects.	No clear definitions, difficult to measure and assess qualitative variables in SIA.
Strategic environmental assessment (1990s)	Broader policy/program level – considers cumulative impact.	Logistically difficult and application to jurisdictions and/or boundaries difficult.
Biodiversity impact assessment (1990s)	Expands EIAs to address biodiversity impacts in development projects.	No recognized standards, incompatible boundaries between ecological and social data, inadequate attention to cumulative impacts.
Logical frameworks (1970s)	Clear structure to project planning, links activities to indicators.	Assumes change occurs in a logical linear fashion, rigid structures limit adaptation.
Results-based management (mid 1990s)	Links interventions to direct impacts, allows efficiency and effectiveness comparisons.	Often ignores process and intermediate steps behind impacts.
Adaptive management (late 1960s)	Uses causal relationships to test effectiveness of interventions, systematic and often rigorous, learn from success and failures, feed lessons back into management.	Institutional resistance to experimenting and learning by doing, long process.
Prototyping (1980)	Systematic, potentially inexpensive way to try new techniques, learn from success and failures, feed lessons back into management.	Untried. Potential institutional resistance to experimenting and learning by doing, long process when managers under pressure to produce results.
Project-cycle management (late 1980s)	M&E fully integrated into management cycle, indicators clearly linked to project goals, objectives and activities, consideration of context and processes.	Time consuming, reluctance to focus on learning process.

Table 2: Development of species and ecosystem status assessment and monitoring and evaluation (M&E) programs (modified from Stem et al. 2005)

4.3 Management cycles as a framework for management effectiveness evaluation

A single monitoring and evaluation tool that covers the diversity of Western Australian ecosystems and biodiversity is not possible due to its complexity and limited knowledge of biodiversity components. This is the case wherever monitoring and evaluation is applied (Hockings et al. 2006). However, a common framework for measuring the effectiveness of management of biodiversity is, and has recently been introduced in NSW and Victoria at a conservation park and reserves level (Stathis 2006, Parks Victoria 2007) and in New Zealand at a landscape level (Stephens et al 2002). The step-by-step approach to implementation of measurement and reporting biodiversity management effectiveness is the same, regardless of where and how the measurements occur. In biodiversity evaluation, the management cycle and planning process through which Nature Conservation Service priorities are set and the scales of measurement between sites, are the same. In Western Australia, the management cycle required to fulfil legislative and policy drivers is described by *A System for the Management of Biodiversity Conservation* at Figure 2. This framework follows an adaptive management approach and has several key elements:

(1) Priority identification and policy setting – where significant biodiversity values, and pressures acting on these, are determined along with conservation targets for management, at a range of biological levels. This element is encompassed in Government policy and strategic documents such as the proposed State 100-year biodiversity conservation strategy and Nature Conservation Service strategic and business plans.

(2) Decision support and information management system tools – provide the basis for priority setting and project/program design, implementation, evaluation and review.

(3) Project and program planning and implementation - which follows an active adaptive management cycle to allow information concerning the past to feed back and improve the way management is conducted in the future. Programs are developed with key elements including evaluation of conservation achievements and management effectiveness, and report to internal and external stakeholders.

This cyclical management approach follows the following four major steps:

Project design or amendment – development of projects or program of activities that integrate operational management and science and aimed at the correct scale to address a variety of factors that often inter-related is critical (see Section 3.4 for more details).

Implementation – action to provide the most efficient and effective means to address biodiversity conservation needs careful execution.

Measuring and Evaluation - outcome evaluation is vitally crucial because it measures the underlying and most important effects of management actions on biodiversity and determines if effort is on track to meet desirable goals.

Reporting – three levels of monitoring that informs the reporting process; Level 1, activity measurement reporting; Level 2, measuring pressure impacting on the identified biodiversity; Level 3, has investment in biodiversity conservation achieved the target outcome? This is expanded in Section 4.

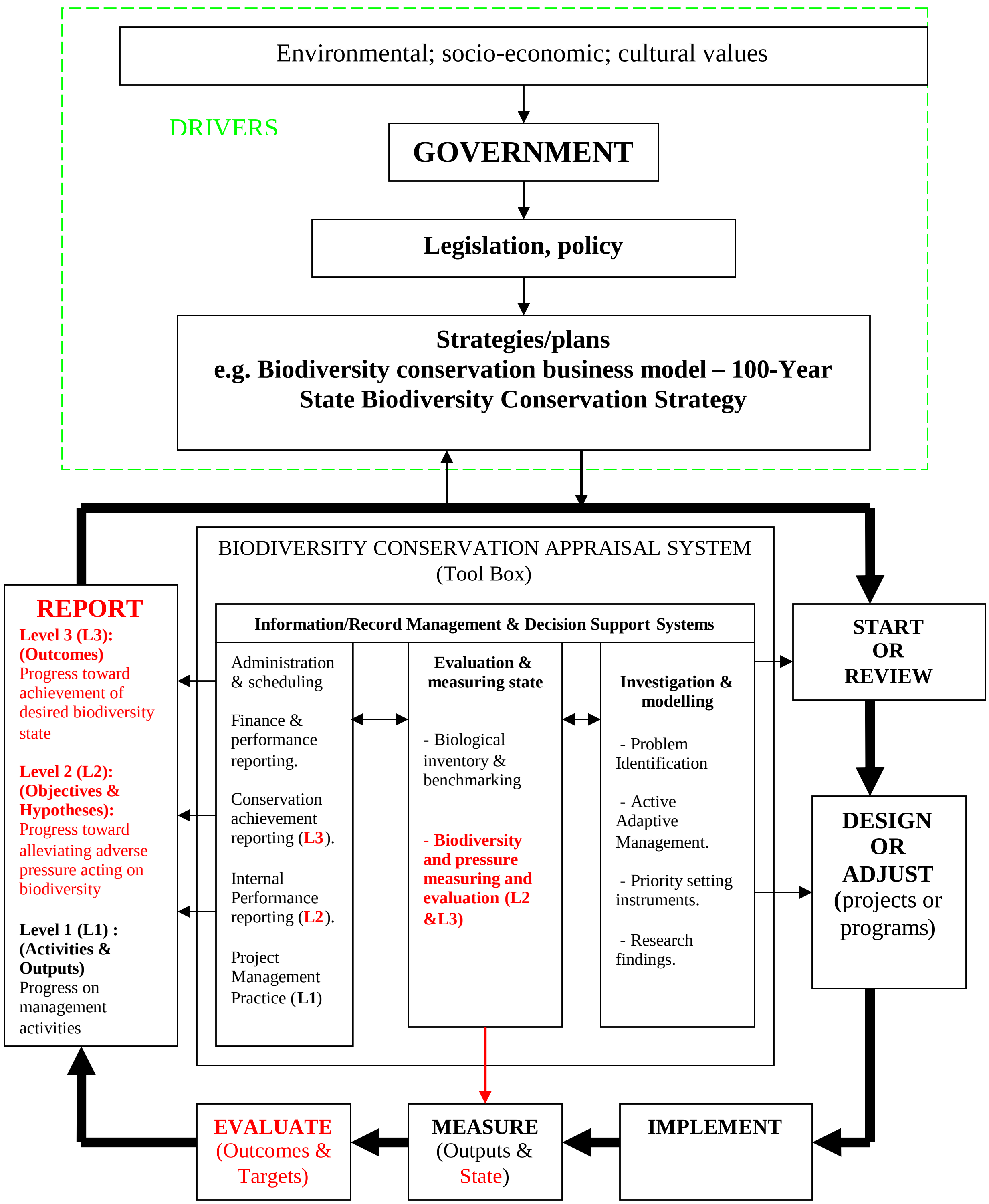

Figure 2: Business model for delivery of the biodiversity conservation, including evaluation of management effectiveness (ME) (expanded from Figure 1). Red font indicates elements that are in development by DEC. Reporting levels are discussed in Section 5.

4.4 Active Adaptive Management

Adaptive management, or 'learning by doing' has long been the basis of many biodiversity conservation projects. Adaptive management and the more intensive "active" adaptive management have been defined by the British Columbia Ministry of Forests (2004) as follows:

"Adaptive management is a systematic process for continually improving management policies and practices by learning from the outcomes of operational programs. Its most effective form, "active" adaptive management, employs management programs that are designed to experimentally compare selected policies or practices, by evaluating alternative hypotheses about the system being managed".

DEC's Nature Conservation Service is increasingly adopting the active adaptive management approach as the benchmark for major programs,

Theoretical and logistical aspects of adaptive management have been widely reviewed and discussed in the literature (see Salafsky et al. 2001; Stem et al. 2005, and Hockings et al. 2006 for examples). This section briefly describes templates for implementation of active adaptive management projects for biodiversity conservation.

Figure 2 outlines the active adaptive management model for program or project development and implementation. An important aspect of this approach is the recognition of a range of factors that need to be addressed when developing projects and programs of activities, and managed together to reach the target desired state or condition of biodiversity when implemented. This approach not only promotes the integration of research and operational management, but it also forces the integration within operational delivery by addressing a number of issues at the appropriate spatial and temporal scales.

For example, in many landscapes and ecosystems, fire and herbivore grazing are key factors affecting the state and condition of biodiversity. Both of these issues need to be managed together, or cognizant of one another, due to their inter-relationship and effects on the target state or condition. By isolating management focus on only one factor, increases the potential of failing to reach the desired goal because the other factor(s) are ignored or managed separately through other management regimes. By mapping the model of the system, the explicit management requirements become obvious, and hence project management accountability clearer. A number of tools, including expert opinion and risk analysis, can be used to prioritise factors of interest and candidate actions that should be pursued.

In conventional management systems, where operational delivery is separate from science delivery, or where there are no formal linkages, a typical approach usually stops after the implementation stage and without knowing whether action have been successful in achieving the desired project goal or in reducing pressures acting on biodiversity.

4.4.1 *Active Adaptive Management Criteria*

There are five primary criteria that should be met and provide a test for an active adaptive management project to be recognised:

1. Must have hypothesis for each objective – otherwise its not active (referring to research component) and the project will be or become intuitive or best guess approach, and result in limited learning – there must be a hypothesis that is testable for each management objective for each factor;

2. Must have accountability – at whole-of project scale (single person to drive integration and progress of steps) and for each action under the objectives for factors (a single person to drive actions to change factors and meet respective objectives);

3. Must build corporate knowledge, rather than individual knowledge being the primary driver – the project must collate data that can be analysed, stored and be readily accessible to all participants and for reporting (one of the aims of active adaptive management is corporate and collective learning); and

4. Must be explicit for all participants, and goal and objectives be understood – the project goal (purpose) in particular must be understood and developed collectively along with the objectives for the factors.

5. Must have appropriate experimental design – that includes spatial/temporal replication, independent and adequate sample sizes), which will allow acceptance or rejection of hypothesis.

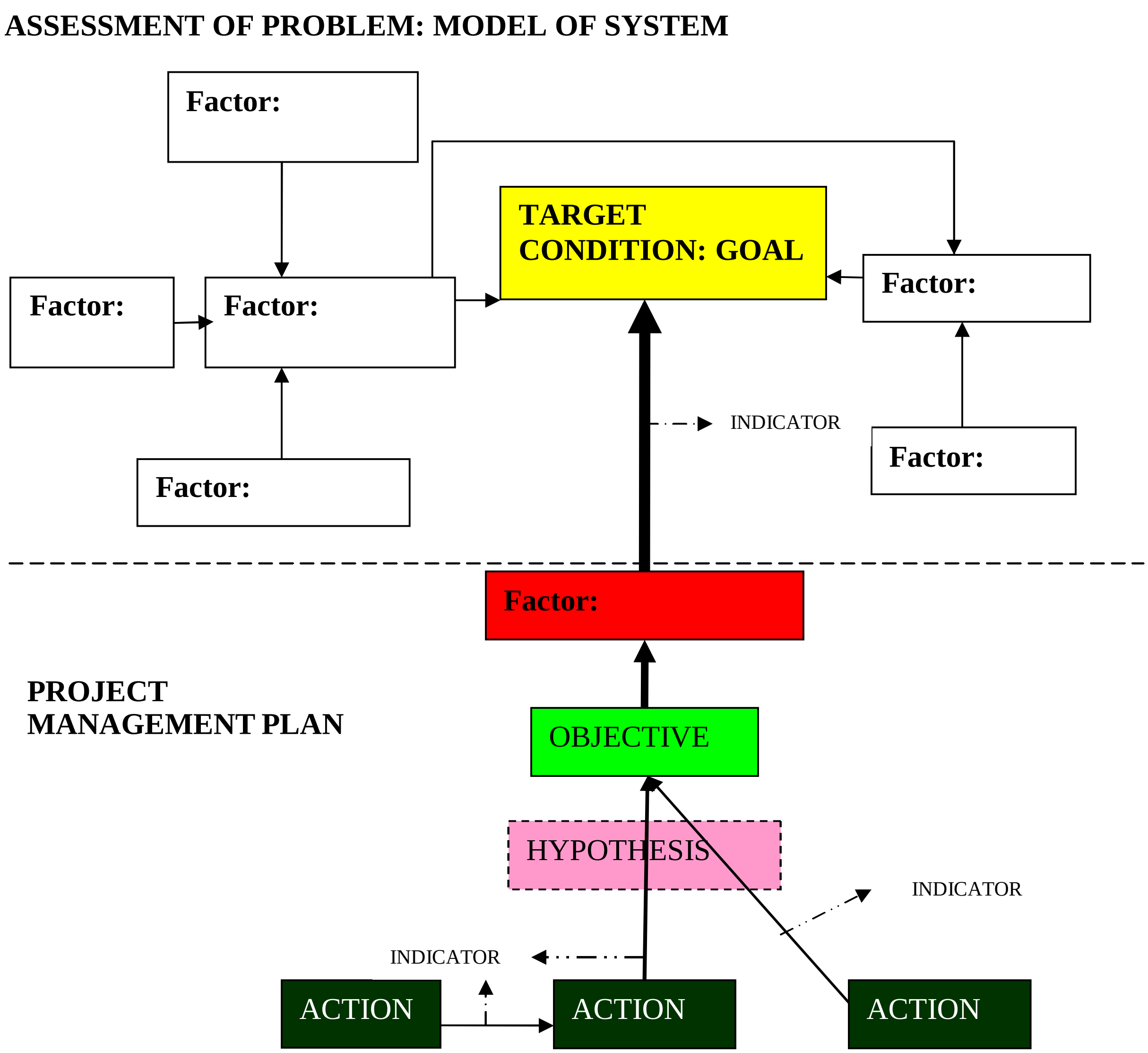

Figure 3: Simplified conceptual model of system and framework for active adaptive management project and program development, showing the two stages of development (1) problem assessment through creating a simplified model of the system outlining priority factors acting on desired target condition or goal; and (2) developing management hypotheses for each management objective relating to priority factors and a set of candidate primary actions. Indicators are measured at various levels of the model to determine management effectiveness and to determine if desired goal as been reached.

5. Measuring conservation achievements and management effectiveness

Previous sections have introduced and reviewed management effectiveness and evaluation models as world's best practise in biodiversity conservation, and indicated planning steps currently underway within the Nature Conservation Service to deliver the policy and legislative requirements for biodiversity management actions. A key to delivering biodiversity legislative and policy requirement through effective management is being in a position to measure and evaluate management effectiveness and achievements.

As noted in Section 3, an important difference between conservation effectiveness measuring and monitoring and project performance monitoring exists. Project performance monitoring is for accounting or certification and considers whether an organisation or program is fulfilling governance and conditions set by a funding body or Government (Stem et al. 2005). All biodiversity conservation expenditure requires project performance monitoring.

In contrast, monitoring for the evaluation of biodiversity management effectiveness is linked to discrete management interventions and biodiversity targets (Stem et al. 2005). Measuring management effectiveness is a scaled approach, with project performance monitoring measuring outputs on all biodiversity investment, and biodiversity management effectiveness evaluation providing proof of the effectiveness of investments on biodiversity outcomes for representative active adaptive management projects. These scales of evaluation and reporting are outlined in Figure 4 (see also Figure 2)

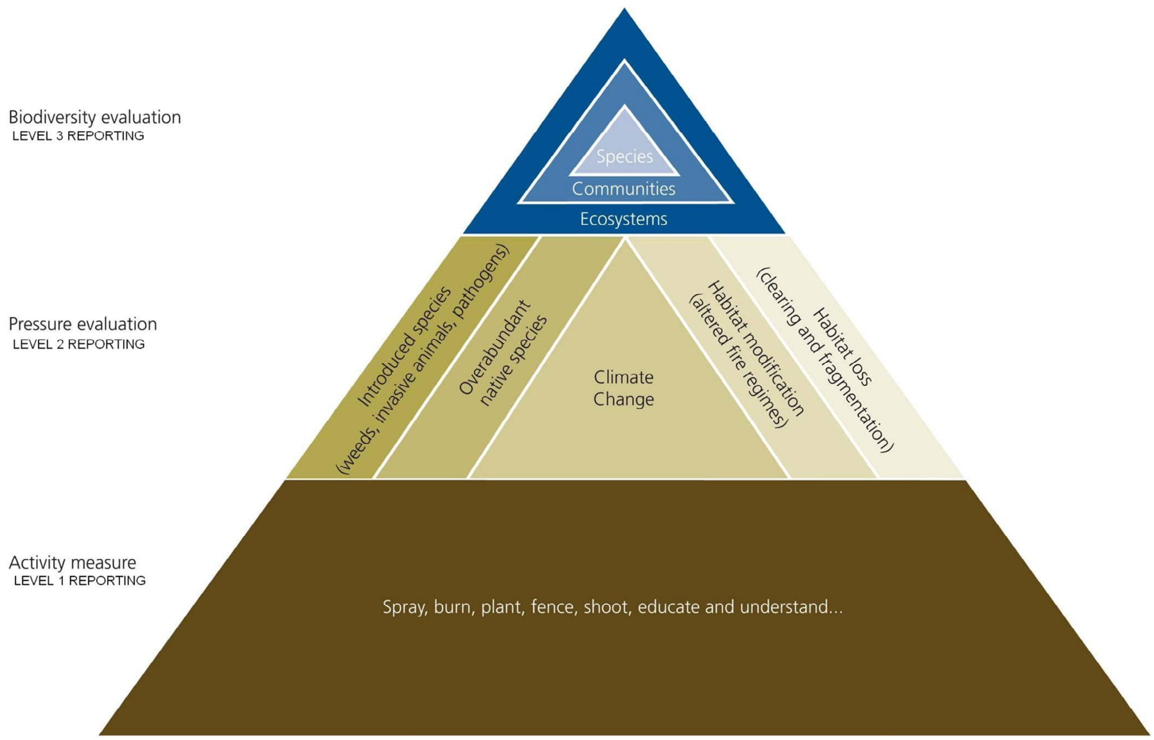

Figure 4: Triangle showing the different levels of evaluation – biodiversity evaluation-pressure evaluation and project activity measuring. Project performance measuring outputs on biodiversity conservation investment, pressure evaluation monitoring allows large-scale assessment of system-wide pressures, while biodiversity evaluation monitoring measures management effectiveness and target states. (Adapted from State of the Parks 2007, Parks Victoria).

5.1 State-Pressure-Response Model: Evaluation within a framework for Management Effectiveness.

A number of approaches have been used in developing indices for monitoring biodiversity outcomes. One common framework, and adopted under the Commonwealth and State bilateral agreement for the extension of NHT and NAP for State-of-the-Environment reporting, is the pressure-state-response model (PSR). *Pressure* includes indirect or direct human-induced processes that affect biodiversity. *State* is a combination of: species richness and/or ecosystem richness; representativeness; condition; variety, composition (e.g. dominant structuring species or population dynamics) (see Stephens et al. 2005). Natural systems can be in different states over time, and these different states are separated by thresholds. Ecosystems may be in desirable or target states, or may be in undesirable states (e.g. degraded vegetation state caused by severe weed infestation). *Response*s are the measures taken to change the state, pressure or use. This approach has been refined by the European Environment Agency to comprise a driver-pressure-state-impact-response.

The PSR model is ideal for use in any management effectiveness framework because it complements the management cycle used in active adaptive management. Establishing hypotheses on the basis of management treatment versus some non-actively managed control provides measures to evaluate the management of pressures that affect biodiversity. The simple repeated measures design (Zar 1984) provides measures to evaluate management effectiveness for biodiversity outcomes that are required to achieve the target state. This simple model of target biodiversity states and pressure evaluation is outlined in the schematic of the on-ground management cycles needed to better measure management effectiveness (Figure 5 a and 5b).

The PSR model is flexible between project (landscape/ecosystem/species) and/or program activities. This simple model outlined in Figure 5 can encompass the full extent of legislative and policy drivers for biodiversity conservation (Figure 1). Currently about 70% of annual expenditure under the Nature Conservation Service is directly attributed to administration, operational management and research activities related to managing pressures on biodiversity, such as introduced species control, threatened taxa and ecological communities recovery and fire management. Hence, the use of the PSR model is highly applicable to measuring biodiversity conservation achievements and management effectiveness.

Given the need to apply active adaptive management within the PSR framework, the next step is the selection of biodiversity indicators that will adequately measure the effectiveness of the management intervention and provide some measure of the State and condition of biodiversity.

5.1.1 Concept of Condition

For the purpose of this model, condition is a measure of quality and presence of sensitive and vulnerable biodiversity components that isn't present in degraded systems and/or biodiversity-derived benefits that can be measured, such as some ecosystem services, e.g. provision of clean water. The concept of condition assists in the selection of target states that are desired from a management intervention. This helps to ensure that management actions are targeted to decrease the pressures of threatening processes (say total grazing pressure from feral goats or exclusion of *Phytophthora cinnamomi* through 'clean-on-entry' management) below an identified (or hypothesised) management threshold. Management thresholds are further discussed below.

Setting condition parameters for target biodiversity states is applicable across all scales of biodiversity values – landscape, ecosystem and species scales. This procedure for identifying target condition for managing the pressures on biodiversity is outlined in the schematic diagram in Figure 6.

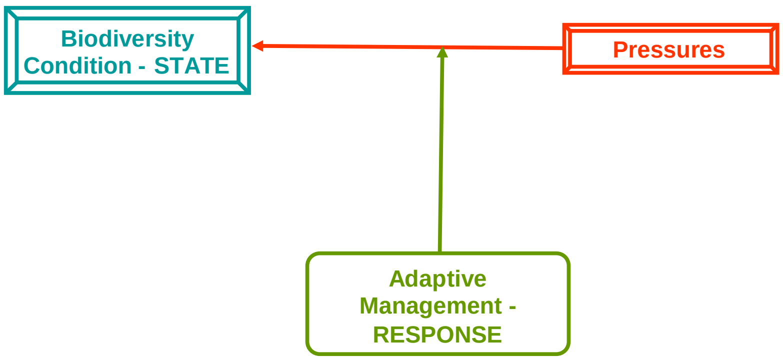

Figure 5a: Schematic representation of pressure-state-response model – where the implementation of management responses aim to achieve a target state of biodiversity condition through the active adaptive management of identified pressures. This is the essence of the pressure-state-response model.

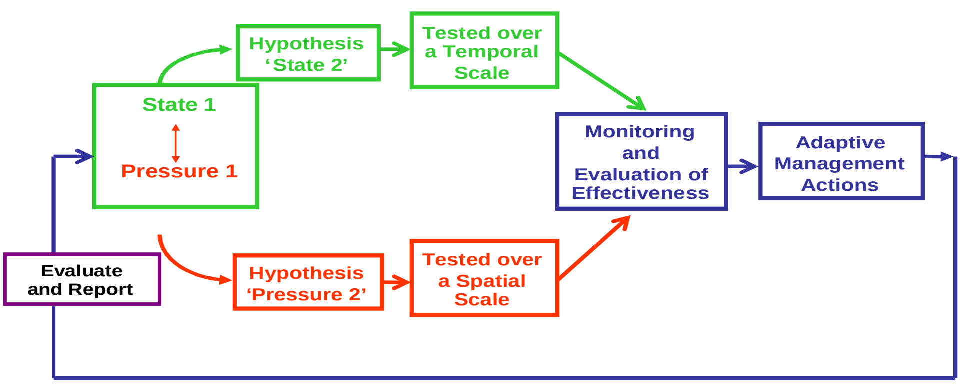

Figure 5b: Pressure-state-response model with an active adaptive management framework. The temporal and spatial measurements that occur as part of evaluation are the basis of any evaluation of conservation effectiveness framework.

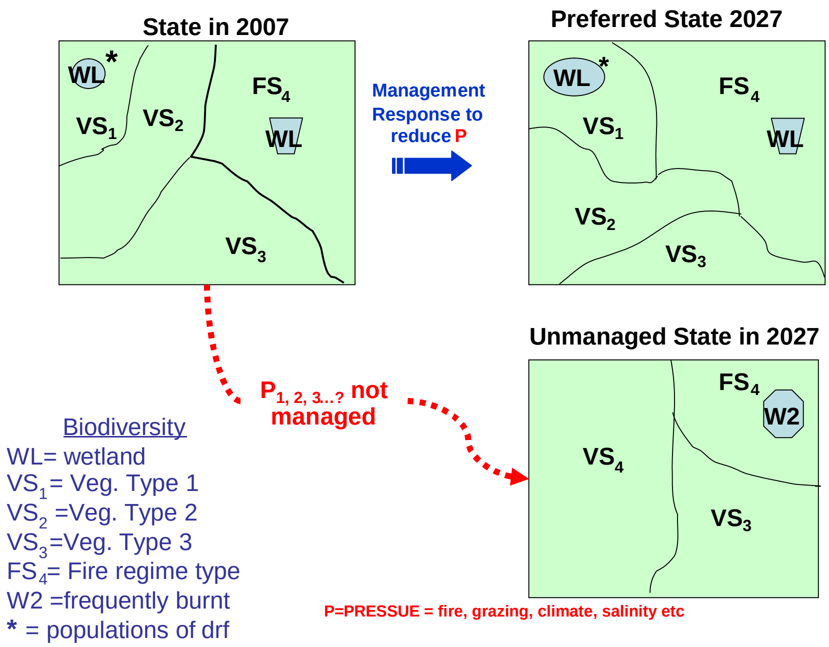

Figure 6: Schematic representation of biodiversity values at landscape, ecosystem and species scales that are degrading toward the unmanaged states in 2027. Management intervention through implementation of active adaptive management aims to achieve the target condition of landscape, ecosystem and species in the 'Preferred State.' It is important to note that pressures (threats) are operating at a landscape, not a point, or species scale.

5.2. Indicators of biodiversity

Biodiversity (resource condition) indicators are a way of presenting and managing complex information sets in a simple and clear manner. However, in many conservation projects, managers and scientists have a difficult time determining what they should be monitoring. In most instances, people attempt to measure a long list of indicators, which involves an extremely large and unfocused data gathering exercise (Salafsky et al. 2004). In the absence of monitoring objectives or questions, which align to policy or management questions, undertaking monitoring or single sampling of indicators amounts to collecting data for the sake of it and a wasted use of resources. Gathering data that remains unanalysed and unreported, and without a clear management or policy question, will lead to failure in knowing whether management intervention is making a difference, and as consequence conservation effort can be wasted.

Biodiversity indicators serve five different functions:

- Simplification – summarize complex sets of data in order to simplify information;
- Representation – provides indirect measurements, often indicative of larger, more complex processes and components of a system, based on a number of assumptions;
- Quantification – provide comparable scientific observations;

- Standardization – of methodology; and
- Communication – provide a clear message to decision makers and (if possible) the general public.

Biodiversity cannot be measured in an absolute sense because of its complexity. Hence, biological indicators (or bioindicators) are used for measuring state and trends in biodiversity condition. An understanding of conditions and states across all scales of biodiversity is required when selecting indicators for monitoring and evaluating biodiversity management activities. This is true of all scales of measurement, and for setting targets and for within or between region (or program) evaluations of biodiversity management effectiveness. The following sections outline the appropriate steps to selecting relevant biodiversity indicators for the evaluation of management effectiveness.

5.2.1 Selecting bioindicators

Indicators are important measurement tools for monitoring biodiversity and are a prerequisite for measuring and evaluating biodiversity management effectiveness. However, selection of appropriate biodiversity indicators that are useful in evaluating management effectiveness requires a step-by-step approach for each program, region or site, ultimately accounting for all of the scales outlined in the previous section.

The points below outline the rules and criteria for selecting biodiversity indicators:

- Choosing indicators should be a cooperative exercise between policy makers, managers and scientists. This should guarantee that indicators are policy and management relevant (aligning with conservation targets and determining baseline choice), affordable, easy to monitor and reliable.

- Many assumptions have to be made about indicators. These assumptions need to be outlined along with their limitations and a consensus formed as to their validity.

- Indicators and monitoring should be designed to detect changes in time frames and on the spatial scales that are relevant to policy objectives and management actions. It is important to detect change before it is too late to correct any observed problems. There needs to be careful analysis of the issues and the scales they occur before selecting indicators and an analysis to determine 'acceptable' change and an analysis to ensure such changes can be detected by the monitoring program proposed.

- Multiple indicators are required to adequately measure biodiversity across all of the scales required. Selection of a representative set of indicators is recommended, with preference being given for a few, simple sand feasible indicators in the short term (1-5 years) and a gradual development and improvement in the long term (15 years).

- To assess improvement or deterioration in the status of biodiversity, baseline and policy objectives are required against which current and expected future states can be compared. The baseline may be the earliest repeated measure of the indicators of biodiversity, or may be a scientifically reconstruction of historical conditions, for example pre-industrial state. The baseline provides a context for the assessment of change and gives meaning to an indicator. It should be emphasized that the baseline is not the target biodiversity state.

- Appropriate indicators should be SMART (specific, measurable, achievable, relevant and timely).

- In addition, biodiversity indicators should meet a number of overarching criteria. These are:

    - Policy relevant and meaningful – Indicators should send a clear message and provide information at a level appropriate for policy and management decision-making by assessing change in status of biodiversity (or pressure, responses, use or capacity) related to baselines and agreed policy targets.

    - Biodiversity relevant – indicators should address key properties of biodiversity or related issues such as state, pressure, response, use or capacity.

    - Scientifically sound – indicators must be based on clearly defined, verifiable and scientifically acceptable data, which are collected using standard methods with known accuracy and precision.

    - Broad acceptance – the power of an indicator is in its broad acceptance and understanding.

    - Cost-effective and involve an appropriate level of effort – indicators should be measurable in an accurate and affordable way using determinable baselines and targets for the assessment of improvements and declines. An initial burst of expenditure when setting up the program is often worthwhile.

    - Affordable modelling – information on cause-effect relationships should be achievable and quantifiable in order to link pressure, state and response indicators.

    - Sensitive or responsive to on-going change – indicators should be sensitive to show trends (both negative and positive), and where possible distinction between human-induced and natural changes. Thus, indicators should be able to detect changes in biodiversity states in timeframes and on scales that are relevant to decisions but also robust so measuring errors do not affect interpretation of results.

    - Representative – a set of indicators provides a representative picture of the pressures, biodiversity state, responses, and uses. A small number of indicators are often more communicable to policy makers and the public.

- Aggregation and flexibility – Indicators should be designed in a manner that facilitates aggregation at a range of scales for different purposes.

Once an appropriate set of indicators are selected, a series of protocols or parameters to undertake measurements are essential to ensure appropriate sampling design and minimise biases in data collection.

5.2.2. Evaluating condition across scales of biodiversity

A focus on conservation achievements and Management Effectiveness means that biodiversity evaluation is required across all scales. This requires a nested series of measured indicators of biodiversity state or condition. The tools (indicators) that are applicable to measure the landscape, ecosystem and species scales of biodiversity are varied, and range from remotely sensed indices of landscape condition to individual population assessments of target species or high value species. Regardless of which indicators are measured, evaluation of biodiversity will require some measure across all of these scales. This is outlined in Figure 7. In terrestrial systems, the key element for understanding the spatial distribution of biodiversity value or threat is vegetation. This is simply because vegetation characteristics can often be measures remotely (see the number of publications by Catling, Coops, J. Wallace, Wilson et al. DATES NEEDED and others), and evaluated across the landscape. This process is currently undertaken manually in the Division of Sustainable Forest Management by analysis of aerial photography for *P. cinnamomi* mapping. Desired target states need to be defined at the landscape-scale since threats also operate at this scale. Logically, parameters that allow the prediction or classification of biodiversity across the landscape are needed to allow these landscape maps to be produced (See Overton et al. 2002, Stephens et a. 2002, Ferrier et al. 2002). The process of landscape scale management products and planning is currently well delivered within the department through Fire Management Services.

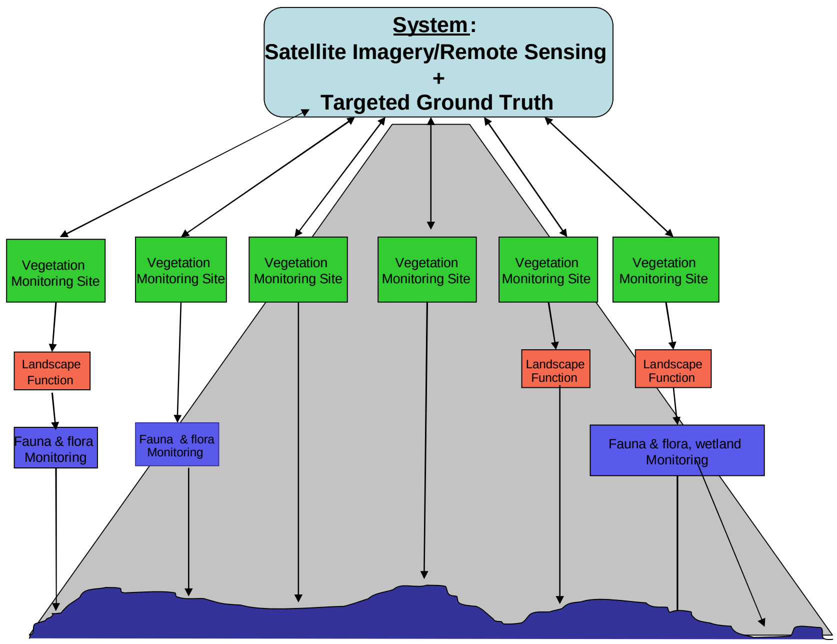

Figure 7: Nested scales of biodiversity condition evaluation in the evaluation of management effectiveness.

5.3 Management thresholds and pressure

Pressures that are degrading the state of biodiversity must be managed to some level that results in a measured improvement in the condition. This level is referred to as a management threshold. For example, the control of total grazing pressure must be to a level that shows a better response in condition of biodiversity in managed areas in comparison to areas where no total grazing management is taking place. In theory, control management actions such as these are considered to be the inverse of sustainable yield (Sinclair et al. 2006). Management interventions (and the departmental costs incurred) that do not reduce the pressures on the biodiversity states below management thresholds are ineffective (Figure 7). A number of excellent case-studies outlining the issues around management thresholds have been published (see Walker and Salt 2006 and hysteresis effects in eutrophication of wetland systems)

The implementation of management effectiveness evaluation is a step-wise process of identification of biodiversity values, pressures and threats affecting the condition of those values, the design of active adaptive management programs to alleviate the pressures, and evaluation of the biodiversity condition to ensure that management thresholds are reached. Application of this framework for DEC is outlined in a series of adaptive management case-studies that are Part II of this paper.

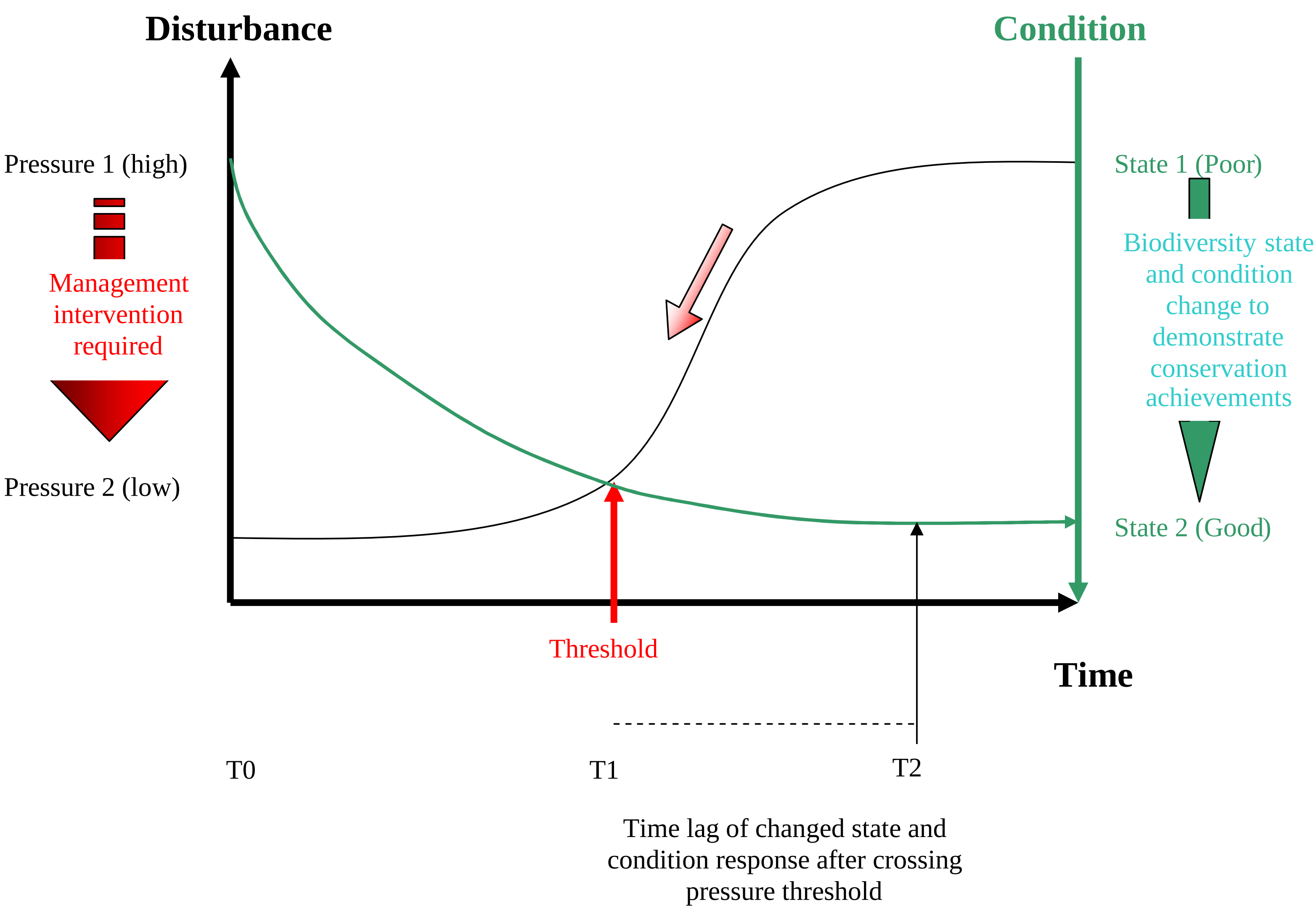

Figure 8: Conceptual model showing a management threshold when actions decrease the pressures on biodiversity below some measured value before a response in target condition results.

CONCLUSIONS

The aim of this paper is to provide a framework for measuring and reporting on biodiversity conservation effectiveness, and to outline some of the tools, levels of reporting and business models needed. This information is synthesised in the business model outlined in the business model Figure 3. This model includes aspects of *reporting* (Level 1 for project outputs to management effective levels of Level 2 (pressures) and Level 3 for biodiversity conservation condition targets), the *Tool Box* of biodiversity conservation appraisal, (including active adaptive management and information management), Legislative, Social and Policy drivers and project *evaluation* and adjustment points. Implementation of such a business model will be a step-wise process. The next objective toward this goal is the development and implementation of large scale-based active adaptive management projects that incorporate all levels of reporting to allow better measurement of management effectiveness for biodiversity conservation.

PART II – CASE STUDY

The following case study implements the concepts and ideas outlined in Part 1.

North Kimberley Biodiversity Conservation Initiative

1. Introduction and Background

The northwest coastal area of the North Kimberley[2] is one of the few remaining parts on the Australian continent where biodiversity is considered to remain mostly intact and functioning as per a pre-European settlement state. However, the biodiversity of this subregion is under increasing threat from altered fire regimes, unmanaged cattle, uncontrolled tourism (both land and sea-based activities), impacts from mining and potential impacts from oil and gas operations and associated onshore facilities. In addition, there are also the likely effects of global climate change, with an expected increase in average rainfall and temperature, and the imminent arrival of cane toads into the Kimberley Region.

Anecdotal and scientific evidence suggests that there has been a major ecological shift in native vegetation structure and floristics in the eastern portion of the sub-bioregion and the rest of the Kimberley, with a resultant simplification or homogenization of ecosystems diversity and loss of soil productivity and some native mammals[3]. This has been brought about through a gradual domination in the abundance and distribution of annual grasses in savanna woodlands, replacing perennial woody vegetation, and the loss of some sensitive ecological communities and flora. The causes of these changes are generally attributed to a significant altering or loss of Aboriginal-related fire regimes in combination with the impact of cattle and other introduced herbivores on native vegetation and soil structure, and the impact of feral cats. The outcome of continued pressures of these kinds will be a decline in biodiversity condition with a possible chnage in state to degraded systems.

Despite the pressures on biodiversity within this sub-region, an opportunity exists to retain biodiversity values in the north western portion, where there have been lesser impacts, and an ability to prevent biodiversity decline remains (refer Figure 1 - map of project area). Land tenure of this area comprises a mixture of protected areas managed by the Department of Environment and Conservation (DEC) under the *Conservation and Land Management Act*, unallocated Crown land and Aboriginal land.

This project offers an investment framework for conservation off-set packages from resource development, including expected oil and gas onshore developments, and the State's fire-related greenhouse gas mitigation proposal. The project is undertaken within an active adaptive management framework and pursues a value-driven (or outcome-based (Stem et al. 2005)) management approach with evaluation of management effectiveness the auditable tool for demonstrating biodiversity benefits derived from the financial investment (Hockings et al. 2006). It focuses on achieving appropriate fire

[2] As per the area delineated as the IBRA sub-region.
[3] Particularly of medium weight range.

regimes for biodiversity and lessening the impact of invasive species, particularly unmanaged cattle, feral pigs and donkeys. This project is linked to conservation targets and activities under DEC's Nature Conservation Service Region Plan and Regional Fire Management Plan.

This project represents one of nine large scale active adaptive management projects in development by the DEC, where biodiversity outcomes are the primary goal.

2. Primary Project Goal:

To retain biodiversity of the North Kimberley sub-IBRA bioregion over a 30 year period, in the coastal area inclusive of Yampi Peninsula to Bougainville Peninsula and at least 50-60 kilometres eastwards including Mt Hart, with a particular focus on maintaining the flora richness and structural diversity of native vegetation, and mammal richness.

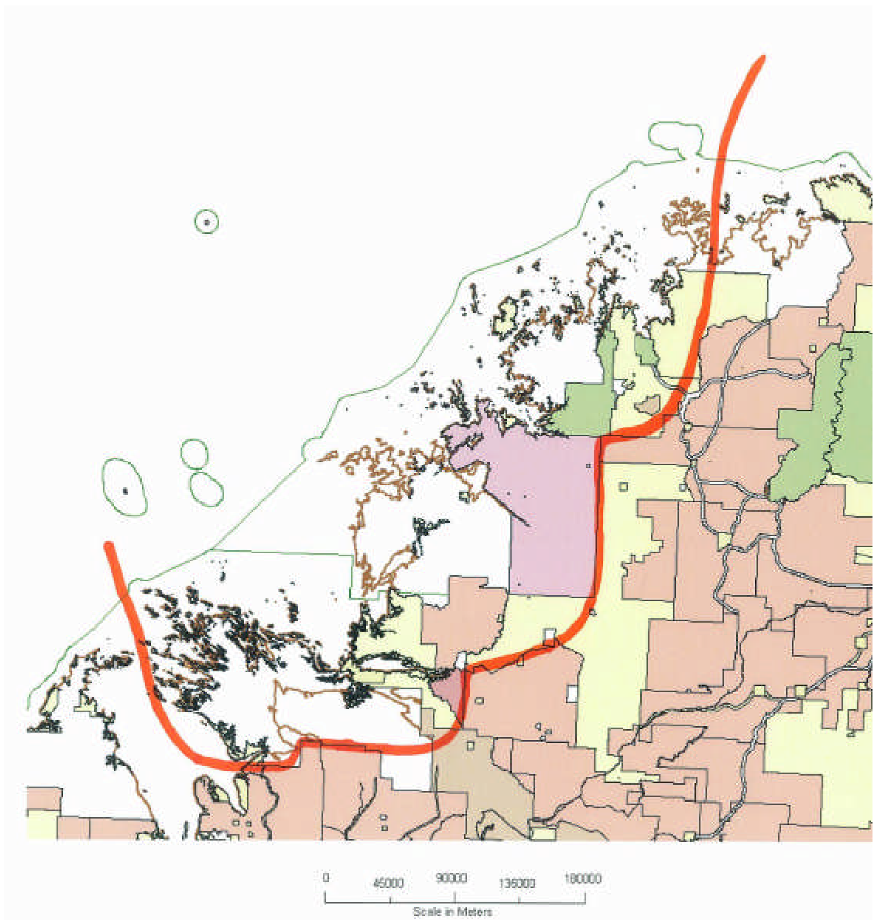

Figure 9: Map of North Kimberley Biodiversity Conservation project area. [REPLACE MAP WITH DIGITISED VERSION]

3. Simplified model of system

The diagram below describes the key factors influencing the target condition of retaining biodiversity with thickness of the arrows indicating the weighting of their perceived significance. The primary factors being tested are shown in red with secondary or indirect factors denoted in blue.

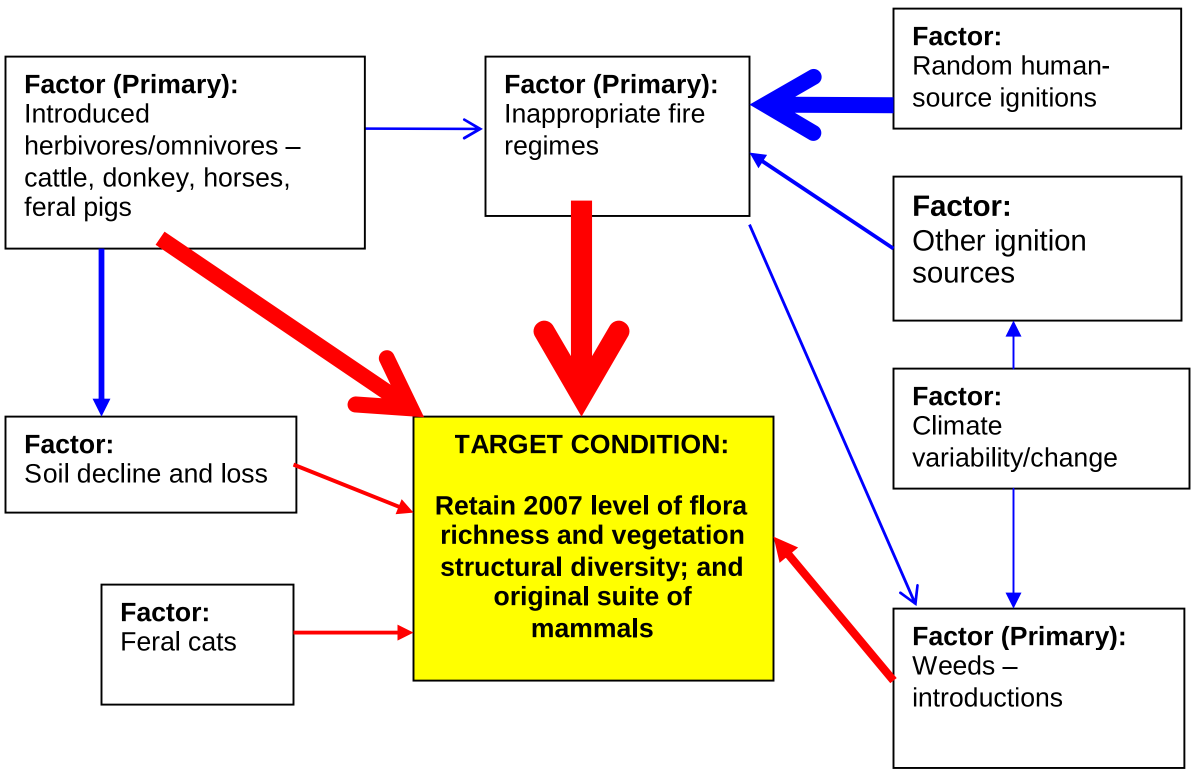

Figure 10: Simplified systems model factors affecting the target condition. Thickness in arrows indicates degree of impact of factor operating on the target condition. This is a Pressure-State model with responses outlined in section 3.2.

The project scope is confined to mounting an immediate and effective response to the three primary factors (threatening processes) identified above (red arrows) as likely determinants in the target condition. These primary factors are:

- Inappropriate fire regimes (Primary Factor 1)
- Introduced herbivores (Primary Factor 2)
- Invasive weeds (Primary Factor 3)

3.1 Target Condition

Objective:

To describe the current (2007) target condition.

Primary Action:

1. Describe the current state of the system – this is a systems model of the states of landscape, ecosystem and species scale biodiversity condition.

Overall responsibility:

Principal Ecologist Nature Conservation

3.2 Primary Factor 1: Inappropriate fire regimes

3.2.1 Objective:

To establish and maintain suitable fire regimes areas in the north western portion of the North Kimberley IBRA sub-region by 2017 that will maintain a diversity of native vegetation structure and flora richness.

Hypothesis:

Variable frequency, low intensity small scale burning will maintain a diversity of native vegetation structure and flora richness than large, frequent, intense fires.

Primary Actions:

1. Develop and implement a fire management program that will:

    a. Create a series of strategic buffers to maintain areas that will exclude (or reduce the risk of) wildfire;

    b. Progressively apply and use fire within each 'protective' area to create prescribed burning regimes of two different pattern size (regimes 1 and 2) within a ten year period, each covering at least an area of 200 sq kms;

    c. Maintain two reference areas (regimes 3 and 4) – no planned burning or unmanaged area, where *ad hoc* ignitions from natural or anthropocentric sources may occur – of comparable size to the actively fire-managed areas above; and

    d. Develop a temporal and spatial mosaic including long unburnt >5years.

Overall responsibility:
Nature Conservation Leader in conjunction with Regional Fire Coordinator, Nature Conservation Division and Science Division.

2. Develop and implement a comprehensive biodiversity evaluation system to gauge the impact and response of different fire regimes (intensity/size) on the desired state and condition of biodiversity (management effectiveness) and detect trends in biota and native vegetation to fire (conservation achievements) (this should include establishing benchmarks of 2007 biodiversity levels).

Overall responsibility:
Principal Ecologist Nature Conservation Division in conjunction with Nature Conservation Leader, Regional Fire Coordinator and Science Division.

Second Order Activities:

1. Develop a vegetation/ecosystem map of the project area for the purposes of planning for fire and stratification of biological reference areas and monitoring sampling (Science Division in conjunction with Regional Services, Fire Management Services and Nature Conservation Division);

2. Develop and implement a rolling five-year prescribed burning program and a suppression program in conjunction with relevant stakeholders, and neighbours, including establishment of a before and after control impact (BACI) design to test the hypothesis at a landscape scale (Regional Services in conjunction with Science Division and Nature Conservation Division);

3. Develop and implement a fire research project that aims to determine the sensitivity and usefulness of biological indicators in the project's biodiversity monitoring system, develop ability to predict global climate change and influences on biota (especially migration of native species and weeds) and other stressors, e.g fire (Science Division in conjunction with Nature Conservation Division);

4. Develop a biodiversity evaluation framework, identify a set of suitable bioindicators including remote sensing indicators (Nature Conservation Division in conjunction with Science Division).

5. Improve and build DEC and local community, including Traditional Owners capacity to use and manage fire in a suitable manner towards the project's fire management objective (Regional Manager and Regional Fire Coordinator of Regional Services);

6. Refine fire predictive and monitoring technologies, particularly remote sensing (Fire Management Services Regional Services);

7. Improve and build DEC's technical capacity, particular Regional Services' ability to support research and monitoring activities (Science Division in conjunction with Nature Conservation Division).

8. Develop and use communication techniques to inform project partners, project investors and neighbours (Regional Manager of Regional Services in conjunction with Development and Corporate Affairs);

9. Develop and use educational material to minimize unplanned fires from tourists, visitors and other land managers (Strategic Development and Corporate Affairs in conjunction with Regional Services and Parks and Visitor Services); and

10. Build partnerships with the Australian Greenhouse Office (fire mitigation project) and other institutions, especially scientific based, to improve the project's resource availability and technical knowledge (Regional Services, Science Division and Science Division).

11. Develop and implement an enforcement program (Nature Conservation Division in conjunction with Regional Services).

Overall responsibility fire component:

Regional Leader Nature Conservation in conjunction with Principal Ecologist Nature Conservation Division

Logistical support responsibility:

Regional Fire Coordinator, and Nature Conservation Coordinators

3.3 Primary Factor 2: Biosecurity and invasive animal management

3.3.1 Objective:

To reduce the density of feral and/or unmanaged cattle (and other large introduced herbivores) to the point where it has negligible impact on native vegetation and floristics at landscape and ecosystem scales, and anticipate and prevent new invasions.

Hypothesis:

That reducing the density of unmanaged cattle (*and other large herbivores*) to less than 0.001[4] animals per 100 square kilometers (in and immediately adjacent to riparian zones and large valley systems) will have detectable benefits for native vegetation and floristic richness as opposed to current cattle density in the project area estimated at 0.01 animals per 100 square kilometers.

Primary Actions:

1. Develop and implement a cattle control plan, based on initial mustering and subsequent annual shooting with a view to maintaining the minimum density of cattle in the project area.

2. Develop and implement a monitoring and evaluation system to determine trends in native vegetation and floristics from the impacts of cattle and fire, and effect of management intervention, including trend in cattle numbers (both removed and still within the project area); and

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[4] Threshold to be re-adjusted after step 2 of second order activities.

3. Develop and implement a biosecurity plan to detect introductions of new invasive species.

Second Order Activities:

1. Determine threshold of cattle density to trigger management intervention based on literature of cattle impacts and results of survey to determine 2007 density prior to control activities (**The hypothesis should be reset or refined after this knowledge is gained**).

2. Build partnerships with and capacity of local pastoralists to prevent straying cattle into project area;

3. Develop capacity to remove and control cattle, including developing DEC capacity to undertake aerial shooting;

4. Build partnerships with Department of Agriculture and Food, and Australian Quarantine Service;

5. Undertake survey of post management intervention(s).

6. Determine high value biodiversity values that need physical protection from cattle; and

7. Provide physical protection of high value ecosystems, where appropriate.

Overall component responsibility:

Regional Leader Nature Conservation in conjunction with Principal Ecologist Nature Conservation Division

Logistical support responsibility:

Nature Conservation Coordinator(s)

3.4 Primary Factor 3: Weed management

Objective:

To control or eradicate weeds causing decline in diversity of native vegetation structure and composition at landscape and ecosystem scales, and anticipate and prevent new invasions.

Hypothesis:

That control and eradication of weeds in key habitats will prevent the decline in diversity of native vegetation structure and composition.

Primary Actions:

1. Develop and implement a weed plan for the project area that focuses on risk assessment and priority setting and primarily on control or removal of 'sleeper' weeds, and weeds impacting on restricted ecosystems.

Second Order Activities:

1. Develop and use a risk assessment framework to prioritise weeds for control;

2. Undertake a survey of weeds and annual seasonal monitoring program;

3. Control weeds according to 1;

4. Estimate any significant changes to weed distribution and/or abundance brought about by climate change predictions, and factor into proposed weed management;

5. Build capacity, including weed identification skill to under weed control work.

Overall component responsibility

Regional Leader Nature Conservation in conjunction with Principal Ecologist Nature Conservation Division

Logistical support responsibility:

Nature Conservation Coordinator(s)

4. Duration of project

Initial duration of project is 30 years.

5. Reviewing and reporting

Overall progress of the project will be undertaken at annual, five yearly and ten yearly intervals. Ten yearly reviews will include independent assessment of the project. Each review will be followed by a report to the Nature Conservation Service Steering Group comprising the Directors of Regional Services, Science and Nature Conservation, and Assistant Director Nature Conservation, and any external investors.

6. Determining conservation achievements and management effectiveness

Monitoring required to evaluate management effectiveness is directed towards the Target Condition and Primary Factors (Fire, feral herbivores, weeds) detailed in Section 3. The scales of monitoring to adequately follow the progress towards the desired system states are *landscape* scale, *ecosystem* (or community scale) and *species* scale. At **TIME 0**, the knowledge regarding the current Target Condition, or likely responses of some species scale indices, may be limited. However, knowledge of these indicators will increase as monitoring continues, following the objectives outlined in 3.2 – *Second Order* activities 3 & 4 (see page 5).

The primary focus for stage 1 **Time 0** data is to describe the state of floristic and structural vegetation communities and soil resource condition. These descriptions of states are in relation to the Primary Factors (fire, feral herbivores, environmental weeds) impacting on the Target Condition:

- Vegetation-fire states (continuum is from low impact states to high impact states);
- Vegetation-grazing states (continuum is from low impact states to high impact states);
- Soil-trampling states (continuum is from low impact states to high impact states);
- Vegetation-weed states (continuum is from low impact states to high impact states).

The Target Condition for each of these states is low impact of primary factor. Schematic representation of the ecosystem states and the target conditions is outlined in Figure 3 below.

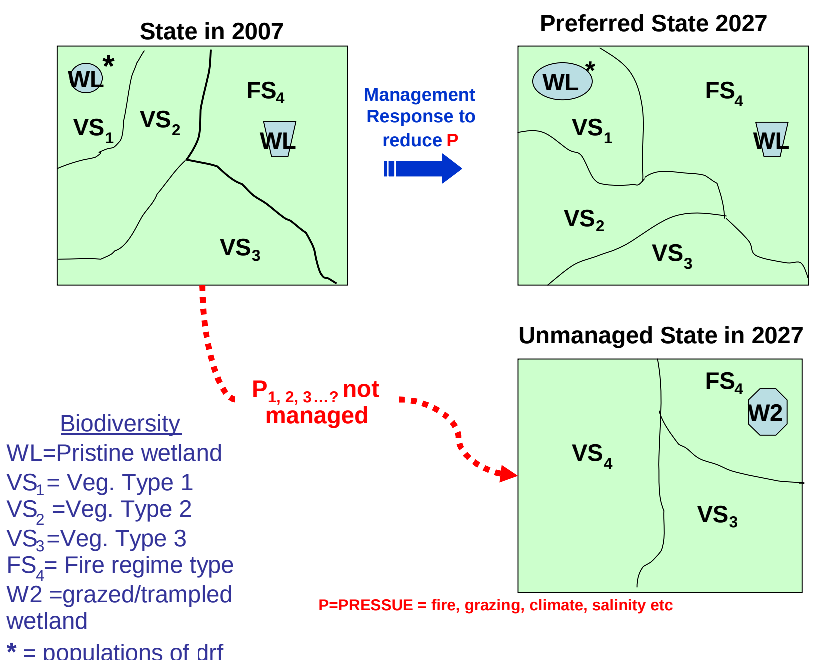

Figure 3: Schematic representation of biodiversity values at landscape, ecosystem and species scales that are degrading toward the unmanaged states in 2027. Management intervention through implementation of active adaptive management aims to achieve the target condition of landscape, ecosystem and species in the 'Preferred State.' (from Western Australian Biodiversity Conservation Appraisal System (draft)).

These data layers will immediately inform the remotely sensed data and the species scale indices of fire, feral herbivore and weed impacts outlined (see measurement nesting schematic in Figure 4 below). Landscape scale and species scale indicators are also suggested, but these will need to be validated in years 2 and 3. To evaluate the effectiveness of reaching the target condition, reporting must be on the basis of indicators across all scales (Figure 4), therefore year 1 reporting for the landscape and species scale data will be for validation of monitoring indices.

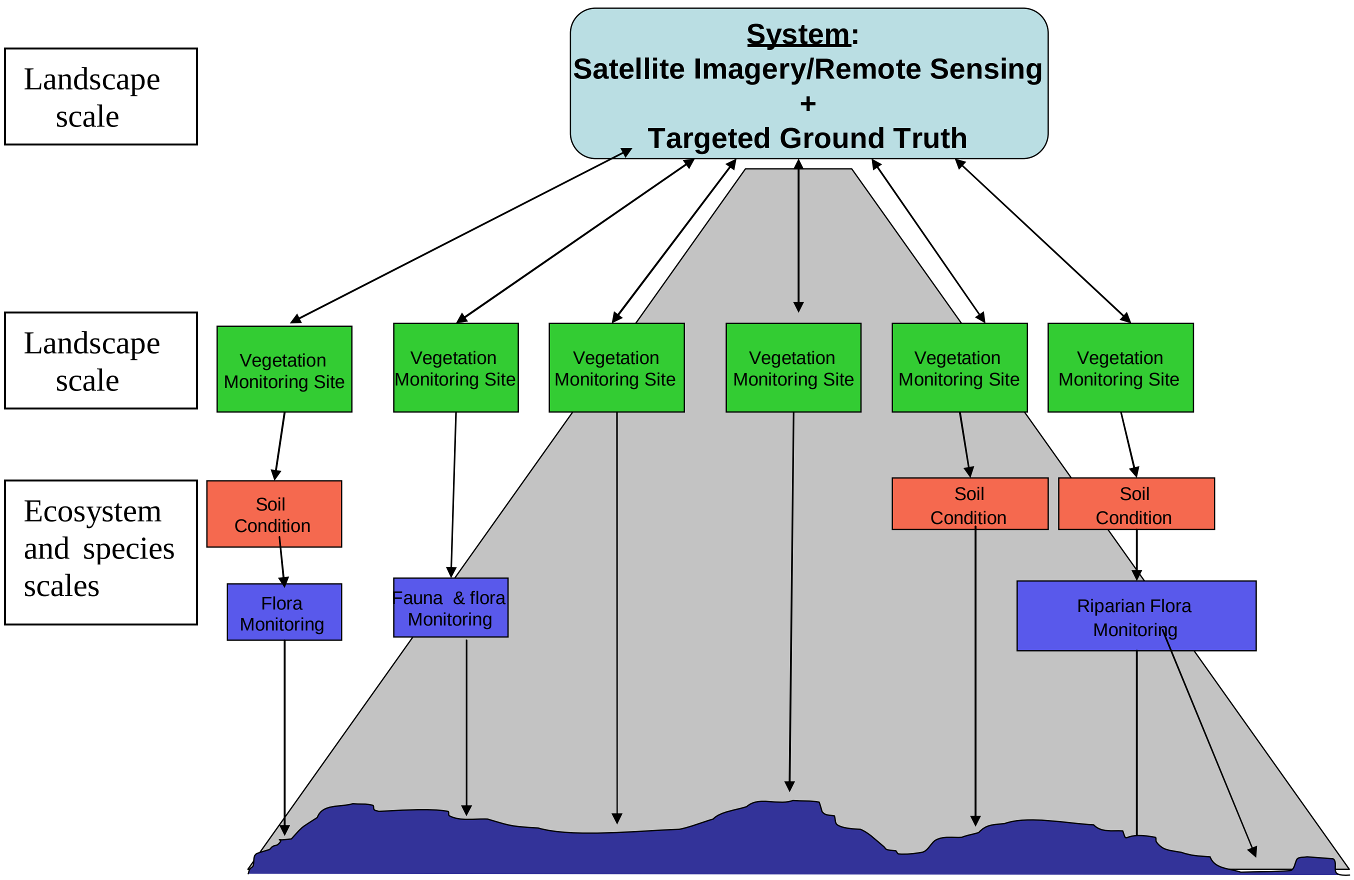

Figure 11: Nested scales of biodiversity condition evaluation in the evaluation of management effectiveness. Detailed floristic monitoring only needs to occur at a few representative sites to link indices of biodiversity across scales of measurement, and to validated annual structural measurements undertaken in all vegetation monitoring sites.

A number of research monitoring questions should be validated by Science Division. These are:

- Fire indices;
- Grazing indices; and
- Fire mosaics and patterns as determined from Landsat TM

6.1 Core set of resource condition indicators- STAGE 1 - Time 0 monitoring data.

6.2.1 Landscape-scale (Objective 3.1 Target Condition)

Monitoring Question – What is the current vegetation condition based on Landsat TM vegetation cover trend for the management area? (Target Condition objective).

Method – Landsat vegetation cover trend, with additional aerial photography interpretation if available.

Stratification – stratification will be based on coarse-scale vegetation community classification. For example, candidate coarse-scale communities will include:

- Rainforest vegetation communities
- Riparian communities
- Adjacent floodplain
- Tropical savannah woodlands

Validation – Remote sensed survey effort based on nested area quadrats using the techniques outlined by Karfs *et al*. (2004). Coarse vegetation community classifications are by ground-truth following Beard.

Repeated measures – Will provide trend in coarse-scale metrics of trends towards the Target Condition. Sensitivity (sic: statistical power) low; however, significant temporal changes toward or away from Target Conditions are more reliable with a repeated measures design (Tabachnik and Fidel 1998).

Area of Assessment - Nested assessment from 100 km^2 (10km × 10km) to 10000 km^2 (100km ×100km). Minimum survey area determined by running mean. (Principal Ecologist, GIS Officer, Remote Sensing Officer). This procedure follows that outlined by Karfs et al. (2004). The Principal ecologist is responsible for testing and validation.

Output - Landscape-scale vegetation cover trend map.

Informs - Landscape-scale state of the system

6.2.2 Ecological community and species scales – Vegetation-Fire states.

Primary Factor 1: FIRE

Hypothesis is fire too:

- *Frequent (between years impact);*
- *Hot (season);*
- The maximum floristic, vegetation structure & cover survey effort will be required at **TIME 0**;
- Survey points are in the most sensitive (threatening process impact/ management response) vegetation communities; and
- Stratified treatment controls ideally located on island and mainland systems.

Target vegetation community
Floristic communities determined by ordination analysis of floristic data from a sub-sample of vegetation structure quadrats with repeat measures every five years. Validation of measurement power (site/community species richness) from nested quadrats at each of three nested zones. Measurement are

- Species presence/absence (all survey points)
- Species counts (increasing effort)
- Species cover (maximum survey effort)

Target vegetation structure
Vegetation structure determined by multivariate tests of significant difference in vegetation structure between treatments. Additional analyses are ordination analysis of structural changes measured at 20 cm intervals using touch pole measurements for vegetation strata 0 cm to 200cm.

Treatments:

Control – Current non-managed burn treatments. These areas will not change there current managed regime.

Treatment – Modified burn regime aiming to achieve target condition.

Interaction: ×grazing

Co-variates - Environmental parameters - rainfall measures in sites that include floristic/structure data will be included.

Analysis and interpretation - ANOVA model with environmental co-variates (ANCOVA) examined. Ordination analyses with temporal trends examined from CONTROL CHARTS (*Primer*). Interpretation on the basis treatment difference of fire sensitive plant species; treatment difference in flora life-forms (fire vital attributes); interactions with grazing sensitive plant species. Candidate sensitive indicator species include:

- Vine thickets (community);
- *Callitris intertropical;* and
- *Pandanus spirilis.*

Research question – Vital attributes in relation to fire will be a parallel research question in this project.

6.2.3 Community and species scales – Vegetation-Grazing (feral herbivore) States

Primary Factor 2: GRAZING

Species communities determined by ordination analysis of floristic data from quadrats or LFA transects (botanical measure is line-intercept). Validation of measurement power (site/community species richness) from nested quadrats at each of three nested zones.

Control - No total grazing pressure site (exclusion) – 100m by 100m cattle proof exclusion fencing.

Treatment - Total grazing pressure site – range of grazing pressure indices included.

Interaction - ×fire

Co-variates - Environmental parameters – rainfall measures in sites that include floristic/structure data will be included.

Analysis and interpretation - ANOVA model with environmental co-variates (ANCOVA) examined using ANOSIM. Interpretation on the basis treatment difference of grazing sensitive plant species; treatment difference in flora life-forms; interactions with fire sensitive plant species. Candidate indicator species are likely to include:

- *Sorghum plumosum;*
- *Alloteropsis semialata* (Cokatoo Grass)
- *Chrysopogon fallax* (Ribbongrass)
- *Dichanthium fecundum* (Curly Bluegrass)
- *Dichanthium sericeum* (Qld Bluegrass)
- *Themeda triandra* (Kangaroo Grass)
- sensitive perennials?

6.2.4 Ecosystem scale – Soil-trampling and erosion states

Analyses of soil resource condition will include detailed measurement of soil chemistry (standard commercial soil analysis of plant available nutrients) and simple physical properties (soil bulk density and slake test) in two strata of the A-Horizon within the survey quadrat at **Time 0**. Soil physical tests will occur annually. Soil chemistry will be measured at 5-year intervals.
(References: Russell 1973, Garkaklis et al. 2004, Bancroft et al. 2005)

Samples will be in vegetation structure survey quadrats (6.2.2)

Analysis and interpretation:

Multivariate analysis of between site soils chemistry, with Repeat Measures Multiple Analysis of Variance to follow changes in soil resource condition at **Time 5 Years** and **Time 10** years

Informs – Trend toward target condition.

Alignment with other monitoring procedures or frameworks -

- National Land and Water Resources Audit Rangelands Monitoring Implementation Project.
- Western Australian Rangelands Monitoring System

6.2.5 Community and species scales – Vegetation-weed States

Primary Factor 3: Weeds

Weed species will be measured as percentage cover of invasive weeds in annual measurements of vegetation structure (6.2.2, 6.2.3). Thresholds for weed treatment will be:

- On the basis of identification of new populations of highly invasive species
- Trend increases in cover of weed species identified from annual surveys.

Treatments are not required. Measurement will be as interactions with Fire and Grazing treatments and controls (6.2.2, 6.2.3).

Co-variates - Environmental parameters – rainfall measures in sites that include floristic/structure data will be included.

Analysis and interpretation - ANOVA model. Interpretation on the basis of treatment difference in different fire treatments or different grazing treatments.

7. Other

Dependant on future threats to biodiversity within the project area, the scope of the project may require alteration or expansion so additional components, such as feral cat, tourism control and resource development mitigation, are developed and forms part of the project's overall goal and objectives.

Research questions

(1) What is the level of impact of cat predation on critical weight range, birds and reptiles?
    a. Complete a dietary analysis of cats in disturbed and undisturbed areas (impacted by grazing; various fire regimes).

    b. Evaluate the benefit and cost effectiveness of a cat control program in terms of likelihood of maintaining viable populations of critical weight range, birds and reptiles.

(2) How sensitive are the bioindicators selected to show effects of fire/grazing impacts on flora diversity;

(3) What is the management threshold for controlling cattle at a landscape scale where there is an acceptable level of impact on flora diversity?

(4) What are good bioindicators/sensitive species of cattle impacts?

(5) What is the optimal (range) of burn patterns and frequency to maintain vegetation structural and floristic diversity.

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GLOSSARY

Achievement = conservation achievement is the change in the state or condition of biodiversity brought about by management. It measures the outcome of conservation effort; the difference made to the state of the system, and hence the flow of biodiversity-derived benefits.

Conservation achievement monitoring is separate and distinct from project performance monitoring, which measures delivery of specific project-derived outputs and inputs, such as tracking expenditure of funding. Project monitoring determines whether project managers are meeting project milestones and are delivering outputs. Project performance monitoring doesn't allow for aggregation and therefore can't be used to measure conservation achievement, but can be used to inform *how* to achieve the desired outcome. Project performance monitoring is used to ensure accountability of agreed outputs only.

Conservation achievement monitoring is also different from project performance monitoring because it promotes accountability for delivery of outcomes (change in state and condition of systems), as well as outputs. It informs management, *where* to do *what*.

State = a combination of: species richness and/or ecosystem richness; representativeness; condition; variety, composition (e.g. dominant structuring species or population dynamics). Natural systems can be in different states over time, and these different states are separated by thresholds. Ecosystems may be in desirable or target states, or may be in undesirable states (e.g. degraded vegetation state caused by severe weed infestation).

Threshold = mark some difference between two system states. A threshold must be crossed in order for a change in state to occur.

Condition = a measure of quality and presence of sensitive and vulnerable biodiversity that isn't present in degraded systems and/or biodiversity-derived benefits, such as ecosystem services, e.g. clean water.

Pressure = a measure of various human-induced disturbances affecting the condition of biodiversity. Pressure can be a surrogate measure of condition, but an inverse factor.

Activity = an action that delivers a measurable output.

Project management system = a database that captures date and information relating to projects, and provides a retrieval system to track expenditure and output milestones.

Biodiversity Indicators = provide the basis for evaluating management effectiveness and informing or adapting future management decisions.

Tool = an 'instrument' that aids in undertaking of biodiversity management evaluation; e.g. adaptive management templates, remote sensed data trend analyses, ordination or statistical analyses of vegetation data and other data that measure spatial patterning or temporal trends in biodiveristy (Stem *et al.* 2005).

Management effectiveness = the assessment of how well biodiversity is being protected and conserved – primarily the extent to which management is protecting biodiversity and achieving goals and objectives.

Monitoring = collecting information on indicators repeatedly over time to discover trends in the status of biodiversity and the activities and processes of biodiversity management.