FINAL REPORT

THE DEVELOPMENT OF PROTOCOLS FOR THE MONITORING AND EVALUATION OF BENEFITS ARISING FROM THE WORKING FOR WATER PROGRAMME

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Executive summary

The aim of this project was to assist with the development of guidelines for an effective and efficient system for the monitoring and evaluation (M&E) of the biophysical goals of the Working for Water (WfW) programme. This report reviews (a) current international best practices for the monitoring and evaluation (M&E) of invasive alien plants; (b) M&E tools and practices currently being used and applied by the WfW programme; (c) assesses current M&E practices at project management level; and (d) provides recommendations for improving M&E within the WfW programme.

Five examples of international best practice in monitoring and evaluation systems were reviewed: (a) The Nature Conservancy's Weeds Information Management System (WIMS) (USA); (b) The Standard Operating Procedures (New Zealand); (c) The National Standards and Targets Framework (Australia); (d) The National Natural Resource Management M&E framework (Australia) and (e) The Australian Weeds of National Significance (WONS). From the review it is clear that effective monitoring and evaluation can only be achieved (i) when it is done within a framework of adaptive management which allows for continual feedback and improvement; (ii) when there are explicit standards for measurements (who, when, where, how); (iii) when there are well-defined data management protocols for data collection to ensure consistency, uniformity and repeatability; (iv) when there are quantified indicators or measures of success that are clearly linked to programme goals, objectives and activities; and (v) when the monitoring component is well resourced.

We identified six information systems that were currently being used by the WfW programme and identified their potential contribution to M&E within the WfW programme. These are (a) Working for Water's Information Management System (WIMS) which is the primary source of information for M&E for the programme; (b) The WfW Self-assessment Standards; (c) The Southern African Plant Invaders Atlas (SAPIA); (d) The National Invasive Alien Plant Survey (NIAPS); (e) Remote sensing tools to determine evaporation rates; and (f) Periodic assessments by means of research projects.

WIMS is currently used to report on the areas treated based on contract records. It captures the necessary information but lacks the tools to assess the impact of control operations on species composition and density. It also does not integrate the current M&E quality control assessments that WfW's Self-Assessment Standards require the managers to record. SAPIA can act as an early warning system to the WfW programme

as it reports on new invasions by existing species, and new species invading. A formal procedure needs to be established to ensure that WfW receives this information and responds to it until the SANBI-developed early warning system is established. When completed, the NIAPS will provide an adequate baseline for quantifying the progress made by the WfW programme, both to date and as the basis for future assessments. If the remote sensing of evaporation project proves successful, it will provide large scale estimates of the impacts of the WfW programme on evaporation, and consequently, the changes in streamflow. Research projects have made, and will continue to make, a significant contribution to the assessment of various aspects of the WfW programme. The Threshold of Potential Concern (TPC) approach used in the Kruger National Park is a good example of the types of measurable objectives that WfW should adopt in implementing the adaptive management approach.

The most critical weakness in the current WfW M&E approach is the lack of specific, measurable, achievable, relevant, time-based objectives which can be used to evaluate progress towards the goals set out in the Strategic Plan. We recommend that WfW managers establish these as soon as possible in line with the adaptive management approach. We propose improvements to their Strategic Plan, Logic Model, Management Plans, contract management and WIMS. In addition, a set of minimum indicators is proposed including the (i) extent of the area treated; (ii) reduction in the degree of invasion; (iii) impact on water resources; and (iv) rate of ecosystem recovery. In conclusion, we recommend some priority actions for WfW including: the development of measurable objectives, addition of new M&E facilities to the WIMS database, taking fixed point photographs of contracted areas, filling their vacant M&E posts, establishment of a baseline and the selection and establishment of permanent monitoring sites.

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1. INTRODUCTION

This report reviews the background to Monitoring and Evaluation (M&E) insofar as it applies to invasive alien plant management in South Africa and makes proposals for the implementation of a system in the Working for Water programme (here-after referred to as the WfW programme). The CSIR's brief was to assist with the development of guidelines for an effective and efficient system for the monitoring and evaluation of the biophysical goals of the WfW programme. This project was undertaken in terms of the Memorandum of Agreement for collaboration between the Department of Water Affairs and Forestry, and the CSIR.

1.1. Background

The WfW programme needs to develop and implement a monitoring and evaluation system for a number of reasons. These include:

- The need to accurately account for public funds expended, especially with regard to the intended benefits of improved ecosystem services;
- The need to assess the degree to which the goals of the programme are being met;
- The need to evaluate priorities and approaches to management in the light of the achievement (or not) of stated goals; and
- The need to adjust management approaches, goals and policies in response to improved understanding (adaptive management).

Currently, the monitoring and evaluation framework within the programme is weak. Basic data on expenses and areas cleared have only been collected in the WaterWorks (or Working for Water Information Management System (WIMS)) database since 2003. This database contains information on all clearing contracts including species composition and density, areas cleared and follow-up treatments as well as records of the people who have worked on the Programme and training received. This dataset is used to provide a monthly analysis of progress relative to the Programme's Key Performance Indicators. The WfW programme also supports the maintenance of the South African Plant Invaders Atlas (SAPIA) database, which provides information about the distribution of invasive

alien plants in South Africa. However, these datasets do not address all of the monitoring and evaluation needs of the programme. For example, they do not supply information that would allow for the assessment of the effectiveness of control operations, recovery of the invaded ecosystems (e.g. biodiversity), reductions in impacts (e.g. delivery of ecosystem services), or on overall progress towards achieving control of invasive alien plant species.

An external evaluation of the WfW programme in 2002/03 by Common Ground Consulting recommended that it needed a more comprehensive monitoring and evaluation programme. A monitoring and evaluation unit was set up in the national office, but there have been difficulties in retaining the staff resulting in delays in the development of appropriate approaches to monitoring and evaluation.

1.2. Project Terms of Reference

The initial terms of reference were:

- "To assess current monitoring and evaluation methods that relate to the biophysical aspects of the programme and their effectiveness;
- To review existing global best practice for monitoring and evaluation of invasive alien clearing programmes; and
- To develop a M&E framework for the WfW Programme."

At a meeting with WfW Managers in Cape Town on 22 August 2007 it was agreed that the project should also address capacity and commitment to solve IAP problems within the WfW Programme.

1.3. Project reference group

A project reference group was appointed at the onset of the project with the following members:

Mr Andrew Wannenburg (WfW Programme)
Dr Helen de Klerk (CapeNature)

Prof. Karen Esler (Department of Conservation Biology & Entomology, Stellenbosch University)
Mr Ahmed Khan (WfW Programme)

Two reference group meetings were held, an inaugural meeting in June 2007 and a project progress meeting in January 2008.

1.4. Documents consulted

The project team consulted a number of WfW's strategic and operational documents to inform this project. We have summarised the key elements of these documents below.

(a) Working for Water's Strategic Plan (2008-2012)

The Strategic Plan sets out the goals of the WfW Programme which are divided into socio-economic goals and goals on natural resource management. This project focuses on developing approaches for monitoring and evaluating the latter goals of the WfW Programme. There are three goals for natural resource management:

Goal 1: Prevent new Invasive Alien Plant (IAP) problems;

Goal 2: Reduce the impact of existing priority IAP problems and

Goal 3: Enhance the capacity and commitment to solve IAP problems.

The Strategic Plan also includes a Logic Model that sets out how the planned activities will produce outputs that lead to outcomes and, ultimately, the achievement of desired objectives. The section of the Logic Model relating to natural resources management has been included below and shows the goals and a set of inputs, activities, outputs and outcomes that are intended to meet the objectives (impacts).

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4 Logic Model: Natural Resources Management

Goals:

a) Prevent **new** IAP problems
b) Reduce the impact of **existing** priority IAP problems
c) Enhance the **capacity and commitment** to solve IAP problems

INPUTS Financial, human and material resources	**ACTIVITIES** Tasks personnel undertake to transform inputs to outputs	**OUTPUTS** Products and services produced	**OUTCOMES** Intermediate effects of outputs on clients	**OBJECTIVES (IMPACTS)** Long-term, widespread improvement in society
Strategic Partnerships Co-ordinator	Meetings?	1. DoA quarantine & screening research? 2. Nursery Partnership 3. Pet Trade Industry Partnership	New species with invasive potential are not released	Assist with preventing the introduction of **new** plant species with invasive potential
1. Strategic Planning Manager 2. Emerging Weeds, Waterweed & Restoration Co-ordinator	1. Establish a nationally co-ordinated emerging IAP alert and early warning system that includes effective surveillance mechanisms 2. Develop and implement a nationally agreed emerging IAP response plan for eradication or containment	1. Southern African Plant Invaders Atlas (SAPIA) Phase II Project 2. Emerging weeds strategy	1. IAPs are detected at an early stage of establishment 2. New IAP incursions are identified and addressed	Ensure early detection of, and rapid response to, **emerging** IAPs
Strategic Planning Manager	1. Determine distribution and densities of IAPs quantifiable by remote sensing 2. Determine the distribution and densities of IAPs not quantifiable by remote sensing, using a stratified-random sampling approach with expert observers based in ultralight aircraft platforms	National Invasive Alien Plant Survey (NIAPS) research project	IAPs are surveyed for management action	**Survey** IAPs
Strategic Planning Manager	1. Select appropriate criteria for the ranking of IAPs 2. Host expert workshops to complete pair-wise comparisons of IAPs, using the selected criteria. 3. Develop strategies and action plans for priority IAPs	Prioritisation research project	IAPs are prioritized for management action	**Prioritise** IAPs
1. Strategic Planning Manager 2. PES Co-ordinator	1. Select appropriate criteria for the ranking of areas	1. Prioritisation research project 2. PES research (e.g. Blue Ridge Mine)	1. Optimised productive potential of land in terms of the	Develop and implement **site-led** approaches to managing IAP threats that

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3. Emerging Weeds, Waterweed & Restoration Co-ordinator	2. Host expert workshops to complete pair-wise comparisons of areas, using the selected criteria. 3. Develop strategies and action plans for priority areas	3. Water pricing strategy 4. Restoration (e.g. St Francis Thatch Reed project, Subtropical Thicket Rehabilitation project, Riparian restoration project) 5. Conflict-of-interest species (Qolora Woodlot Project)	mandate of the Department of Agriculture, including: rangeland, soil erosion, soil quality, nutrient cycles, natural resource harvesting. 2. Enhanced delivery of ecosystem services and environmental security in terms of the mandate of the Department of Environmental Affairs and Tourism, including: species diversity, ecological functioning of natural systems, regulation of invasive alien plants on transformed land, fire, carbon sequestration, non-consumptive value (eg, tourism, existence value). 3. Optimised water security in terms of the mandate of the Department of Water Affairs and Forestry, including: yield, ecological reserve and in-stream flow requirements, groundwater, flood control, siltation of dams, ecological functioning of estuaries, water quality (turbidity, temperature, eutrophication), damage by invasive alien plants to river banks, structures, and other impacts, impact on fresh-water biodiversity	protect key assets & values
1. Communication Co-ordinator 2. Education Co-ordinator 3. Research & Policy Development Co-ordinator	1. Develop and implement a national plan for communicating with stakeholders and engaging them in IAP management 2. Develop and implement nationally consistent and targeted weed awareness activities 3. Provide ready access to high-quality IAP identification and management information 4. Develop and implement targeted incentive programmes	1. Communication & education strategy 2. Private landowner incentives & disincentives schemes (see WfW ExCo Policy)	1. Stakeholder base is increased and stakeholder awareness of and action on IAP problems is improved 2. Greater awareness of the impacts of IAPs and motivation to act 3. Decisions are based on the best information available 4. IAP management efforts are increased	**Raise awareness and motivation** to strengthen commitment to act on IAP problems
1. Research & Policy Development Co-ordinator	1. Prioritise IAP research needs and identify and facilitate programmes to	1. Research collaboration agreements with WRC, ARC, CSIR, SANBI	1. Research on IAPs is undertaken based on priority	**Build capacity** to address IAP problems and improve management

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2. Biocontrol Research Co-ordinator 3. Value-added Industries Co-ordinator 4. Training Co-ordinator 5. Health & Safety Co-ordinator	develop new approaches 2. Strengthen collaboration between research institutes, industry and government on weed research issues 3. Develop improved management practices and promote their adoption	2. Integrated control (i.e. mechanical, chemical, biological, utilization, cultural, grazing, burning) 3. Training 4. Health & Safety 5. Value-added industries (e.g. Eco-Coffins)	needs 2. Improved IAP management is achieved through increased knowledge and new techniques 3. Collaborative and co-ordinated IAP research is undertaken 4. IAP impacts are reduced through improved management practices	
1. WfW ExCo Chair 2. Director: Working for Water	1. Establish nationally consistent legislation to address IAP problems 2. Lead and co-ordinate the implementation of this Strategy 3. Develop and implement national plans for managing priority IAPs	1. NEMBA Regulations 2. CARA Regulations 3. National strategy 4. National & provincial government EMPs/EIPs 5. Municipal IDPs 6. Protected Area plans	1. IAP legislation is nationally consistent 2. The strategy is effectively implemented 3. Priority IAPs and areas are subject to co-ordinated national action	Manage IAPs with **consistent** policy, legislative and planning frameworks
1. M&E Co-ordinator 2. Information systems officer 3. Regional compliance managers	1. Develop goals of management at both national and provincial (or biome) levels. 2. Develop a minimum set of indicators to underpin a monitoring programme. 3. Identify a representative set of sites to be monitored. 4. Develop a plan for the regular assessment of indicators	1. M&E research project 2. WIMS 3. Self-assessment standards	1. Accurate accounting of public funds expended, especially with regard to the intended benefits of improved ecosystem services 2. Degree to which the goals of the programme are being met assessed 3. Priorities and approaches to management evaluated in the light of the achievement of stated goals 4. Management approaches, goals and policies adjusted in response to improved understanding (adaptive management)	**Monitor and evaluate** the progress of the IAP management effort

(b) Working for Water self assessment standards (Version 2)

This document was derived from a set of operational procedures and checks developed by the forestry industry for its clearing operations. It is described in more detail in Section 3.2.2

(c) Management Unit Clearing Plans

The team was provided with one example of a Management Unit Clearing Plan which was for the Mthatha River Basin in the Eastern Cape. This plan contains detailed data and maps of the current invasions and a 10 year plan for prioritising control operations.

(d) Monthly Key Performance Indicators (KPIs)

We were also provided with a set of the monthly KPIs which the WfW programme uses in its current performance evaluations. The specific example was for the Free State region for the 2007/08 year. There currently are more than 70 KPIs grouped into 12 categories with most of them focussed on costs and human resource information. There are three groups that deal with natural resource management and address the areas treated and whether or not the actual areas treated match the areas planned in the annual plan of operations. Only one KPI requires the manager to confirm that treated areas have in fact been cleared. There is a set of additional indicators which require the manager to report on the area rehabilitated and the amount spent on rehabilitation. The sample spreadsheet made available to us contained an even longer list of KPIs called the “new format” which include requirements for the managers to explain deviations from their planned progress.

1.5. Project structure

The project was conducted over 12 months from the date that the contract was signed. The work was divided into four distinct tasks:

Task 1. Complete a review of international best practice relating to monitoring and evaluation of invasive alien plant species, and of control and rehabilitation projects (Section 2);

Task 2. Review existing monitoring tools available, assess their use and usefulness and identify gaps (Section 3);

Task 3. Develop a Monitoring and Evaluation Framework with clear goals and objectives. The rationale here was that monitoring and evaluation must be carried out within a framework of clear goals and objectives. Develop a minimum set of indicators to underpin a monitoring programme. Where necessary, identify a representative set of sites to be monitored. Develop a plan for the regular assessment of indicators (Section 4); and

Task 4. Produce a detailed report outlining the findings and recommendations.

2. REVIEW OF BEST PRACTICE

2.1. INTRODUCTION

The aim of this chapter is to provide an overview of best practice, nationally and internationally in the monitoring and evaluation of invasive alien plant management programmes.

Alien invasive species have numerous deleterious effects on the environment (summarised by Macdonald et al. 1996), and require effective management and control if the effects are to be avoided. Successful management of invasive weeds requires a systematic and strategic approach and includes active attempts to prevent new introductions, vigilant detection of nascent populations and persistent efforts to eradicate the worst invaders (Rejmanek, 2000; Clout & Veitch, 2002). Successful control of pest species depends on proper planning, a commitment to complete, putting the entire population of the target species at risk, removing them faster than they reproduce, and preventing re-invasion (Bomford & O' Brien 1995 in Clout & Veitch, 2002).

Organisations that undertake alien clearing should have an effective implementation plan or programme in place to ascertain whether clearing efforts have been successful or whether they have failed. The plan must therefore contain clear and concise goals with supporting and measurable objectives to ascertain if it is achieving

short and long-term goals. A well thought-out and thorough monitoring and evaluation system underpins future policy and management decisions and assists in targeting funding at a national or even international scale. Decision-makers and funding bodies need reliable and accurate information which addresses their needs when making decisions. Monitoring and evaluation programmes must always be designed top-down, beginning with the information needed to guide decisions, a sound understanding of the background and knowledge of the end users. The top-down requirements must then be balanced with the bottom-up realties of the resources and skills of the people who will collect the data, of the type and replicability of data and the and cost effectiveness of the monitoring programme.

The purpose of the review of best practice is:

- to establish what M&E techniques exist, insofar as they pertain to alien plant control programmes; and
- to identify which techniques, if any, would be of use to the WfW programme.

2.2. EFFECTIVE MONITORING AND EVALUATION

Management of complex problems such as invasive alien plants cannot be effective if it is not based on well-designed monitoring and evaluation systems which give managers appropriate feedback which enables them to improve (Brougham et al. 2006). Monitoring and evaluation entails using a set of indicators to measure progress towards achieving programmatic goals, objectives, activities and management processes (Roux, 2006).

2.2.1. What is Monitoring and Evaluation?

There are various definitions of monitoring, depending on the context in which it is used (UNICEF, 2002; Hurford & Schneider, 2006, Hellawell, 1991). The definition which we find most applicable to this study is the definition based on Hellawell (1991):

"*Regular surveys/observations carried out in order to assess compliance with a predetermined standard or the degree of variation from an expected norm*."

Evaluation is derived from a Latin word which means to "*ascertain the value or worth of*." We use the definition as proposed by UNICEF (2002):

"*Evaluation is a process which attempts to determine as systematically and objectively as possible the relevance, effectiveness, efficiency and impact of activities in the light of specified objectives*".

2.2.2. The relationship between monitoring and evaluation

Both monitoring and evaluation are management tools. In the case of monitoring, information for tracking progress according to previously agreed on plans and schedules is routinely gathered. Monitoring is the continuous observation of an activity and aims to identify the need for corrective action by measuring change (input, output, processes, instruments) over time (Table 2.1). Monitoring is an extremely important part of an invasive alien species management plan. Information gathered through the monitoring process will enable managers to adjust their weed management plan to adapt to changes to treated areas, and improve future outcomes. Collecting meaningful monitoring data ensures your results can be used to develop and improve best-practice guidelines for management (Brougham et al. 2006).

Evaluation on the other hand is preoccupied with the interpretation of monitoring data, the attempt to discern, explain and assess change patterns and their causes (Table 2.1). Evaluation typically happens at more than one level. There is the immediate evaluation of the data from a set of measurements executed as part of a monitoring programme. The level above this may involve asking questions about whether the measurement techniques are appropriate, or whether the data from those measurements really provide the information the manager needs. A level above this may address the question of whether the goals and objectives of the activity are appropriate. Evaluations at these "higher" levels typically occur less frequently. Evaluation always focuses on specific questions related to effectiveness and impact in order to identify discrepancies between actual and planned implementation and corrective actions taken.

Table 2.1: Complimentarity and differences between monitoring and evaluation (CHE, 2004)

	Monitoring	**Evaluation**
Purpose	Adjust implementation; identify necessary actions	Effectiveness/Impact analysis; policy adjustment
Main Action	Keeping track (of trends and progress)	Assessment; compares plan and achievement
Focus	Inputs; outputs; processes; instruments (actions)	Outputs *vs* inputs; process *vs* results; results *vs* costs; impact; relevance to values
Data sources	Management information systems; progress reports	Monitoring data; case studies and surveys
Undertaken by	Implementing agencies, social actors	Evaluations on behalf of implementing agencies; social actors
Frequency	Continuous	Periodic

Monitoring activities in themselves will not contribute positively to the management of invasive aliens, unless they are coupled with a management process which compels the managers to respond to the issues, successes and shortcomings it identifies. This approach to management is commonly termed adaptive management.

2.3. ADAPTIVE MANAGEMENT

Traditionally, M&E efforts focussed on identifying indicators of conservation impact. Lately, the trend has shifted towards more comprehensive M&E approaches which are characterised by an emphasis on learning, measuring effectiveness, adapting and improving programmes (Stem *et al*., 2003). Monitoring and Evaluation is therefore most effective when undertaken in the context of a complete process, called adaptive management. The latter is “a way of incorporating reflection into action- to enhance the practice of conservation and learning” (Berkes and Folke 1998). The outcomes of management interventions are routinely measured, and management policies, guidelines and activities are adapted as knowledge about the ecosystem and its responses to intervention increases (Figure 2.1). Adaptive management incorporates research into conservation action and involves the

integration of design, management and monitoring to systematically test assumptions in order to adapt and learn (Salafsky and Margolius, 2003). It is in other words a process that links indicators to project goals, objectives and management activities as opposed to considering indicators on their own. The main advantage of this approach is that it emphasises the learning aspect of monitoring and evaluation. This implies that managers must be allowed to make mistakes, learn from them and improve. Thus they need to be willing to change, not too over-burdened to take the time to learn, and they must see willingness to change as being as important as action (Stem et al. 2005).

An important application of adaptive management is to improve the quality of goals and objectives that guide management. It is important to revisit goals and objectives regularly to determine if they are appropriate or need to be revised to make them more clearly defined, measurable, and useful for future management purposes (Pomeroy, 2004). In addition, indicators of success should be clearly linked to programme goals, objectives and activities. Only when managers recognise shortcomings in the cycle can they make adjustments that will, if correctly addressed, ultimately lead to more effective conservation action taking place.

Adaptive management comprises the following key steps (after Salafsky and Margolius, 2003; Figure 2.1):

- *"Establish a clear and common purpose, which includes defining a clear operational objective for the project that should be worked towards;*
- *Design an explicit model in order to understand the cultural, social, economic and political systems that influence the behaviour of the many stakeholders at the project site (stakeholder dialogues might prove to be a useful tool here);*
- *Develop a management plan that maximises results and learning by outlining the factors that need to be affected and the specific actions that need to be taken to change them;*
- *Develop a monitoring plan to test assumptions and collect only the data needed to test these assumptions;*
- *Implement the management and monitoring plans;*
- *Analyse data and communicate results in order to transform raw data into usable information; and*
- *Use the results to adapt and learn by improving management policies and practices and communicating the changes to key audiences."*

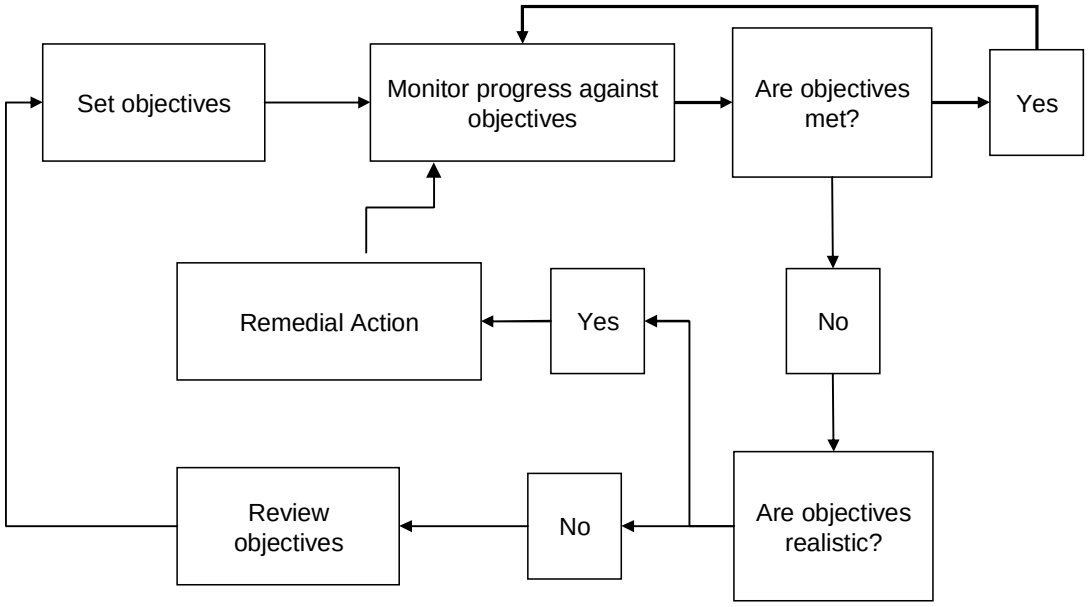

Figure 2.1: Adaptive Management: How the monitoring of "progress against objectives" can be used to prompt remedial action or to review objectives to set more realistic ones if necessary.

2.4. What are the requirements of a good monitoring programme?

There is no cookbook recipe for the success and effectiveness of long-term monitoring programmes (Legg and Nagy 2006). Strayer (1986) emphasised the importance of a simple and accommodating design in which the essential measurements and experimental treatments should be straightforward and unambiguously repeatable even by staff lacking sophisticated training. Several authors have recently enumerated the key criteria a monitoring programme must meet if it is to be effective (Box 2.1).

Box 2.1: Criteria for good management of a monitoring programme (Legg and Nagy, 2006, adapted from Stohlgren, 1995, Stewart et al., 1989 and Hirst, 1983)

• secure long-term funding and commitment;
• develop flexible goals;
• refine objectives;
• pay adequate attention to information management;
• train personnel and ensure commitment to careful data collection;
• detail locations, objectives, methods and recording protocols in the establishment report;
• obtain peer review and statistical review of research proposals and publications;
• obtain periodic research programme evaluation and adjust sampling frequency and methodology accordingly and
• develop an extensive outreach programme.

It is critical that managers consider these issues thoroughly before commencing the monitoring and evaluation assessment and determine whether the proposed assessment will achieve the desired outcomes. The questions that need to be addressed include (Ervin 2006):

- "*What are the specific objectives of conducting the assessment?*
- *How will the information be used and by whom?*
- *Who will participate in the process?*
- *How will the results be communicated?*
- *What resources are available for conducting the assessment?*
- *Who will be responsible for coordinating and undertaking the assessment?*
- *What is the time frame for completion?*
- *What are the follow-up steps planned after the assessment is completed?"*

Field et al. (2007) group the general problems associated with monitoring under three broad headings: (i) funding; (ii) objectives and (iii) sampling design. Funding should be seen as covering more than just the financial resources; it includes the personnel, skills, equipment for measurement and data capture and software for data analysis and to maintain the monitoring programme.

(i) Funding

In terms of funding, the commitment needs to be sufficiently long-term to allow a change to be detected over and above the natural temporal fluctuations in the system in question. It is suggested that a minimum of years is more likely to show significant change and that 10 years is a sensible minimum target for most ecological monitoring programmes.

(ii) Objectives

A monitoring programme cannot possibly succeed without a clear articulation of what success would mean. This entails choosing a suitable variable(s) to represent the change of interest, and specifying what degree of change (effect size) would be considered sufficient to trigger a management response.

(iii) Sampling design

The most fundamental requirement of the sampling design is that it should be capable of detecting that change if it actually occurs, that is, that it will yield adequate statistical power. This entails not only obtaining a sufficient sample size, but also setting an ecologically appropriate level of power as a target. Another neglected issue in sampling design is that it should be approached with learning and improvement explicitly in mind, that is, it should be experimental and highly adaptable. Early results should be analysed promptly and, if they point to deficiencies, used to refine the sampling regime so that it becomes progressively more efficient (Field et al. 2007).

Field et al. (2007) identify three ways to make monitoring more useful: (i) Trade-off statistical significance in return for statistical power; (ii) Estimate how long would be required to obtain adequate statistical power and (iii) Analyse data promptly and use it to refine the monitoring design.

Few monitoring programmes pay sufficient attention to the details of hypothesis formulation, survey design, data quality and statistical power at the start. There is, therefore, a high probability that most monitoring will fail to reach the necessary standard of being capable of rejecting a false null hypothesis with reasonable power. It is the responsibility of the organisation that commissions the monitoring to ensure that a high standard is maintained. ‘When planning budgets, managers should either give scientists sufficient funds and time to carry out a high power test of the null

hypothesis, or not fund them at all' (Peterman, 1990a,b).

2.5. MONITORING & EVALUATION PROGRAMMES FOR INVASIVE ALIEN SPECIES CONTROL

The effectiveness of invasive alien plant control operations cannot be assessed without a monitoring and evaluation programme. The true measure of success of control is not just the removal of the invaders, but includes the response of the species, habitat, ecosystem or landscape to the control operations. The relationship between the density and species composition of the invaders and their impacts is rarely a simple one. It can be quite difficult to identify and adequately monitor the appropriate measures of success, but it is essential to determine whether the goal of preventing biodiversity losses is being achieved (Shine et al. 2000).

The following section gives examples of international monitoring and evaluation systems that have been identified in the review. We focus on the following countries: Australia, New Zealand and the United States of America, including Florida and Hawaii.

2.5.1. Australia

Prevention and early intervention are the most cost effective means of dealing with potential, new and emerging weeds in Australia (Weeds CRC, 2007). The National Weed Detection Project was launched in 2006 under the auspices of the Cooperative Research Centre for Australian Weed Management to develop and test a community-based weed alert system.

The Natural Resource Management Ministerial Council was established to develop a coordinated approach to issues affecting natural resource management in Australia (DAFF, 2007). Governments of all states and territories as well as the Australian Government are represented on the council. The council has two national documents to assist with monitoring, evaluation and reporting on natural resource management and these are reviewed briefly below.

(a) National Standards and Targets Framework

The National Standards and Targets Framework sets out the national outcomes that investment in natural resource management should aim to achieve (National Framework, 2003b). The framework sets out eight aspirational outcome statements, three of which have direct relevance to the issue of invasive alien species and their management:

- "Biodiversity and the extent, diversity and condition of native ecosystems are maintained or rehabilitated.
- Populations of significant species and ecological communities are maintained or rehabilitated.
- Ecosystem services and functions are maintained or rehabilitated."

Indeed, "ecologically significant invasive species" appears as one of the ten "matters for targets" - a list designed to assist with the natural resource planning and investment needed to deliver the outcomes.

(b) National Natural Resource Management Monitoring and Evaluation Framework (National Framework)

The National Framework is based on a nationally agreed set of principles for the monitoring, evaluation and reporting on natural resource condition (National Framework, 2003a).

The framework recommends that a set of indicators that can operate through a range of spatial and temporal scales is used. Indicators are units of information that are measured and reported on in an evaluation and allow users to document changes to specific attributes of an entity of interest over time (Barber et al., 2004; Pomeroy et al., 2004). Indicators that have been developed under the framework fall into three categories:

(a) resource condition (e.g. extent and impact of selected ecologically significant invasive plant species)

(b) management action (e.g. adoption of improved management practices) and

(c) social and economic (e.g. effectiveness of information networks).

It is recommended that indicators should be:

- simple (easily interpreted and monitored);
- measurable (statistically verifiable, reproducible and show trends);

- accessible (regularly monitored, cost effective and consistent);
- relevant (directly address the objectives of the relevant programme); and
- timely (provide early warning of potential problems).

The framework emphasises the need for a consistent approach to data handling and management. Under the framework, data should be collected once, with the aim of using it to support many activities. The data infrastructure required to support the framework ensures that users can obtain the data and that users can easily enquire whether suitable data already exist (data are stored in the Australian Spatial Data Directory). The infrastructure also supports meaningful interpretation of data over time by establishing standard national indicators, protocols for their sampling, measurement and interpretation. All these serve to minimise cost and increase efficiency. The National Land and Water Resources Audit (NLWRA) is responsible for coordinating consistent data collection, management and assessment.

A protocol for data collection and management is provided within the National Framework (Box 2.2).

Box 2.2: Proposed Structure of Data Protocol (National Framework, 2003a)

Indicator name

1. Definition
2. Rationale
    - 2.1.1 Monitoring location selection (scale)
    - 2.1.2 Why do we want to know it? i.e. rationale for measuring it
    - 2.1.3 Context in which it is being measured with regard to national, state and regional resource management programs.
3. Monitoring Methodology
    - 3.1 Monitoring location selection (scale)
    - 3.2 Monitoring frequency required
    - 3.3 Data measurement method
    - 3.4 Data collation/calculation method
    - 3.5 Data analysis and interpretation
    - 3.6 Robustness or quality assurance
4. Reporting Products
5. Current Monitoring and Reporting Products
    - 5.1 Monitoring location selection (scale)
    - 5.2 Monitoring frequency required
    - 5.3 Data measurement method
    - 5.4 Data collation/calculation method
    - 5.5 Data analysis and interpretation
    - 5.6 Robustness or quality assurance
6. Proposed Responsibilities
    - 6.1 Data collection (i.e. 3.1-3.3)
    - 6.2 Data collation (i.e. 3.4)
    - 6.3 Data analysis and interpretation (i.e. 3.5)
    - 6.4 Generation of reporting products (i.e. 4)
    - 6.5 Data storage and management
        - 6.5.1 sub-regional data collection and collation
7. Future development
8. Links to other indicators
9. Further information

A number of inadequacies have been identified in the National Framework which affect its ability to rigorously document ecological change (Field et al. 2007), notably problems in securing long term funding, the programme design and data analysis protocols. Many of these problems are due to different sectors adopting different approaches to monitoring including: using short-term ecological field experiments which are incapable of demonstrating trends; many organisations use designs that lack scientific rigour and produce low to medium quality data. They emphasise the need to change to a culture of promptly and rigorously analysing data and using the results to both leverage further funding and inform future sampling.

There is no generally accepted way of evaluating weed management projects across Australia, so it is difficult to assess the effectiveness of the various programmes. Martin & Grice (2006), Panetta & Lawes (2005) and Panetta (2007) suggest criteria by which progress towards the objective of eradicating weeds can be evaluated:

- the delimitation criterion which relates to the degree of knowledge of the total extent of a weed invasion;
- the containment criterion relating to the prevention of further spread of an invasion; and
- the extinction criterion i.e. the elimination of individual infestations.

(c) Weeds of National Significance

Australia needed an approach for prioritising weeds that occur in a range of land uses, affect many land-owners and fall under the jurisdiction of a variety of management agencies. This led them to the idea of developing a meaningful set of indicators on which to base future weed decision-making and a framework for prioritising weed management at the state, regional and local levels. They identified 20 plant species as Weeds of National Significance (WONS), based on their invasiveness, potential for spread and environmental and economic impacts (Thorp and Lynch 2000). These include Boneseed (*Chrysanthemoides monilifera* ssp. *monilifera*), Lantana (*Lantana camara*) and Mesquite (*Prosopis* spp.). The Department of Natural Resources and Water developed manuals on control and management for each of these weeds. The section below summarises the monitoring practices proposed in these manuals.

The development of a weed management plan involves a number of steps as indicated below (Brougham et al. 2006):

"Step 1: "Site assessment to help plan weed control activities

Step 2: Set goals that focus on what needs to be protected and restored, rather than on weed control alone

Step 3: Prioritise areas for control, beginning with areas of highest conservation value

Step 4: Develop a control plan to determine the best control methods for initial and follow-up treatments. Establish a long-term plan and schedule control and follow-up activities. Include time for monitoring in an annual timetable.

Step 5: Monitor progress to:

- *Assess the effectiveness of control measures*
- *Assess the rate of establishment of desirable vegetation*
- *Identify new weed infestations*
- *Identify any new issues that will affect the control program and*
- *Demonstrate progress to the group or funding body"*

Step 5 is described here because it is directly relevant to this review. There are many different methods of recording progress and monitoring the success of control over time. These include a map of the property or site, 'before and after' photographs (also known as photopoints) or quantitative measures such as density or cover. The choice of a suitable method depends on the resources available, the expertise of the people carrying out the monitoring, the questions that need to be answered, and the intended audience. For example, photopoints can be used to demonstrate the native regeneration following control to the wider community. In addition, plot transects can be used to monitor the number of plants which can then be used to present qualitative data on control activities to the funding organisation. Additional methods to monitor progress are described in Appendix 1.

Monitoring needs to be done at a similar time of year and in a consistent manner to ensure that valid comparisons can be made. It needs to be incorporated into the annual activity timetable. Monitoring can be combined with follow-up operations. A site diary is useful for documenting activities undertaken, as well as observations about seasonal conditions or other factors that may influence the results of the control program. Recording the cost of control is important for evaluating the cost-effectiveness of different methods and to stay within budget.

2.5.2. New Zealand

New Zealand's Biosecurity Act of 1993 provides for the eradication and effective management of harmful organisms including pest plants (Ikuma, et al., 2002). This Act has enabled local governments in New Zealand to pursue the eradication of 69 different invasive plant taxa. It allows for the mandatory control of pest plants in the road corridors by local governments. The Act has a strong emphasis on specific management objectives, annual plans and performance measures, but data to support meaningful eradication performance measures are still rare despite these requirements (Holloran 2006).

Biosecurity programme

Holloran (2006) states that evaluating trends in site status (whether above-ground plants are present or absent) and site population size (based on complete censuses) may help biosecurity staff to evaluate progress, improve eradication efforts and communicate their successes. He illustrates these performance measures using a seven-year dataset from the eradication efforts of the New Zealand Department of Conservation on Raoul Island[1] that targets seven species across more than 3400 sites. An Access database implemented in 1997 contains the date and number of individuals (separated by age class) for every site visit. The database is essentially a spreadsheet containing six columns: species, infestation, seedling population size, adolescent population size, mature population size and date (Holloran 2006).

Sites with plants visible above-ground at any point during a given year were classed as "active". Sites with no plants during a given year were classed as under "Surveillance", although they were not marked as Surveillance until a second year had passed with no evidence of plants. This approach was first used to track progress towards eradication of Class A noxious plant species (Randall 1996, Champion & Clayton 2003). The best way to present the data and assess performance is a stacked bar chart tracking changes in site status for a specific species over time along with an aggregated mean across species. Tracking the

[1] Raoul Island is located approximately 1000km northeast of New Zealand.

status of individual sites (new sites; still active, relapsed, newly eradicated) over time in a table format provides additional insights into the progress of eradication efforts (Holloran 2006).

Biosecurity New Zealand, a division of the Ministry of Agriculture and Forests, was established under the Biosecurity Act of 1993. Their lead role is to prevent unwanted pests and diseases from reaching New Zealand, and to control, manage or eradicate them should they arrive. Biosecurity New Zealand has identified a few WONS for eradication. Some of these species (water hyacinth, salvinia, Johnson grass and cape tulip) have been under national control for years, and progress is closely monitored (Ian Popay, pers comm., December 2007).

Regional pest management programmes

Biosecurity New Zealand has developed regional pest management programmes for different pest species for all the regions of New Zealand. The programmes are classified according to management objectives and have clearly defined time frames and monitoring and surveillance plans. Examples of different invasive plant management programmes with a monitoring and surveillance plan are given in Appendix 2. These illustrate the kinds of measures that the WfW programme could adopt in developing a monitoring and evaluation programme. Although it would be difficult to measure many of these aspects at a national scale, several of them may be more appropriate at the regional and project level. A major shortcoming of these pest management programmes is the lack of detail pertaining to how and when the monitoring should be carried out.

Weed Control Monitoring Standard Operating Procedure

The Weed Control Monitoring Standard Operating Procedure (SOP) contains detailed standards and specifications of how monitoring should be done. It was developed by the Department of Conservation (DOC) in New Zealand (Department of Conservation 2001). The objective of SOP is to provide relevant and robust vegetation monitoring methods for DOC staff to evaluate the results and outcomes of weed control programmes.

The SOP distinguishes between result and outcome monitoring (Department of Conservation 1999):

Result monitoring for weed control programmes involves measuring change in the abundance of weed populations over time and quantifying any non-target damage to native plant species. The long-term purpose is to evaluate whether control:

- is progressively reducing the weed population or maintaining it at a target level (for site-led programmes)
- will achieve the eradication or containment objective within 5-10 years (for weed-led programmes).

The short-term purpose is to evaluate:

- whether the result targets for the current year's control work were achieved, i.e. a percentage reduction or a "residual" target level
- whether the level of non-target damage to native plant species is acceptable.

Outcome monitoring for weed control programmes involves experimentally measuring changes in the abundance and condition of native vegetation and weed populations (over time) in relation to weed control. The purpose is to:

- evaluate whether changes in the vegetation can be attributed to the weed control (as opposed to other factors)
- evaluate whether control of the weed population/s brought about the pre-defined conservation outcomes
- evaluate whether the pre-defined conservation outcomes are appropriate
- set meaningful result and outcome targets, given knowledge gained

The Standard Operating Procedure is divided into 15 modules which give practical advice and guidelines but are too extensive to include in this review (most of these modules have their own appendices, see Appendix 3).

The Standard Operating Procedure outlines:

- the process for monitoring the response of weed and native plant populations to weed control;
- the accountabilities for the various procedures involved in monitoring weed control;
- scientifically and statistically rigorous methods for collecting and analysing data;
- standards to ensure that the data collected from monitoring are reliable, comparable and that collection and analysis are repeatable;
- and includes procedures for staff to undertake their work.

The procedures mentioned above are explained as steps in great detail in the SOP. A table summarising the key points for each step is given in Appendix 4. Further details for each step with appendices can be found in the SOP document itself.

Monitoring of the spread and impact of released biocontrol agents has often been a neglected part of weed biocontrol programmes (Fowler et al., 2000). This can be attributed to the long-term nature of the ecological studies needed to demonstrate impacts of biological control. Funding agencies tend to focus on the next biological control programme rather than using funds to monitor a species that is no longer considered a serious weed (Fowler et al. 2000). The same applies in South Africa, with the exception of Acacias.

2.5.3. United States of America (USA)

There are many agencies involved in invasive species control programmes in the USA but it was difficult to obtain information on how they monitor and evaluate control programmes. The Nature Conservancy is the only one we found that had this information on a readily accessible website (http://www.nature.org/initiatives). The mission of The Nature Conservancy (TNC) is to preserve the plants, animals and natural communities that represent the diversity of life on earth by protecting the lands and waters they need to survive. Their head offices are based in the USA and most of their projects are located there.

The Nature Conservancy

The Nature Conservancy's Global Invasive Species Initiative is a network of conservation scientists and specialists who focus on invasive species management. It provides worldwide leadership by catalyzing high impact partnerships, developing policy strategies and leading research, science and innovation about invasive species and conservation. Their staff are based in offices across 50 states and over 30 countries. They work on the ground and in the water with local landowners and governments to ensure that the threat of invasive species is reduced.

The Nature Conservancy emphasises that the most cost-effective way to manage invasive species is to prevent their arrival in the first place. When invasions do occur,

detecting the invasive species when its populations are still small can dramatically change the course of the invasion. In such cases, eradicating the invasive can be easy, which allows TNC to turn their attention to preventing further invasions.

All too frequently though, detection of an invasion is not early enough, and TNC must deal with large infestations of invasive organisms. At such times, their efforts to control the invasions need to be as effective as possible. The Nature Conservancy determines the appropriate method based on best practices they have established and follow stringent guidelines to reduce any potential side effects of their efforts. They follow the adaptive management approach by setting realistic targets for control, identifying the best response and evaluating how effective their efforts have been once the plan has been implemented. This approach has led to the reduction of invasive Japanese knotweed populations by 80% over two years along the banks of the Sandy River in Oregon (http://www.nature.org/initiatives/invasivespecies).

The Nature Conservancy is addressing the threat of invasive species by:

- Providing science based solutions;
- Managing invasions and restoring habitats;
- Encouraging better business practices and
- Promoting stronger public policies.

Providing science-based solutions

The Nature Conservancy provides science-based information to inform governments' and policymakers' decision-making on combating invasive alien species. Their scientific assessments determine the extent and nature of invasions and identify which invaders must be prioritised for prevention and control. In South America they are rolling out an invasive species database developed in partnership with the Universidad del Sur in Argentina. Countries such as Chile, Paraguay, Ecuador and Brazil have adopted the database and are using it to carry out national inventories. The information gathered is providing governments with a nation-wide understanding of the impact of invasive species in their countries. The findings pave the way for new policies and legislation to combat the problem, including banning the sale of certain invasive plants.

The Conservancy is spearheading the use of new technologies such as remote sensing and satellite imagery to map the location of invasive species. Once

completed, these maps provide accurate information that allows conservationists to establish the best way to respond to invasions. These techniques are being applied in New England to assess the presence of bush honeysuckle, which spreads quickly and chokes native forests. By identifying sites of new invasions, plants can be removed before they spread further.

Remote sensing is a technology which is able to identify objects through their density; it can even distinguish between different plant species. Data taken from a distance, such as images from a satellite or an aircraft, can be used to identify particular types of plants and chart their exact location. By focusing on a specific species, conservation scientists can evaluate the presence and extent of invasions.

Monitoring and Applied Research

Biological monitoring is an essential part of TNC's conservation process. By monitoring changes in the species and habitats they are managing, they can determine whether they are making progress toward conserving these systems in the long-term. The Conservancy conducts monitoring at all of its reserves and at many of its other projects as well. The data gathered through these efforts are used in management and shared with others to add to the general body of scientific knowledge about our natural world (http://www.nature.org/initiatives/invasivespecies).

The Nature Conservancy's Weed Information Management System (WIMS)

The Nature Conservancy has long realized the need to keep better track of its weed management activities. They were motivated by the serious threat of invasive species and the lack of information systems that can successfully capture and share lessons learned from their weed inventory and control efforts. They developed a Weed Information Management System (WIMS) to assist natural resource managers in managing their weed data (http://tncweeds.ucdavis.edu/wims.html, January 2008). WIMS is a Microsoft Access-based relational database application that can be used as a stand-alone, software application on a laptop or desktop computer. It can also be used in combination with a Pocket PC handheld unit to collect field data.

Once data have been entered into the database:

- they can be easily exchanged between users as Excel spreadsheets;
- they can be exported in formats defined in the North American Weed Management Association standards;

- shapefiles (a widely used GIS data format) can be automatically produced for use in any standard GIS application programs; and
- a variety of reports can be generated.

WIMS keeps track of three types of data records: weed occurrences (GPS point locations), assessments (size and status of the weed infestation to facilitate monitoring over time), and management treatments applied to those weed infestations.

Anyone who is interested in invasive species management can use WIMS. It was initially developed for use by TNC field staff only, but there has been so much interest from their various partners that WIMS is now freely available to all interested users from the following website: http://tncweeds.ucdavis.edu/wims.html). The TNC has also produced some "model" plans for areas based on actual projects they have supported.

Hawaii

The invasion of Hawaii by alien invasive species (IAS) is cited as the greatest threat to the economy, the natural environment, as well as the health and lifestyle of the citizens (DOFAW 2002). Provisions for the control and management of IAS are made in the constitution of the state (e.g. Act 259 of 2001 and Act 85 of 2003). There is also a concerted drive to create public awareness and to involve the public in the fight against IAS, e.g. the "Keep Hawaii Pest Free" campaign, where the public is encouraged to report sightings of pest species using a dedicated toll-free number (the so-called "pest hotline"); the "report a pest"; "don't plant a pest" and the "don't pack a pest" campaigns (ISC & CGAPS, 2003). Three major groups have been formed in recent years to deal with the IAS problem, viz. Hawaii Invasive Species Council (HISC) to provide cabinet-level leadership; the Coordinating Group on Alien Pest Species (CGAPS) for inter-agency and NGO communications and collaborative projects; and the Invasive Species Committees (ISCs) for island-based rapid response (HEAR, 2007).

Monitoring in IAS management programmes used to be a problem in Hawaii (Tunison et al., 1992). Since then, tools have been put in place to alleviate this problem. For example, the Hawaiian Ecosystems at Risk (HEAR) project has a database (Hawaiian Natural Resources Monitoring Database) that contains information on invasive species and any information related to them. The "Monitoring

Database" is a software package designed as a tool for data entry and analysis for resource monitoring by land managers in Hawaii. The purpose of the Monitoring Database is to facilitate standardized and fully-documented data collection efforts by federal, state, and private agencies, thus enabling comparability of data collected by various agencies in different areas. This, in turn enhances the value of each agency's work by allowing them to compare their data to similar data collected by other agencies.

The monitoring database is designed in *Paradox* for Windows which was chosen because of its combination of ease of use for end users and flexibility of programming capabilities. Thomas (1996) gives a detailed description of how the database should be used as well as procedures for collecting field data for entry into the Monitoring Database. The section on field data collection provides practical guidelines to ensure that the data entry and analysis phases also go smoothly. This prevents the inefficiency that results from the collection of irrelevant data that cannot be analysed. A summary of the guidelines follows:

- Before going to the field: review previous data sets, use properly-prepared field data sheets, review data collection procedures
- While in the field: code data collection sheets properly
- When you return from the field prepare field data sheets for data entry.

The HEAR project does not specifically mention and evaluation component so it seems that the WIMS monitoring database is used to inform land managers about the extent of the invasive species problem as well as the effectiveness of any control operations.

Remote sensing data have also been used supplement field data when monitoring the responses to mangrove management actions (D'Iorio et al., 2007). A comparison of three widely used remote sensing technologies: Aerial photography, unsupervised ASTER multi-spectral imagery and AVIRIS hyperspectral imagery found that the second one was the most efficient and accurate option based on: (i) visual interpretation; (ii) ISODATA unsupervised classification; and (iii) Spectral Angle Mapping supervised classification. .

Monitoring of and reporting on the IAS problem is now provided for in Hawaiian legislation, where Act 259 of 2001 clearly states that "*funds be expended for the purposes of invasive species committees and that progress reports concerning the*

effectiveness, expenditure and justification for expenditure on invasive species programs be submitted to the legislature" (DOFAW, 2002).

Florida

The successful invasions of weedy plant species in southern Florida are primarily due to human acceleration of the rate of species introduction, resulting in the transplanting of hundreds of thousands of plants for use as landscape ornamentals, food sources, and medicines (La Rosa et al. 1992). Southern Florida is essentially a subtropical island, surrounded on three sides by water and to the north by temperate ecosystems, which limits the natural rate of species arrival. Southern Florida is also geologically young, with the current plant communities in existence for only the past 5,000 years (Long 1974; Watts 1975). The natural disturbances that are part of the South Florida environment allow opportunities for weedy species to become established (Myers 1975; Wade et al. 1980). Alien species are so well adapted to an altered niche that they outcompete native species (Meador 1977; Ewel et al. 1982).

Alien plants have been actively managed for the past 40 years at Everglades National Park located in south Florida. Primary control efforts have been aimed at Australian pine, Brazilian peppertree, and cajeput. The first alien plant management plan was written in 1969 and has been revised many times. A comprehensive plan for control of some alien plant species has been prepared for Everglades, and parkwide mapping for major species has been done (La Rosa et al. 1992).

Alien plant management is a program developed in response to several laws, general directives, and policies (National Park Service 1978; Everglades National Park 1982, 1983). National Park Service policy states that introduced species will be controlled or eradicated if park resources (native species, natural communities, and ecological processes) are threatened. This is always subject to funding availability. Management of alien plants was given a high priority in the Park's Resources Management Plan (Everglades National Park 1979, 1982). The management plan is developed by the Park Resources Management staff of the Ranger Division and articulated in the Everglades Exotic Plant Control Handbook (Doren and Rochefort 1983; Whiteaker and Doren 1989). The handbook establishes priorities, control methods, and guidelines.

Much of the alien plant control work is carried out by rangers in the various districts of the Park. They are guided by an annual work schedule outlined in the control

handbook. Species and known locations are prioritized within each district for control. The work effort varies among districts and years, due to other work assignments and funding. Introduced plants are placed in five categories within the handbook for management purposes; these groupings aid in assigning priority and subsequent management action (Whiteaker and Doren 1989).

In late 1987, work was initiated to conduct a systematic inventory of alien plant distribution (for cajeput, Australian pine, Brazilian pepper, and lather leaf) within Everglades National Park. The work effort produced a parkwide map of these alien plants in order to guide control work. The map was generated from interpretation of low-level false-color infra-red aerial photographs. The map also forms a baseline inventory from which future control work can be quantitatively evaluated by following changes in spatial distribution of these plants.

Alien plant management in southern Florida is a regional problem that transcends political boundaries. Alien plants range throughout the area, and even if complete eradication is accomplished within natural, protected areas, external populations will still pose a threat. Governmental agencies, conservation groups, and concerned individuals have held informal meetings to exchange information on aliens since the early 1970s (La Rosa et al. 1992).

Following several such meetings, the Exotic Plant Pest Council was formed in 1984 at Everglades National Park. The council is a multi-member task force to meet common objectives regarding management and control of alien plants. To date, over 50 groups, including local, state, and federal agencies, conservation groups, local native plant nurseries, and universities hold active memberships.

The specific functions of the Council are:

- To provide a focus for the issues and concerns regarding introduced pest plants and promote understanding of problems and possible solutions.
- To facilitate communication and exchange of information on alien plant control and management and to disseminate this information and
- To serve as an advisory panel for various interests concerned with introduced pest plants, suggest management actions and coordinate the acquisition and dispensation of funds towards mutually beneficial programs.

The program has been successful in some areas but has suffered some setbacks over the years. Successful control of alien plants will require a long-term commitment of fiscal and human resources. Long-term control can only be achieved by consistent and adequate funding and planning.

2.6. CONCLUSION

Monitoring and evaluation can only be effective when there are well-defined goals and objectives against which targets and performance can be measured. The feedback provided by an M&E system allows managers to learn from their mistakes and build on good practises to promote continual improvement. "*Through evaluation, every success and failure can be used as an opportunity for learning, and continual improvement can be combined with anticipation of future threats and opportunities"* (Barber et al., 2004). This approach to management is termed adaptive management and it is an approach that we strongly recommend that WfW adopts.

Monitoring and evaluation also needs to be done at various levels. At one level it can be used to evaluate whether a particular action was effective or not. At another level it can be used determine whether the current goals and objectives are appropriate or need to be revised to make them more clearly defined, measurable, and useful for future management purposes (Pomeroy, 2004). Monitoring and evaluation are an essential and integral part in the project and programme cycle and not an afterthought. Effective monitoring and evaluation can only be achieved when there are explicit standards for measurements (who, when, where, how) and well-defined data management protocols for data collection to ensure consistency, uniformity and repeatability. These procedures in turn, enable the data from different areas to be compared and make the data easier to interpret. Indicators or measures of success must be clearly linked to programme goals, objectives and activities. When managers are able to recognise shortcomings they will be able to make adjustments that will, if correctly executed, ultimately lead to more effective management actions.

3. REVIEW OF MONITORING & EVALUATION TOOLS CURRENTLY USED BY THE WORKING FOR WATER PROGRAMME

3.1. Introduction

The project brief specifies that the outputs must "assist with the development of guidelines for an effective and efficient system for the monitoring and evaluation of the biophysical goals of the programme". The purpose of this review is described in Task 2 of the terms of reference: "Review existing monitoring tools available (these include the WIMS database and SAPIA), assess their use and usefulness and identify gaps."

The review of the current tools takes into account the overall goals of the WfW programme in addressing whether or not the current monitoring and evaluation (M&E) tools can supply the information required to measure the achievement of those goals.

3.2. Current M&E tools used by the Working for Water Programme

We were able to identify six information systems that were currently being used by the WfW programme, to various degrees, or are being developed for future use:

- The WfW Information Management System (WIMS);
- The WfW Self-assessment Standards;
- The Southern African Plant Invaders Atlas (SAPIA);
- The National Invasive Alien Plant Survey (NIAPS);
- Remote sensing tools to determine evaporation rates; and
- Periodic assessments by means of research projects.

One of the agencies that is working closely with the WfW programme on controlling invasive plant species is the South African National Parks (SANPARKS). They use

an adaptive management approach to M&E called Strategic Adaptive Management (SAM) (Foxcroft 2004). Thresholds of Potential Concern (TPCs) form the basis of an inductive approach to SAM because they are invariably hypotheses of limits of acceptable change in ecosystem structure, function, and composition (Rogers 2003). Thresholds of Potential Concern were developed and applied to the entire biophysical management program in the Kruger National Park. This approach is, apparently, not yet used in any other national parks. Each of the systems and the Strategic Adaptive Management approach are briefly described below.

3.2.1. Working for Water Information Management System (WIMS)

A major achievement of the WfW Programme has been the development and implementation of a contract and project-based planning system, based on GIS mapping and geo-referencing, called the WfW Information Management System (WIMS) (Common Ground 2003).

WIMS was piloted in KwaZulu-Natal, Mpumalanga, North-West and Gauteng in 1999. Thereafter it was extended to all nine provinces by 2002/03. The Western Cape was added in 2000 and Limpopo and Northern Cape in 2001. Data for all national parks were collected separately from 2002, as was information from the Eastern Cape, Free State and Northern Cape. The records are complete and up-to-date except for certain provinces where there still is some backlog. This is a considerable improvement on the situation in 2002/03 financial year when the percentage of expenditure accounted for ranged from 48% to 100% depending on the province (Marias et al. 2004).

Data recorded in WIMS

All clearing projects in the WfW programme are run as contracts, and the project or contract information is captured on WIMS. The following information is recorded for the area defined for each contract:

- the spatial unit (polygon) associated with each treatment contract is allocated a WIMS treatment area identity number (13 digits) which includes the NBAL (Natural Biological Alien Land-cover attribute) code; the NBAL code is derived from the quaternary catchment in which it is situated (a quaternary is

a 4th order catchment and the naming and boundaries follow those used in the WR90 study (Midgley *et al.* 1994);

- the species present;
- the density class for each species; seven density classes are used, based on aerial canopy cover; the classes are: 0.1–1%, 1–5%, 5–25%, 25–50%, 50–75% and 75–100%;
- the area to be treated (which is captured spatially at a scale of roughly 1:50 000 to 1:10 000);
- the workload is automatically calculated from established norms which are based on the species composition and density of the invasion and the characteristics of the area to be cleared (expressed in person-days per hectare); the manager can also adjust the values derived from the norms using their discretion;
- the norms (or adjusted values) are also used to calculate the contract value: money spent on direct clearing operations, including direct supervision, labour, equipment, protective clothing, transport, and administration costs incurred by the contractor;
- the details of the agreement with the landowner are entered;
- timesheets are used to record daily worker attendance and entered into WIMS; the originals are kept on file. Details of new appointments must be submitted on the WIMS timesheet; and
- records are kept of equipment and consumables issued by the WfW programme for a contract (including herbicides, fuels, blades etc).

WIMS includes only the direct costs of contracts awarded for the clearing of invasive alien plants. Overhead costs (e.g. staff employed in the programme, and all activities other than direct clearing contracts) are not included in WIMS. These are estimated by subtraction from expenses recorded in the financial management system, and adjusted for the proportion of the budget accounted for in the project management system.

The design of the WIMS database allows all this information to be aggregated to the project, provincial and national level and for specified time periods. Likewise, the contract information can also be aggregated for quaternary and higher level catchment units.

Potential contribution to Monitoring and Evaluation within the Working for Water Programme

WIMS provides the following information that can be used by a monitoring and evaluation system:

- The species cleared and their density classes;
- The extent of the area cleared and the overall density of the invasion; and
- The norms that were provided to the contractor and their actual performance relative to those norms.

The management procedure is to award a separate contract for each stage of the treatment of a particular area. This means that the information on the species composition and density is recorded for the initial treatment and any follow-up treatments that may be done. Therefore it can be used to track the overall impact of the control operations using the changes in species composition and density recorded for the successive treatment contracts in a particular area. This calculation apparently is not currently done by the WIMS system, but it could be automated very easily.

Gaps

WIMS does not record information on the effectiveness of the actual clearing operation although the self-assessment standards (WfW 2002, section 2.4.3) do specify that the WfW project manager needs to sign-off that the contract was satisfactorily completed before payment can be made. There is also no provision for recording how effective the treatments have been in restoring the biodiversity and ecosystem function of the indigenous communities in the invaded area. The system also does not estimate the impact of the treatments on water resources in the area although there are models and procedures available for doing these calculations (Le Maitre and Görgens 2003; Dzvukamandja et al. 2005).

3.2.2. The WfW Self-Assessment Standards

This document was derived from a set of operational procedures and checks developed by the forestry industry for its clearing operations. It provides a detailed set of standards covering all aspects of operations, planning and administration. This

section focuses mainly on the standards that are relevant to monitoring and evaluation (Table 3.1).

Assessment of use, usefulness and gaps

These standards make references to a number of quality control measures but there are no specifications or indications of what data are actually recorded in terms of these standards. For example paragraph 2.3.3 refers to clearing specifications that must be included in each contract and cover methods, standards and results. The self-assessment standards document does not provide specifications and the WIMS system only covers the methods and standards, it does not provide or record information relating to results. Similarly paragraph 2.4.3 refers to a quality control sheet. These are in use, and kept on file, in some regions, but, apparently, there are no WfW specifications for what must be recorded and there is no provision to capture the data in the WIMS database. In paragraph 8.4 there is a requirement that the clearing methods should be optimal and cost-effective but there are no definitions what is meant by "optimal", "maximising cost-efficiency" or "environmental compatibility". The same issues apply to most of the standards in section 8 of the document (Table 3.1). Section 9 relates to biological control and has similar deficiencies but these are, apparently, being addressed in the biocontrol monitoring facility that is being added to WIMS at present. The same issues apply to environmental awareness (section 10), fire fighting and protection (section 12) and overall impressions, public and worker participation (section 17) where it is not clear what, for example, "comply with the CARA regulations" means and who audits this.

The Self-assessment Standards (WfW 2002) do not give any guidelines for determining when rehabilitation or erosion control may be required, but this deficiency is being addressed, in part, by the current studies on the rehabilitation of riparian areas and other research projects (see section 3.2.7). There is no provision in the WIMS system for recording any actions that are taken to address soil erosion or rehabilitation.

Table 3.1: Summary of the paragraphs in the Self-Assessment Standards (WfW 2002) that relate to M&E, and comments or recommendations on their use.

No	Self-assessment standard	Comments and recommendations

1	***Project operational planning***	
1.3.2	A clearing strategy must be evident.	The strategy should also include assessment of the degree of invasion and their impacts
1.3.4	Bio-control options must be considered as an integrated part of clearing.	*Biocontrol reporting requirements are being finalised at present.*
2	***Contract/treatment area administration***	
2.3.3	Clearing specifications (methods, standards) must form part of contract document.	*WIMS generates these automatically but does not specify the desired outcomes*; *reporting of outcomes should be added.*
2.4.3	A quality control sheet signed and certified by the Project Manager must record ongoing quality checks and the final check before payment. This must certify that the work done complies with contract specifications.	*No specifications for this form were included in the standards document. Create a facility in WIMS to record the data captured on this form.*
2.5.2	The area manager must verify a minimum of 10% of the cleared areas monthly and record these checks.	*Create a facility in WIMS to record the data from the confirmation sampling.*
2.6.1	Payment must not be made for work that does not comply with contract specifications.	
8	***Method of work***	
8.2	National Mapping standard	*The standards and procedures for this are available and WIMS captures the outputs.*
8.3	Clearing methods (initial & follow-up) specified for the site must be optimal to achieve the desired results, while maximising cost-efficiency and environmental compatibility.	*WIMS automatically supplies this information and it can be modified by the manager while setting up the contract.*
8.4	Follow-up operations must be done and timed to apply the optimal site / species specific treatment.	*Create a facility in WIMS to record the timing when this measure is complied with and reasons for failure to meet it.*
8.4.4	When follow-up operations are not done at the most cost-effective stage, there must be specified planned reasons on record (e.g. repeat	*See above*

	cut-stump due to registered method or sensitive surrounding plants).	
8.6	Work methods conform to contract requirements.	
8.6.1	Compliance must be checked with quality control checks.	
8.6.4	Work methods must be applied according to the relevant WfW standards (e.g. correct use of c/saws by trained operators) and compliance must be monitored.	
8.6.5	Other requirements must be specified & controlled; e.g. removal of litter, erosion control, removal of timber.	
10	***Environmental awareness***	
10.5.4	Damage to indigenous/desirable vegetation must be minimised.	
10.6	The potential dispersal of alien plant seeds or fruit by WfW activities must be assessed and preventative measures must be taken	*The recommended measures must be specified.*
10.7& 10.8	10.7 Site stabilisation / anti-erosion / rehabilitation measures 10.8 Site stabilisation / anti-erosion / rehabilitation records	
12	***Fire fighting and protection***	
12.2	Projects in Fire Protection Areas (FPA) and / or involved in Fire Protection	
15	***Costs***	
15.1	KPI tables	*Are referred to but not included in the document*
15.2	Costs & person days per hectare within norms.	*Norms are built into WIMS and can be adjusted by the managers if necessary*
17	***Overall impressions, public and worker participation***	
17.3.3	Regional, Area and Project offices and stores complexes and their immediate surroundings must comply with the CARA regulations, i.t.o.	

	alien invasive plants.	

Application to the Working for Water Programme

The Self-Assessment Standards prescribe monitoring and evaluation of the quality and effectiveness of the control operations. They also prescribe any further work on site needed to address impacts of the treatments including soil erosion and site rehabilitation. If these monitoring and evaluation requirements were included in WIMS this would allow them to be analysed and reported on and would address many of the current criticisms of the control operations being done by the WfW programme. Monitoring and evaluation of the recovery of the natural ecosystem and the successfulness of rehabilitation measures is a more complex problem and we discuss this in chapter 5 of this report.

3.2.3. Southern African Plant Invaders Atlas (SAPIA)

The Southern African Plant Invaders Atlas (SAPIA) is a project which collects information on the distribution, abundance and habitat associations of alien invasive plants in South Africa, Swaziland, Lesotho (Henderson 1998; 1999; 2001). The SAPIA project has been running since 1994, but the database includes information from surveys dating back to 1979. It also includes records from the literature and herbarium specimens, for some species, which represent the first known records of these species. The SAPIA project is an initiative of the Weeds Division of the Agricultural Research Council-Plant Protection Research Institute which conducts[2] research on the ecology and control of invasive alien plants in South Africa. Information about the current status, scope and activities of the project can be obtained from the following Web Page: http://www.agis.agric.za/wip/. A field guide that facilitates the identification of all listed species was also compiled as part of this initiative (Henderson 2001).

The SAPIA database currently contains almost 60 000 locality records of approximately 600 naturalized alien plant species. Twenty three thousand records come from the roadside surveys carried out from 1979 to 1982 and again from 1986 and 1993 and more ad-hoc surveys. Since October 2006 the project has been funded by the WfW Programme and systematic surveys are now being done. The

[2] There are other organisations that do this as well.

project places particular emphasis on emerging and proposed weeds and invaders under the Conservation of Agricultural Resources Act, Act 43 of 1983 (CARA) and those that may be listed under the National Environmental Management: Biodiversity Act, 2004 (Act 10 of 2004) (NEMBA).

An important component of the project is the detection, identification and documentation of new weed species and new localities for known weeds. The website provides the option to view species distributions in relation to climate, soil types, vegetation (biomes, and Acocks Veld Types), land use and other variables. Information available on the website includes:

- distribution maps;
- species descriptions, species photos and ID expert;
- custom and standardized queries;
- electronic submission of records – online (at the Weeds and Invasive Plants website: www.agis.agric.za/wip or by e-mail: Henderson@sanbi.org); and
- electronic newsletters.

Information available from SAPIA database

The information collected by SAPIA is recorded on a 15 minute square scale (Quarter Degree, QD) (see Figure 3.1) but many of the more recent records have localities to the nearest minute or from a Geographic Positioning System (GPS).

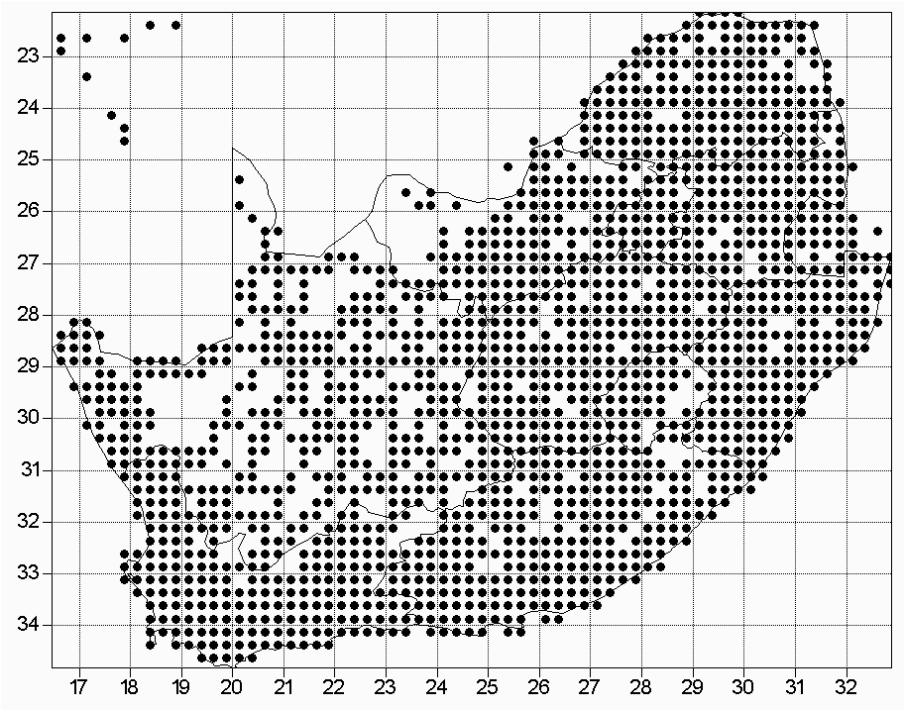

Figure 3.1: The map shows the quarter degree square coverage in the SAPIA database from 1979-2000 (since then more surveys have been done, but only a few new squares sampled).

SAPIA data are typically provided by observers working in the field. Forms are available for recording the field data and there is also an online system. There are two standardized atlas sheets, each with a slightly different species list which covers the western and eastern halves of the atlas region. The data are stored in an Access database as linked tables with each table containing information on specific aspects. For example there is a table with detailed information on a species (e.g. scientific name, common names, legal status, weed type and other attributes). The following information is recorded for each locality or record:

- Date of the observation: minimum is a year, but the exact date (day, month and year) is preferred;
- Quarter Degree (QD) and, for more recent records, a location in decimal degrees with the accuracy (to 1 or to 5 minutes) sometimes obtained from a hand-held GPS;
- Description: country, region, locality (e.g. closest town, farm, river);
- Observer's name and address and

- Plant species name (preferably botanical).

Additional information on the location:

- species abundance (rare, occasional, frequent, abundant, very abundant) divided into dryland versus water courses/wetlands;
- vegetation type invaded (forest, savanna, grassland, fynbos, karoo, transformed);
- disturbance associated with invasion (road or rail side, human habitation, plantation, arable land, pastoral land, waste land);
- landform (watercourse, wetland, dry land, rocky, ravine, deep sand);
- area invaded [recently introduced] by degree of invasion (slight, moderate, severe) and control operations if any;
- biocontrol if present (agent, release, abundance, damage, site disturbance); and
- additional notes and any supporting references from the literature.

Potential contribution to the Working for Water Programme

The SAPIA database provides the most comprehensive record of the broad-scale occurrence of invasive plant species for the region and has been used in a number of research projects and studies (Henderson (1998, 1999), Mgidi et al. (2007), Nel et al. (2004), Richardson et al. (1996, 1997), Rouget et al. (2003, 2004) and Rouget and Richardson (2003)). The information is best suited to analyses of the broad scale (national and provincial), current and potential distributions of species, and for assessments of the degree of invasion, potential for invasion and impacts (Richardson and van Wilgen 2004; Van Wilgen *et al.* 2004, 2007). The data have also been used, together with expert input, to identify major and emerging invaders (Nel *et al.*, 2004). This information can be used for broad scale prioritisation in, for example, determining whether the resources allocated by the WfW programme to different provinces were commensurate with the scale and severity of the impacts in those provinces.

However, SAPIA's descriptions of the extent of the invasion are difficult to convert to an actual extent. For example, it is easy to find out how many records there are for a QD, how many species or records of dense stands occur in QD, but this information can only be crudely translated to estimate the percentage invasion or mean abundance of an invader in a QD or other geographic area. The accuracy of the majority of the records is only at the scale of a QD, which limits their use in climate

envelope or niche modelling. The data are not suitable for planning or guiding clearing operations at the project or contract scale. Information on new species and new records for species could be used to direct short term control operations aimed, for example, at preventing invasions of new areas or eradicating new or emerging invasive species while this is still feasible.

SAPIA can assist biological control programmes in the following ways:

- Providing information on the geographical distribution and density of populations invasive plant species;
- Facilitating early warning of new invaders or new foci of spread; and
- Making provision for observers to record basic information about biocontrol agents occurrences and their impacts.

There are no formal systems for disseminating information from the SAPIA database to managers in the WfW programme or to other agencies involved in control operations. There is only a newsletter which is circulated to a mailing list. Although information gathered for SAPIA can be used to respond to new invasions (which addresses the objective of preventing new invasions, WfW 2005), there is no formal arrangement to ensure that this actually happens.

3.2.4. National Invasive Alien Plant Survey (NIAPS)

The National Invasive Alien Plant Survey (NIAPS) project is funded by the WfW programme and is conducted by the Agricultural Research Council's Institute for Soil, Climate and Water. The project commenced on 1 April 2005 and is scheduled to end by 31 March 2010. The intention is that the national survey will be repeated every five years.

The project aims to develop a cost-effective, statistically sound and repeatable method, based on remote sensing, for quantifying invasive alien plant invasions in South Africa, Lesotho and Swaziland at a quaternary (4^{th} order) catchment level. The objectives of the study are as follow:

- *"To update and improve the Versfeld et al. (1998) data on the range and abundance of invasive alien plants in South Africa, at a national scale, for use by planners and decision makers."*
- *In doing so, to review all previous methodologies used to map invasive alien plants and to develop and describe the most cost-effective and repeatable (i.e. suitable for use in a change-detection programme), methodology for invasive alien plant mapping in a peer-reviewed journal.*
- *To provide invasive alien plant "users requirement" input to the Stellenbosch University satellite (SUNSAT) programme on behalf of the Working for Water Programme.*

The Versfeld *et al.* (1998) report made a number of recommendations which were considered in the approach followed by the current project. Below are some of these recommendations (ARC 2007):

- *"Establish an effective and readily accessible information system or database on alien plant invasions…";*
- *"Find ways to enhance the database by adding new and more accurate data; make this the focus of an ongoing mapping project in close co-operation with the SAPIA initiative";*
- *"To update the needs of the needs of the database needs to be kept updated and active";*
- *"Standards for information capture should be improved";*
- *"The information gathering and processing should be continued";*
- *"Establish a standardized methodology with regard to information and data capture";*
- *"Establish a full-time portfolio for the updating and improvement of aliens information (link to SAPIA);" and*
- "The scale of information should be improved to serve in regional and local management planning".

Project plan

The NIAPS project plan indicates that the project will undertake a number of tasks (Table 3.2).

Table 3.2: Planned tasks for the National Invasive Alien Plant Survey project (ARC, 2007)

Tasks	Description of tasks
1. Literature review	A literature review is to be conducted on work done on Invasive Alien Plants (IAP) in South Africa and abroad. One of the objectives of the review is to determine growth requirements by targeted IAP to be used for modelling purposes.
2. Compilation of all existing spatial data	The objective of this task is to source and prepare all existing spatial data and to incorporate it into a spatial database.
3. Target species	Identify a core species group to be mapped based on the literature review
4. Determination of a Stratification approach	The first step will be to divide the country into species potential distribution areas as obtained from the literature. The second step is to stratify these distribution areas per species according to the ecotope classes and then to mask out any unnatural areas within these ecotope areas
5. Species quantifiable by remote sensing	A particular sensor must be identified and a study conducted to determine via this sensor the distribution at identifiable densities throughout the potential distribution area of such an IAP.
6. Statistical approach to map IAP at a National and International scale	A sampling technique will be developed to sample areas for those species that cannot be effectively quantified by means of remote sensing within their potential distribution range. A study area will be identified to be used for the development of the statistical approach before it is expanded to the rest of the country.
7. Ground-truthing	A ground-truthing exercise will be conducted per species to verify the results obtained in tasks 5 and 6.
8. Updating the Versfeld *et al.* (1998) map	Results obtained in tasks 5,6 and 7 will be used to update the existing IAP map.
9. Model potential distribution	Model potential sensitive areas for future IAP invasion per species.
10. Establish a permanent monitoring programme at a National level for IAP	A monitoring programme will be put in place using permanent monitoring plots to determine the rate of spread of IAP (per species) within their potential distribution area (task 4) and landscape position (task 9). This can be done by means of remote sensing or traditional methods. Such a programme will also serve to monitor progress made to control a given species either through mechanical or

	biological control methods.
11. Develop an automated updating technique on the state of IAP	This can be done using the permanent monitoring programme (task 10), remote sensing techniques (task 5) and SAPIA.
12. Build a spectral library for IAP	The spectral library can be used in hyperspectral studies for future identification and monitoring programmes for IAPs
13. Provide invasive alien plant "users requirement" input to the SUNSAT programme	Provide input to the Stellenbosch University satellite (SUNSAT) programme on behalf of the Working for Water Programme using the results obtained in task 12.
14. Preparation of guidelines and publication of research results	A set of monitoring guidelines will be developed to be implemented at a management level to assist with monitoring.

The expected outputs are:

- A robust methodology - published in a peer-reviewed journal;
- Datasets in an ArcView shapefile format; and
- The Estimated cost of IAP clearing derived from information on the species composition, density and area invaded.

The plan is to use approximately 72,000 stratified-random sampling points (recording the size and density of the 3 dominant species) and fixed-point photographs for ground-truthing the image interpretations.

Progress to date

A project progress report, covering the period from April 2005 up to September 2007 was submitted to the WfW programme in October 2007 (ARC, 2007). The focus of the project is on the development of a cost effective, objective, statistically sound and therefore repeatable monitoring system in line with the recommendations of the Versfeld *et al.* (1998) report. The proposed system has been designed to provide a continuous update of the national distribution map of woody invasive alien vegetation and user requirements have been taken into consideration on an ongoing basis. Thus the focus has shifted from simply updating the Versfeld *et al.* (1998) map to the establishment of the Woody Alien Invasive Monitoring System (WAIMS).

A sampling strategy has been developed based on an analysis of the association between species distribution and abundance from the SAPIA database and environmental variables (climate, soil and terrain). Data from the field and remote sensing interpretation are being used to calculate the actual proportion of invasive alien plants in each catchment. A dynamic spatial and attribute database system has been created to capture the survey results and provide data products at the scales that meet user requirements.

Survey work commenced 30 July 2007 in Mpumalanga and the strategy is to focus on the summer rainfall areas before the onset of thunderstorms and to try and include the flowering period of certain species within environmentally more complex areas such as the Lowveld. To date (October 2007), 8 154 points have been sampled, just over 10% of the total points to be sampled.

The following attributes are recorded for each survey plot:

- Overall density of invasive alien plants;
- Three dominant invasive alien plant species;
- Density per dominant invasive alien plant;
- Size class per invasive alien plant; and
- Relevant comments.

There are also photographs which establish a benchmark for change detection (ARC, 2007).

Application to the Working for Water Programme

The NIAPS is intended to provide a more accurate baseline for the WfW programme to use in assessing progress. The Versfeld et al. (1998) map and summaries provide a baseline that is acceptable at the scale of a primary or secondary catchment or province but the spatial coverage was not sufficiently complete for it to serve as a baseline at finer scales such as quaternary catchments. The SAPIA data are also problematic because the data on the extent of the invaded area are not in a spatially explicit (mapped) form.

It is very important that this project succeeds in providing an adequate baseline for quantifying the progress made by the Working for Water programme, both to date and as the basis for future assessments. Attention needs to be given to capturing the

pre-WIMS data on control operations to ensure that the data on control operations are as complete as possible and can be used to refine the baseline data. Consideration should also be given to adding baseline data to WIMS as the NIAPS completes its surveys in different areas. There is no need to wait for the end of the project to start this process.

3.2.5. Remote sensing tools for monitoring hydrological benefits

One of the key motivations for the WfW programme is the reduction in the consumption of water by invasive alien plants following control operations. A number of research projects have been commissioned which estimated the impacts of water resources based on; (a) models which used data from long-term catchment-based experiments; (b) measurements of short-term increases in streamflow; or (c) measured the water use of individual plants or stands of plants (e.g. Prinsloo and Scott 1999; Le Maitre et al. 2000; Dye and Poulter 1995; Dye et al. 2001; Dye and Jarmain 2004).

These data have been very valuable but they have only dealt with very limited areas and a few species. It is difficult to scale the results up to larger areas or mixtures of species or both. New approaches using remote sensing allow for the estimation of evaporation from whole landscapes involving mixtures of invaded and un-invaded land as well as mixtures of species. The CSIR and WaterWatch (Dr Wim Bastiaansen) have recently launched a research project using the Surface Energy Balance Algorithm for Land (SEBAL) model to estimate evaporation. The project is funded by the WfW programme. An advantage of this approach is that it can use historical images to estimate evaporation and thus compare past evaporation losses with current ones to estimate the benefits of control operations carried out during that period provided data are available on the structure and species composition of the invaded areas. The aims of this project are to:

(1) Assess water consumption (total evaporation) over a 10 year period for areas in the Western Cape and KwaZulu-Natal cleared by the Working for Water Programme and

(2) Compare water consumption of areas with different IAPs over the period 1998 to 2007, in the Western Cape and KwaZulu-Natal.

The project will take place over 18 months, spanning calendar years 2007/8 and 2008/9 and the outputs will include a report as well as scientific and popular papers.

Application to the Working for Water Programme

If this approach proves to be successful, which is likely given that it has produced good results for various vegetation types and crops in South Africa and internationally, it will provide large scale estimates of the impacts of the WfW programme on evaporation, and consequently, the increases in streamflow. The ability to use historical datasets means that baselines can be established and historical and current progress can be measured against those baselines. The SEBAL model will also permit estimates of the net change in evaporation as the indigenous vegetation recovers, which is a gap in the current data because the WfW programme has not been able to maintain long-term studies of cleared catchments. It will also be suitable for regular (e.g. 3-5 yearly) assessments of large areas as well as smaller areas for particular purposes.

3.2.6. Approaches to monitoring and strategic adaptive management in the Kruger National Park

A workshop on the conservation of biodiversity held in the Kruger National Park (KNP) in 1997 rated invasive alien species the greatest threat to KNP's biodiversity, ahead of the well-recognized threats of poaching and fragmentation (Anon 1997). Despite this, invasive alien species were afforded low priority in the KNP with management efforts being directed towards other more traditionally recognised problems and impacts. The pollution control section was formed in the early 1980's to focus on the mechanical and chemical control of various plants, mainly along the Sabie River (as well as solid waste management). In 2001, the section adopted the name of the "Invasive Alien Species Section", with the aim of developing research and monitoring programmes to support and further develop management strategies (Foxcroft and Richardson 2003).

Simply allocating funding was insufficient to ensure an impact on the presence of alien species. For invasive species management to be effective it needed to be incorporated into a system which allows managers to recognise the problems and address them at the correct level. Managers within the KNP recognised that new

paradigms in ecology and conservation biology required them to change their approach to one which promoted accountability and transparency (Rogers and Bestbier 1997). The net result was that the KNP revised their management plan and adopted a type of adaptive management approach, called Strategic Adaptive Management (SAM) (Foxcroft 2004). This approach provides a framework for setting (and revising/updating) objectives (Appendix 5) and auditing the extent to which they are realized (Foxcroft and Richardson 2003). Consistent throughout these frameworks are feedback loops, which provide opportunity for continuous self-assessment and revision (Foxcroft 2004).

Thresholds of Potential Concern (TPCs)

A key component in the functioning of SAM is the Threshold of Potential Concern (TPC). TPCs are those ‘‘upper and lower levels along a continuum of change in selected environmental indicators’’ (Biggs and Rogers 2003). They therefore provide a set of operational goals that define variability or heterogeneity of the KNP ecosystem, over multiple spatial and temporal scales (Biggs and Rogers 2003, Rogers and Bestbier 1997).

The TPCs are based on mutually agreed upper and lower limits of acceptable change in ecosystem structure, function and composition over time and at a specified spatial scale (Rogers 2003). A TPC is reached when one or more of these limits are exceeded. When this happens, management actions are then instituted (Foxcroft and Richardson 2003; Biggs and Rogers 2003).

Foxcroft and Richardson (2003) documented the use of TPCs for invasive alien species in the KNP. The aim of the TPCs for invasive organisms is to assess whether the control operations are making acceptable progress in reducing the extent and impacts of invasive alien plants in the Park. Currently, TPCs dealing with invasive alien species are based on basic measures while the necessary monitoring programmes are established. TPCs listed at this stage may represent a first record for a new species in the KNP or a first record from a new management unit. The current TPCs for monitoring invasive alien species are given in Table 3.1.

Table 3.1: Themes or levels of Thresholds of Potential Concern (TPCs) defined for invasive alien species. Densities are measured using modified canopy cover estimates and grouped into a number of classes (after Foxcroft 2004 & Foxcroft and Richardson 2003)

Level 1 TPC: rate of spread vs. rate of clearing	**Level 2 TPC: species distribution**	**Level 3 TPC: changes in density**
Number of new blocks infested greater than number blocks cleared	Any new occurrence of an alien species in the KNP	An increase of density two classes upwards in any (previously invaded) block.
	Imminent external threat by an alien species to the KNP	Overall increase in density
	Extension of range (first ever report from a new block, or from blocks not contiguous with neighbouring blocks)	
	Expansion of blocks, which represents more than a 5% increase in distribution over the number of blocks infected the previous year.	

Essentially the TPCs for alien invasive species address five different elements of the invasion problem:

- New distributions records in the KNP or increases in distribution ranges;
- Increases in density;
- The rate of spread versus the rate of clearing;
- Impact on biodiversity; and
- Threats posed by alien species occurring outside the park.

The current TPCs for invasive alien species need to be refined and calibrated to represent real and meaningful points of concern: what rates of invasion, or increases in density should initiate management actions aimed at that specific problem (Foxcroft and Richardson 2003).

Progress to date in the Kruger National Park

The managers identified a number of shortcomings when developing the TPCs for the KNP, and subsequently tried to address them. One shortcoming was the lack of an approved policy for the systematic removal of invasive alien species from rest camps and staff gardens. In 1999, a policy was adopted by the KNP Management Committee for the control of invasive alien plants in the KNP staff villages and rest camps (see Foxcroft 2001). Another shortcoming was the need for a monitoring programme and a GIS-based system to record data on invasive species and control operations. The current development of a monitoring programme for IAS in the KNP aims to assess and monitor the extent of invasive alien plants in the KNP according to defined criteria (TPCs).

Previously, the distribution of invasive alien species, density responses and the impacts of clearing operations in the KNP were poorly recorded. Currently the abundance and densities of alien vegetation are monitored in relation to indigenous vegetation and the impact of alien vegetation on biodiversity.

Another issue was to form partnerships with the national WfW programme (Foxcroft and Richardson 2003). This partnership was formed and led to the launch of the first joint project in the KNP in 1997 to boost the Park's own alien plant control initiatives (van Wilgen et al. 1998). Later, the Poverty Relief programme of the South African Government launched a further project in the Park with an amount of R6 million. The park management also initiated formal co-operation with interest groups involved in managing alien plants (to help motive them) as well as with local government. This outreach initiative is an essential part of the strategy for managing invasive alien plants in the KNP, and addresses the critical aspect of creating awareness of problems associated with alien plants. The final steps were to promote effective control by ensuring that best management practices were adopted and that control operations were planned within a regional strategic plan. Management plans for invasive alien plants typically focus on measures for clearing invasive alien species

and logistical arrangements (Moody and Mack 1988), but fail to provide an objective means for prioritising actions.

In conclusion, managing invasive alien plants in the KNP relies on the integration of research and management in a system that allows for adaptive management in a fluctuating environment. The system allows for setting of defined goals (TPCs) over temporal and spatial scales, monitoring and evaluating progress and implementing corrective actions as well as auditing the response of the ecosystems to control measures. Since the revision of the KNP Management Plan and the development of the hierarchy of objectives, invasive alien species have been afforded higher status; this is reflected in the level at which the objective on the impact of aliens is stated.

Application to the Working for Water programme

The TPC-based approach to M&E provides an excellent example for the WfW programme to follow in establishing a basis for its own M&E system. It also provides a good example of the adaptive management approach which we believe that WfW should formally adopt and implement because it (a) places the right emphasis on the M&E components; and (b) makes it an integral part of the way than managers do their jobs and measure how effective they are. The criteria set for the TPCs, although very basic, provide examples of those that should be considered by the WfW programme in developing their own criteria for measuring their effectiveness at contract, project, provincial (regional) and national levels.

3.2.7. Periodic assessments by means of research projects

Research projects are an excellent way of providing periodic and detailed assessments of the effectiveness of control operations carried out by WfW. The programme has commissioned a wide variety of studies since its inception in 1995, many of which have gathered data on, for example, areas invaded (e.g. Gelderblom et al. 1997) or cleared (Marais et al. 2004). The Water Research Commission has also funded a number of studies (e.g. Versfeld et al. 1998; Le Maitre and Görgens 2003). We have not conducted a comprehensive review of the research projects but highlighted some that could provide useful inputs to the M&E process in the form of baseline data or data on progress and impacts.

A number of projects have mapped invaded areas and developed management plans (Gelderblom et al. 1996; Bailey et al. 1997; Nel et al. 1999; and Le Maitre et al. 2002). As far as we know, the progress made by the WfW programme in these areas has not been assessed against these baselines. Some studies have monitored the short-term effects of clearing on stream flows (see review by Görgens and Van Wilgen 2004), but all the longer-term catchment monitoring projects apparently were terminated before they yielded useful results. A few projects have measured and assessed the effects of clearing and restoration practices; most of these were in the fynbos biome (Holmes and Richardson 1999; Holmes et al., 2000; Holmes 2002; Holmes et al. 2005; Prins et al. 2005; Richardson et al. 2007) with few in the grassland and savanna biomes (Holmes 2007). Biocontrol is the one field of research where there has been some reasonably consistent monitoring of progress and impacts (see Zimmermann et al. 2004 for a review).

The most comprehensive assessment of the effects of clearing and restoration actions is the three-year research project initiated in May 2004 (Holmes 2007). This project involved sites in the Fynbos, Grassland and Savanna Biomes and its aim was to recommend realistic and achievable targets for ecosystem repair following invasion. Research sites covered the Boland Mountains in the Western Cape, the Featherstone Kloof and Berg River areas in the Eastern Cape, and the Sabie River in Mpumulanga. Results suggested that lower density invasions (<75%), in which indigenous vegetation persists among the aliens, recover well following careful clearing. In such cases, the recovery of riparian vegetation structure and functioning is a realistic target through alien clearance alone. In closed alien stands on the other hand, alien clearing may be sufficient to restore ecosystem structure and functioning. Vegetation surveys along the Sabie River suggested that clearing was succeeding in removing the larger individuals of alien species, but not in controlling the subsequent regeneration or colonisation by new species. In many of these sites, a lack of records of original vegetation condition, clearing and follow-up severely hampered the interpretation of the surveys. These projects have concluded that accurate mapping and recording of management actions is critical for assessment and evaluation, a recurrent theme in reviews of WfW. The biggest constraint to the research has been in accessing information on the management histories of clear, alien-invaded sites. The studies concluded that it is important that current and future management actions are rigorously recorded. A set of papers based on this research will be published soon in the South African Journal of Botany (Holmes 2007). The results of this project support our argument that the WIMS system should be enhanced to

capture data on the state of the natural ecosystems in these areas and their responses to clearing.

Application to the Working for Water programme

Research projects have made, and will continue to make, a significant contribution to the assessment of various aspects of the WfW programme. They are by nature limited in scope and duration so they cannot replace a properly designed and executed M&E programme. In addition, it is very important that the M&E process is fully integrated into all the management activities as it is the managers who are the prime beneficiaries of the outputs of the M&E process. Research projects typically are done by independent researchers who do not have direct links to the managers or the ability to ensure that management systems procedures are altered to put research findings and recommendations into operation.

3.2.8. Conclusions

The tools mentioned above can assist the WfW programme with its monitoring requirements to a certain extent. The WIMS database is clearly the primary source of information for M&E for the programme and is currently the best source of information on areas treated by treatment stage (e.g. initial clearing) aggregated at various management levels. It should be relatively easy to add routines to the WIMS system which could provide more useful data for the M&E outputs. For example the degree to which successive operations in a contract area were succeeding in reducing stand densities based on data captured for successive contracts (treatments) in the same area. Routines could also be added to estimate the impacts of these changes on water resources. The system does not capture information on how effectively the control operations are carried out although the WfW self-assessment standards indicate that this should be recorded. The WIMS database does not capture information on the recovery of the natural vegetation (e.g. measures of biodiversity) in the cleared areas. Monitoring procedures can be developed and added to the system to do this but biodiversity assessments are complex and typically require expert input. They may have to be done either by suitably qualified appointees within the WfW programme or by consultants. Whichever approach is adopted, it is absolutely critical that this information is

collected so that it is scientifically sound and consistent and can be used to assess the impact that the WfW programme has had and will have over the coming decades.

The most important contribution of the SAPIA database is in the form of records of new invasions by existing species, new species invading and indications of the distribution and status of biocontrol organisms. Its primary role is, therefore, as an early warning system for the WfW programme, but there is no formal mechanism to ensure that WfW responds to this information. The primary contribution of the NIAPS will be to provide a baseline which WfW can use in assessing progress. The baseline data can be progressively added to the WIMS database and used in the M&E process prior to completion of the entire project. Experience in the KNP shows that the TPC approach can be successfully implemented and we suggest that it should be adopted by the WfW programme.

Time scale (years					
	10-yearly				SAPIA
	5-yearly			WIMS; NIAPS; Research reports	SAPIA; NIAPS Research reports
	Annually	SAS	WIMS	WIMS; Research reports	SAPIA; Research reports
	Quarterly	WIMS; SAS	WIMS		
	Monthly	WIMS			
		Contract	Project	Regional/ Agency	National
		Organisational units			

4. EVALUATION OF THE IMPLEMENTATION OF THE CURRENT MANAGEMENT SYSTEMS

4.1. Introduction

There have been various reports which have indicated that WfW managers at various levels have been doing some monitoring of their operations but it was not clear how widespread or standardised these practices are or how effective they are. After consultation with the client we decided that the best way to gather this information would be through a questionnaire aimed at project managers. We were specifically interested in information on the actual monitoring and evaluation practises being used as opposed to the ideals specified, for example, in the Self-Assessment Standards (WfW 2002). The time scale of the project and the large number of managers within the programme meant that we could only survey a sample of the managers. After consultation with the client we selected project managers who received first prize awards for their outstanding projects in the flagship programme. We selected this group[3] because their example should motivate others to follow their example and because they were believed to be most likely to be willing to be interviewed or complete a questionnaire. Ten project managers received first prize awards - their details are given in Appendix 6. Eight of them were interviewed, but the other two could not be contacted. To address this shortcoming we interviewed two more project managers from the Western Cape: Mr Raymond Pretorius from Calvinia and Mr Patrick Jeftas from Citrusdal. Mr Pretorius and Mr Jeftas received second and third prizes in the Flagship programme respectively.

4.2. Analysis of the questionnaire survey

All the project managers undertake some monitoring. Most of them are quite experienced with six of them having worked in the area for 2-5 years; two for 5-10 years and one for <2 years. All 10 knew the extent of the total area cleared by their projects to date and indicated that it was more than 100ha. Only four knew how much area had been treated in follow-up operations. Two managers identified only

[3] It does, however, bias you sample and so it is not representative.

one main invasive alien plant species in their area, namely Acacia in the Northern Cape (Namaqualand area) and *Prosopis* in Mpumalanga (in the Vygeboom area), one identified two invasive plants and the remainder were able to identify four or more main invasive species. Thus it is clear that they do have some knowledge of the areas they have worked in and the main species they are dealing with.

Nine project managers took over from someone else but Ms Dinah Cloete was the first project manager for the Namaqualand area. She also proudly declared that she was the first female project manager to be appointed in the WfW programme in 1998. Nine project managers indicated that there were maps, reports and data on methods in place when they took over this position from the former project manager. Four of them indicated that the records were satisfactory and six indicated that the records were good. Mr Jeftas went on to say that the records that were in place for Citrusdal were excellent. Nine project managers indicated there were no records on success rates in place when they started. The existence of this historical information is important because it could be added to the WIMS database to present a more complete picture of the operations to date.

All the managers indicated that their monitoring data are fed into WIMS. Six of them knew how long WIMS has been used in their project area. There was an equal split between those who identified challenges associated with monitoring and those who did not. Four out of the five who did, identified a lack of skills and three identified time constraints as the challenges they currently experience. Ms Elize Pienaar from the Free State also identified a lack of equipment and staff, and financial constraints as serious challenges. Ms Cloete noted that she has to attend a lot of meetings. She suggested that her area manager should attend these meetings enabling her to do more fieldwork. Mr Curtis Mabaso from Mpumalanga indicated that the areas they are working in are far apart so it is difficult to visit all of them on a regular basis.

The amount of time project managers believed they had available for monitoring varied considerably. One of them indicated that 70-100% of his time was available; five indicated 50-70%; two indicated 30-50% and two indicated 10-30%. This suggests that most of them do, indeed have sufficient time to do some basic contract and project M&E. All the project managers indicated that they are willing to establish permanent monitoring sites; nine indicated they are willing to measure the rate of recovery of cleared sites and mark relocatable plots to establish a basis for future assessment of benefits. Five project managers indicated that they do take

photographs of the areas they are working in. Four of these managers take photos before the project starts and when it finishes; and one only takes a photograph before the project starts. The other five who do not take photographs say they cannot because they do not have a camera. They were, however, willing to take photographs if they were supplied with a camera.

All the project managers measure the extent of the area cleared and the density of the species cleared in the initial treatment and in the follow-up treatments as this information must be fed into WIMS. All the project managers indicated that the areas are mapped before it is cleared. This is done because all the tenders have to include maps of the areas and their extent is calculated by WIMS. The mapping is either done by a GPS-trained person employed by WfW, a private consultant or, in the case of the Calvinia area, the mapping is sometimes done by the project manager.

All the project managers make use of WfW's self assessment standards. They all comply with the standards:
Standard 2.3.3: that clearing specifications must form part of the contract document;
Standard 2.5.2: that the area manager must verify a minimum of 10% of the cleared areas monthly and record these checks and
Standard 2.6.1: that payment must not be made for work that does not comply with contract specifications.

All of them indicated that, when work does not comply with contract specifications, the contractors have to go back and redo it according to the specifications before payment is made. Six of them visit project sites more than once a week and the rest visit sites once a week or once every second week. Four indicated that they sign inspection sheets when they do their site visits. All the project managers complete check sheet for the final site inspection. If the work complies with the specifications, the inspection sheet is then signed off by the project manager, the land owner and the contractor. The project manager then makes a recommendation to the area manager that payment can be made.

4.3. Lessons and implications for Monitoring and Evaluation

These project managers represent the best in the WfW programme and it is likely that others do not practice M&E as comprehensively or thoroughly as our sample. It was clear from the interviews that these project managers are very dedicated,

committed and passionate about their work. It is likely that most, if not all, at least meet the basic requirements of the Self-Assessment Standards (e.g. using the WfW mapping standards and norms) because the WIMS system needs this information to generate contracts. The same probably applies to the completion of the inspections needed to authorise payments to contractors, although some may simply complete these forms without doing adequate inspections. Nevertheless, the results of this survey indicate that a lot of information is being gathered but not used for reporting, simply because procedures and systems for capturing, analysing and creating summaries of the data are not available. These managers have all indicated that they do have time available and are willing to improve what they do, provided they have the necessary skills and equipment.

Recommendations: We recommend that facilities be created in WIMS to capture both the photographs of treated areas and the site inspection sheets. We also recommend that, in future, one of the criteria for selecting the flagship projects should be an evaluation of the manager's compliance with the M&E requirements. This requirement would also help to address part of Goal 3 which relates to keeping WfW staff motivated to do their work well.

5. PROPOSED IMPROVEMENTS TO THE FRAMEWORK FOR MONITORING AND EVALUATING THE BENEFITS OF THE WORKING FOR WATER PROGRAMME

5.1. Introduction

This chapter sets out proposed improvements to the current Working for Water (WfW) programme's monitoring and evaluation (M&E) system based on our knowledge in this field, review of best practise, assessment of current monitoring tools available to WfW, and interviews with project managers. There are a number of levels in the programme where improvements are needed and each of these is described below. It is critical to focus on properly implementing a few key M&E

measures rather than adopting an extensive list which exceeds the capacity and skills of the staff.

The proposed improvements are aligned with Working for Water's Strategic Plan (2008-2012) which sets out the goals of the WfW Programme, including the three goals for natural resource management:

Goal 1: Prevent new Invasive Alien Plant (IAP) problems;
Goal 2: Reduce the impact of existing priority IAP problems; and
Goal 3: Enhance the capacity and commitment to solve IAP problems.

These goals cover the general areas in which WfW should be active, but they do not provide quantitative measures for assessing progress and effectiveness. The following sections deal with the M&E shortcomings and requirements in relation to each of these objectives. However, before we deal with that we need to deal with the context and the basic principles required for an effective monitoring and evaluation system.

5.2. Improving Management Effectiveness in Working for Water

Information gathered during this project shows that WfW is addressing certain aspects of M&E, but they are not being as effective as they could be. They are also recording information which could be used, for example, to report on the effectiveness of treatment operations, but this information is not recorded in WIMS and cannot be analysed and reported on regionally or nationally. Although they are recording this information, it is not being used to formally evaluate their progress and effectiveness, identify aspects needing improvement and to address those.

Adaptive management is specifically aimed at ensuring that the outcomes of actions are monitored and evaluated and used to modify the subsequent management actions to make them more effective. In the adaptive management approach all the actions and all the monitoring and evaluation measures are designed to ensure that the goals, objectives or targets of the organisation are met.

We recommend that WfW formally adopt an adaptive management approach. We also recommended that WfW develop measurable objectives or targets because these are needed as inputs for designing and developing monitoring and evaluation procedures.

Although WfW is doing some M&E, there are some critical weaknesses that need to be addressed:

Monitoring and Evaluation must become a core management function:
The best way to ensure that M&E is fully integrated is to include M&E in every manager's performance measures from the general manager of the programme down to the project manager level. These measures must explicitly assess how well they undertake M&E activities. The role of the M&E staff is to support managers in doing that.

Monitoring and Evaluation must be adequately resourced:
An M&E system cannot be effective if it is not adequately resourced and sustained as a core management function. In addition to this, the staff in the M&E group within WFW need sufficient resources to enable them to fulfil their core functions of:

- supporting management;
- quality control over data capture, storage and analysis;
- commissioning additional research; and
- regularly reviewing the WfW M&E system.

Under resources we include the skills level of the staff themselves. They need to be adequately trained, especially if they are to undertake any of the specialist evaluations we recommend below. The posts for the M&E co-ordinators (4) and regional compliance managers (3) are all vacant at present and they need to be filled with adequately skilled people.

Long-term commitment:
M&E is expensive and time-consuming and cannot deliver a good return on investment if it is not sustained in the long-term. The long-term commitment is particularly important in the case of WfW because the full benefits of the programme's interventions cannot be quantified without long-term, regular and consistent recording of the relevant data.

Simple and systematic approach:

One of the key lessons from the long history of M&E is that it is far more important to do a few things and do them very well than to do many things poorly. Effective M&E depends on regular data collection, using consistent methods of collecting data, ensuring that the data are checked for errors in measurements and data input, evaluating whether the right methods are being used and that data being collected are appropriate and sufficient to evaluate progress towards WfW's goals, objectives and targets.

We recommend that WfW consider using a TPC approach when formulating its measurable objectives or targets and in determining measures of its performance in meeting these.

5.3. Proposed improvements to the Strategic Plan

The current "logic model" used in the strategic plan does not provide measurable objectives or targets for WfW which can be used measure their progress. We have organised our recommendations for introducing quantitative measures under the three goals for natural resources set out in the strategic plan.

Goal 1: Prevent new Invasive Alien Plant (IAP) problems

This goal was not included in the terms of reference of this project but was identified when evaluating the potential applications for the information collected by the SAPIA project (see section 3.2.3). This project currently provides early warning information but there is no formal system for ensuring that WfW responds to it. There is a separate WfW project which is developing an early detection and response system based on the provisions in the Biodiversity Act. It is being managed by Philip Ivey of the South African National Biodiversity Institute, but it will be some time before this is completed.

As an interim measure we recommend that WfW implement a formal procedure for ensuring that early warning information (both of new invaders or new foci of spread) reaches the relevant managers in WfW and that they evaluate and respond to it. The system should also ensure that the decisions and the resulting actions and outcomes are recorded. We recommend that the data on these new invasions should be stored in the WIMS database. Ideally, data on new species and occurrences should be

transferred electronically between SAPIA and WIMS and the various options for implementing this should be investigated.

Goal 2: Reduce the impact of existing priority IAP problems

The first step in making this goal operational is to develop objectives or targets which specify details such as by when, by how much and by whom. The establishment of this quantitative measures is beyond the scope of this report but critically important. Without these specific measures, WfW will not be able to properly evaluate its progress or how effectively it is reducing impacts, all it can do it report how much area it has treated and the species involved. The objectives or targets should be derived from (a) an understanding of the scope of the problem and WfW's capacity to deal with it, and (b) a set of measurable national objectives based on priorities determined by biome, impacts on biodiversity and ecosystem services, opportunities for employment and other issues. These priorities are being investigated in a separate research project by the CSIR which will be completed by May 2008. This project is determining priorities for both areas and species in such a way that the priority species are included as criteria for deciding the priority for areas. At the national and regional scale the area-based priorities are being determined according to biomes because biomes typically have particular suites of invaders which have different habitat preferences and impacts. The importance of different ecosystem services, and thus the impacts, also tend to differ between biomes. The completion of this project will enable WfW to establish priorities and use them to derive quantitative objectives or targets at the regional and national level.

The second key shortcoming is the lack of a baseline against which overall progress can be measured.

We recommend a two-fold approach to addressing this short-coming. (a) Establish a general baseline that can be used at national and regional, or even project, levels. The current mapping by WfW only covers areas that are designated in contracts, it does not deal with areas outside the contracts. The National Invasive Alien Plant Survey project is intended to produce this baseline but it will be some time before the data are available. (b) Provide measures of progress at the contract area level (NBAL) which can be aggregated to the national level. Each contract area (NBAL) must be mapped using the WfW standards and the information is captured in WIMS. Each successive contract for treatment of that area is mapped. This information can

be used to assess how much area has been treated per treatment type (a facility already in WIMS) but WIMS does not calculate the net change in species composition or structure. This procedure could easily be added and used to assess progress in reducing the density and changing the species composition after each treatment. The procedure should include a simplified version of the proportion flow reduction model (Dzvukamanja et al. 2005) to estimate the potential increases in surface water runoff.

One of the key deficiencies that has been highlighted by several reports and studies (e.g. Holmes 2007) is the difficulty of accessing data that preceded the implementation of the WIMS system in 2003. Data were collected on GIS that dated as far back at the late 1990s but these have not been incorporated into the WIMS database. It is not clear whether the data and the management plans form this early period still exist but if and where they do, they can provide a basis for assessments of long-term progress and provide a more balanced picture of WfWs progress and impacts to date. We recommend that WfW commissions a research project to assess the potential for including the data in WIMS to make it available for use in reports and research projects.

Goal 3: Enhance the capacity and commitment to solve IAP problems

Goal 3 is to enhance the capacity and commitment to solve IAP problems. The CSIR initially decided not to focus on this goal as it is a social one, but it was agreed at the managers' meeting on 22 August 2007 in Cape Town that we will address it only in respect of internal (staff) capacity and commitment.

The WfW programme needs to appoint M&E staff as a matter of urgency. They also need to adopt an overarching statement on M&E policy (e.g. a minimum set of plans to be monitored and assessed). We propose three objectives in support of this goal (Table 5.1)

Table 5.1: Recommendations on how the goal of enhancing capacity and commitment should be monitored

Objectives	Measure	Who?	How often?
Raised awareness	Degree of awareness in: • Key stakeholders (land owners,	Specially-appointed survey	Now, to establish

	managers, public) • WfW personnel	teams	baseline. Every 3 – 5 years
Evidence-based decisions	Availability of information Evidence of adaptive management and policy revision	WfW M&E co-ordinator	Annually
Collaborative governance and management	Consistent legislation Multi-stakeholder management plans in place	WfW M&E co-ordinator	Annually

Improving the Logic Model

The table that presents the Logic Model in the Strategic Plan lists a number of items under the three strategic goals for natural resources management: inputs, activities, outputs, outcomes and objectives (see section 1.4). The "objectives (impacts)" in the Logical Model describe broad categories of activities which cover different aspects of each of the goals. The descriptions of what the activities are to achieve are not under objectives but are listed in the category "outcomes". Whilst the outcomes are appropriate, and are things WfW should be aiming to achieve (e.g. optimised water security), they do not give any quantitative measure that can be used to assess whether WfW is doing the right things in the right places to, for example, optimise water security. The bulk of the Logic Model is a list of activities but these, again, provide no measure to assess progress of effectiveness. These deficiencies need to be addressed by restructuring the Logic Model around a set of measurable objectives as outlined in the sections on each goal above.

An area that needs specific attention is the section on M&E. The current activities listed for the M&E team are to develop goals of management, to develop indicators and to develop a plan for assessment. This is not the correct approach because adaptive management identifies these activities as a core management function, one to be done by the national, regional and project level managers themselves. We recommend a different approach which is set out in Table 5.2. The outcome of M&E

should be tangible progress towards measurable objectives which are aligned with the overall goals and improved programme management.

The M&E team primary activities should be focussed on three aspects: (a) supporting managers in developing measurable objectives and in putting in place the systems needed for them to capture, analyse and respond to results (e.g. tools in WIMS) in accordance with the adaptive management approach; (b) reviewing the manager's assessments of their progress; and (c) reviewing and improving the M&E system. They should also be commissioning research on aspects of the M&E that the managers do not have the expertise to do themselves.

Table 5.2: An example of a revised logic model with examples for the proposed changes in the structure and content emphasising the role of the M&E component, managers and M&E staff. The specific roles of the M&E staff are shown in bold italics.

Inputs	**Activities (*responsible staff*)**	**Outputs**	**Outcomes**	**Objectives**	**Goal**
Provide the resources required to support an effective and integrated programme for clearing of invasive alien plants and restoring ecosystem health	Establish goals of management (***managers***)	Clear goals	Measurable reduction in the state of invasion in: • key catchment areas • wetlands, • riparian zones, • conservation areas, • biodiversity hotspots and • grazing lands. Progress towards securing water resources Improved programme management	To have reduced the extent of invasions of the fynbos biome by A% by 201X in the following priority catchments: G, H…; to make W% more water available in catchments….; and rehabilitate X% of the cleared, densely invaded riparian zones	Goal 1: To enhance the state of biosecurity and water security, and in so doing make a tangible contribution to sustainable development to the benefit of all citizens.
	Establish priorities in terms of species and impacts (***managers***)	Clear priorities			
	Establish measurable objectives based on the goals and priorities (***managers***)	**S**pecific, **M**easurable, **A**chievable, **R**elevant, **T**ime-based objectives			
	Establish an adaptive management framework & culture (integrating M&E) (***managers supported by M&E staff***)	Evidence of ongoing adaptive management			
	Establish cost-effective ways of monitoring and evaluating achievement of the objectives (***managers supported by M&E staff***)	Accepted and implemented protocols for M&E			
	Establish a research programme on monitoring and evaluating key activities related to the clearing of invasive alien plants and restoring ecosystem health (***M&E staff with managers***)	Regular evaluations of the effectiveness of the management activities with a specific emphasis on specialist evaluations of rehabilitation and recovery of natural ecosystems in cleared areas			

5.4. Proposed improvements to management plans

This section is focused primarily on goal 2 and focuses on the measures needed to ensure that WfW reduces the impacts of priority problems. All project (area) planning must be done on an annual basis (annual plan of operations) within the framework of a 5-year plan. Only one example of a 5-year management plan was provided by WfW, namely for the Mthatha Basin in the Eastern Cape. This had detailed maps of the species and extent of their invasions. The clearing operations were prioritised over 10 years, but planned according to inputs (person-days and costs) and not outputs (e.g. cleared areas). No measurable goals were provided nor are they explicitly specified in the Self-Assessment Standards (SAS) (WfW 2002). Section 1.3 of the SAS should be expanded to require the management unit clearing plan to include measurable objectives or targets for IAPs so that progress against the mapped baseline can be monitored and evaluated in terms of the reductions in extent, density and impacts. Each 5-year plan must have a well-defined, measurable overall objective and a set of targets so that progress towards goals can be monitored. Periodic assessment of these objectives needs to be done at the regional level.

5.5. Proposed improvements to contract management

All the treatment programmes managed by WfW are on a contract basis and contract information is recorded in the WIMS database, including the extent of the areas treated, the herbicide use, costs and a range of human resource related statistics (see section 3.2.1 of this report). The data on the existing invasions in each contract area (NBAL) are mapped according to WfW's National Mapping Standards and captured in WIMS. The information on the state of the treated areas can be aggregated for different areas and time periods using tools in WIMS. As noted above, the WIMS tools can be extended to analyse and report on: (a) the change in status of the invaders in a contract area from one contract (treatment) to the next, and (b) the potential increases in streamflow.

The Self-Assessment Standards (SAS) (WfW 2002) give detailed specifications of the information that projects managers must maintain on each project and contract. Any improvements suggested for monitoring and evaluation at this level should be included in the SAS so that they become standard practice. The SAS include a number of specific monitoring requirements that are not currently recorded in WIMS (see section 3.2.2) although some of them are recorded and kept on file by the project managers. Section 2.3.3 specifies that clearing standards must be included in a contract and 2.4.3 that a quality control sheet must be completed to confirm that the contract complies with these standards. An example of a quality control sheet (supplied by Derek Malan) shows that the managers record all the information specified in the SAS that is needed to confirm that the contractor has complied with the conditions, including completeness of the treatments, methods used, handing of cleared material, and environmental impacts such as erosion control and damage to non-target species. The quality control sheet also includes a note that: *If after a reasonable time excessive re-growth occurs and or the mortality rate on follow-up areas is below the acceptable standard the contractor will be held liable to make corrections to bring those areas in line with WfW standards even if a satisfactory certification was issued previously*. The quality control information is not currently captured in the WIMS database but it should be as it would address concerns about the effectiveness of the treatments.

Although section 10.7 of the SAS covers rehabilitation measures and 10.8 requires that rehabilitation records are kept, the quality control sheet does not address this issue. The monitoring measures specified in the SAS do not explicitly address or assess the recovery of the natural vegetation. This deficiency is currently being addressed by research on guidelines for rehabilitation in riparian zones which aim to produce guidelines that the WfW project managers will be able to use to determine when to rehabilitate (Holmes 2007). This project did not cover non-riparian areas. Assessment of ecosystem recovery typically requires expertise that we believe we cannot expect WfW project managers to have.

- We recommend that assessments of the recovery of the natural ecosystems should be done either by the regional M&E officer (if suitably trained) or through commissioned research projects. The minimum requirement for the managers is that they should record whether or not the area was rehabilitated and what treatments were done even if the quantification of the outcome of the rehabilitation is left to the regional M&E staff or for research studies.

Section 9 of the SAS requires the managers to record information about biocontrol. A facility is currently being developed for WIMS to store and process this information in its database, so we have not covered biocontrol in our recommendations.

The SAS do not specify that photographs should be taken of the area to be treated (NBAL) at the commencement of each contract.

- We recommend that photographs should be taken both at the commencement and at the completion of the project.
- Whenever possible, these photographs should be taken from the same point (preferably permanently marked and easily identified), in the same direction, at the same time of day and with the same camera settings (lense length or zoom setting, aperture setting).
- The location of the photographer should be recorded using a GPS together with the other information above so that someone else can take a matched photograph.
- Ideally, these photographs, together with their data, should be stored in the WIMS database or in another, linked, database if this is not possible.

The current monthly Key Performance Indicators (see SAS 1.7) require the managers to report on a variety of aspects of their projects based on an example for the Free State (2007/08) supplied by Andrew Wannenburgh. Most of the KPIs focus on inputs in the form of human resources and costs but there are several measures of quantitative outputs in terms of the area subjected to initial clearing and to follow up that are provided by WIMS. The KPIs also require the manager to report on whether or not the actual progress matches the annual plans for each project and to give formal confirmation that the areas have actually been cleared. These measures appear to conform to the requirements of the SAS but there is no explicit link between these two systems. For example the requirement for formal confirmation of the cleared areas appears to match with the information recorded on the quality control sheet (SAS 2.4.3) but there is no statement or link to indicate that this is the case. The KPIs report on a number of statistics on the treatment operations that seem redundant and make them more numerous and complex than they need to be.

We recommend that WfW explicitly align the SAS requirements with the KPIs and with our recommendations on additional measurements and seek to restrict the reporting to the minimum information to assess progress.

Long-term monitoring

The WfW programmes involvement in the treatment of an area typically only lasts for the period between the initial clearing and the 2nd or 3rd follow-up. The recent project on rehabilitation found very few sites (NBALs) where the record of the treatments was sufficient to enable them to assess the longer-term impacts of clearing (Holmes 2007). This information is needed to demonstrate that the programme is effective and the reductions in the impacts of the IAPs are sustained in the long-term. We recommend that each region should select a sample of treated areas (NBALs) that are suitable for long-term monitoring. These areas should:

- Have detailed record of the initial conditions and the treatments and their outcomes
- Have any rehabilitation measures that were applied
- Have in sites where they will remain natural vegetation and not be changed to other land uses (e.g. cultivated or afforested) in the foreseeable future
- Represent a range of habitats
- Represent a range of states of invasion prior to the treatments.

The sites that were identified and used in the rehabilitation guidelines study (Holmes 2007) should be included as permanent monitoring sites. Consideration should be given to monitoring entire catchments to get an integrated record of the long-term impacts of clearing at scales larger than individual contract areas.

5.6. Proposed improvements to WIMS

We have a number of recommendations for improvements to WIMS which were discussed in the sections above. The following facilities and/or tools need to be developed:

- Early response: A facility and a protocol for adding records of new species invasions and new occurrences of existing species to the WIMS database. Provision should also be made for transferring data in electronic form between the SAPIA and WIMS databases. This facility should record information on the responses of WfW to this information so that it can be used in reporting on these activities.

- Changes in IAP status: A routine should be added for analysing the data from the contract database to calculate the net changes in the density and species composition from one treatment contract to the next. This would supplement the current routine which is used to calculate the area treated (by treatment type) at project, regional and national scales.
- Impacts on surface runoff: A routine for estimating the potential increases in surface water runoff using (a simplified version of) the proportional flow reduction model developed by Dzvukamanja et al. (2005) for water resource assessments.
- Quality control sheet data: A facility for capturing and analysing the data from the quality control sheet that project managers must complete before they can authorise payment of a contract.
- Photographs: A facility for storing photographs of contract areas and the associated information on the: name of the photographer, time, date, direction of the photograph and the GPS location of the photographer. The camera settings should also be included. If the data cannot be stored in the WIMS database itself or in another linked database.

The following facilities are considered important but should be given a lower priority than those listed above:

- Rehabilitation: A facility for recording information on whether or not the contract area, or part(s) of it, was rehabilitated and basic information on the rehabilitation measures. The minimum set of information on the rehabilitation to be captured in WIMS should be determined in consultation with specialists in rehabilitation. Provision should also be made for recording key information on rehabilitation success for specific sites or areas assessed during specialist studies or research projects.
- Recovery of natural ecosystems: Provision should be made for recording key information on rehabilitation success for specific sites or areas assessed during specialist studies or research projects.

5.7. The importance of making a start with monitoring and evaluation

The programme already records much of the information it requires to report on its progress and effectiveness. However, there are some key deficiencies either

because the data are not recorded or because the data are nor captured electronically and are, therefore, not available for routine reporting. It is critical that these deficiencies are addressed as soon as possible. Most of the deficiencies can be addressed by making sure that the necessary facilities are created in WIMS to record or report on these items. At the same time the SAS and the KPIs must be addressed and aligned so that the managers begin collecting the additional data that are needed to report on the M&E measures recommended in this report. The basic information can be easily collected, or is already being collected, and can be very useful.

5.8. Proposed minimum set of indicators

The suggested minimum indicators for natural resource management are:

- extent of the area treated (e.g. initial clearing, 1st follow-up)
- quality control of the treatment operation
- reduction in the degree (e.g. density, species composition) of invasion
- impact on water resources
- site rehabilitation measures taken
- rate of ecosystem recovery

Assessment of the rate of recovery of the natural ecosystems is a complex matter requiring specialist input (e.g. Holmes 2007) and is probably beyond the skills of the project managers. We recommend that this is done either through research projects or by the M&E staff provided they are adequately qualified. A summary of the basic information to be collected at a project level is given in Table 5.3 below.

5.9. First priorities

The following items should be given a high priority:

- Make an immediate start with the collection and effective curation of the basic information recommended in section 5.7.
- Continue or make an immediate start to record the baseline by taking fixed point photographs (see section on photopoints in Appendix 1).
- Add the high priority facilities to WIMS to address the key deficiencies in the current M&E system.

- Make an immediate start with the selection and establishment of permanent monitoring sites.
- Appoint M&E co-ordinator(s) to ensure that standards are met and maintained, that managers comply with the new measures and are adequately trained, and that all the M&E data is properly curated.
- When the project on priorities is completed, incorporate the results into refined targets that address these priorities.
- Continue with the establishment of a baseline (NIAPS).
- Continue with (and increase) targeted research projects aimed at quantifying the impacts of the programme.

Table 5.3 Basic information to be collected at a project level. A shaded cell indicates that the facility needs to be added to the WIMS database. SAS = Self Assessment Standards

Goal	Objective	Method and/or measure	Who?	How often?	Data and records kept
Prevent new Invasive Alien Plant (IAP) problems	Quarantine measures				
	Respond to emerging invaders and new invasion foci	Evaluation committee decisions minuted, including actions and responsible persons.	M&E section staff & WfW research manager	Quarterly meeting of evaluation committee	WIMS (record of new invader, new foci and location)
	Respond to emerging invaders and new invasion foci	Where an action is required a report should be submitted on the action and its outcome	Relevant project manager	Quarterly feedback to the National M&E manager or regional M&E officer	WIMS (record of action and outcome)
Reduce the impact of	Establish a baseline for	Record the density and species composition of the	All project managers	Prior to commencement	WIMS & contract files

Goal	Objective	Method and/or measure	Who?	How often?	Data and records kept
existing priority IAP problems	each treatment	stand using the WfW Mapping Standards (SAS 8.2)		treatment	
	Record the baseline state and the progress	Fixed-point photographs of the NBAL	All project managers	Prior to commencement and at completion of the treatment	WIMS & contract files
	Record rehabilitation	To be determined in consultation with specialists	All project managers	Completion of treatment	WIMS & contract files
	Assess quality of treatment	Quality of clearing and follow-up recorded (SAS 2.4.3)	All project managers	Quarterly	WIMS & contract files
	Estimate impacts of treatments on invasive species	WIMS facility for analysing the treatment history for each NBAL based on the difference in state between the previous and the current treatment contract as calculated by WIMS	All project managers	At the closure of each treatment contract	WIMS
	Estimate	WIMS facility for calculating	All project	At the closure of	WIMS

Goal	Objective	Method and/or measure	Who?	How often?	Data and records kept
	impacts on water resources	the impact using the proportional flow reduction model algorithm and contract data	managers	each treatment contract	
	Estimate impacts on recovery of natural ecosystems	Periodic assessments by researchers of selected sites (criteria for selection to be developed)	All Regional Managers	Annual?	WIMS
	Establish a set of long-term monitoring sites in each region for future assessments of benefits	Marked and re-locatable plots (e.g. 10 x 10 m); depends on the aim of the study, the natural ecosystem and the type of invasion; methods to be determined in consultation with specialists	Regional M&E staff in consultation with the regional and project managers	As soon as possible; depends on the data required and the methodology adopted	WIMS?
	Establish priorities	Subject of a current research project	National, Regional and Project	5-yearly?	

Goal	Objective	Method and/or measure	Who?	How often?	Data and records kept
			Managers		
Meet the social goals on enhancing capacity and commitment	Raised awareness	Degree of awareness in: Key stakeholders (land owners, managers, public) and WfW personnel	Specially-appointed survey teams	Soon, to establish baseline. Every 3 – 5 years theerafter	
	Evidence-based decisions	Availability of information Evidence of adaptive management and policy revision	WfW M&E co-ordinator	Annually	
	Collaborative governance and management	Consistent legislation Multi-stakeholder management plans in place	WfW M&E co-ordinator	Annually	

6. SUMMARY OF RECOMMENDATIONS

This section provides a summary of the recommendations that are proposed in the document. The section/(s) where the detailed recommendations are found are put in brackets.

General recommendations.

We recommend that WfW should:

- Formally adopt an adaptive management approach (sections 3.2.6, 3.2.8 & 5.2).
- Use the information from the current project on prioritisation as inputs into the development of specific and quantitative objectives and targets that address these priorities (section 5.9).
- Use these objectives and targets as inputs for designing and developing M&E procedures (section 5.2).
- Fill the vacant posts for M&E co-ordinator(s) (sections 5.2 & 5.9).
- Include M&E in every manager's performance measures (section 5.2).
- Make an immediate start with the collection and effective curation of the basic information (sections 5.7 & 5.9).
- Continue or begin immediately to record the baseline information on all projects and supplement it with fixed point photographs (sections 5.5, 5.9 & Appendix 1).
- Make an immediate start on the selection and establishment of permanent monitoring sites (section 5.9).
- Continue with the establishment of a baseline (NIAPS) (sections 3.2.4, 5.3 & 5.6).
- Continue with (and increase) targeted research projects aimed at quantifying the impacts of the programme (sections 3.2.7 & 5.6).
- Use targeted research projects to provide useful input to the M&E process in the form of baseline data or data on progress and impacts (section 3.2.7).

We also recommend that the following facilities and/or tools need to be developed and added to the WIMS software:

- A facility and a protocol for adding records of new species invasions and new occurrences of existing species to the WIMS database (sections 5.3 & 5.6).
- A routine should be added for analysing the data from the contract database to calculate the net changes in the density and species composition from one treatment contract to the next (sections 3.2.1, 5.3 & 5.6).

- A routine for estimating the potential increases in surface water runoff (sections 3.2.1, 3.2.8, 5.5 & 5.6).
- A facility for capturing and analysing the data from the quality control sheet that project managers must complete before they can authorise payment of a contract (sections 3.2.3, 3.2.8, 5.5 & 5.6).
- A facility for storing photographs of contract areas (section 5.6).
- A facility for recording information on whether or not the contract area, or part(s) of it, was rehabilitated and basic information on the rehabilitation measures and rehabilitation success (sections 3.2.1 & 5.6). The specific information needs should be determined in consultation with specialists in rehabilitation.
- Provision should be made for transferring data in electronic form between the WIMS and SAPIA databases (sections 3.2.1, 3.2.3, 3.2.8 & 5.6) and
- WfW should commission a research project to assess the potential for including data in WIMS that preceded the implementation of the WIMS system in 2003 (section 5.3).

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Appendix 1: Methods to monitor effectiveness of control operations (Brougham et al. 2006)

Photopoints

Photopoints are a photographic record of changes occurring at a site over time, taken from the same point each time. They are an excellent tool for demonstrating progress to members of community groups, the public, and funding bodies.

Setting up a photopoint

• Choose sites that will best represent the work undertaken at the site, such as an area with significant ecological values, or a heavily infested area.
• Place a permanent marker such as a stake at the point from which the photo will be taken each time.
• Label an A4 card with the date and photopoint location, and attach to another stake approximately 10 metres from the camera position.
• Stand at the marker, face the labelling card, and take the photo.

The description also includes some important tips for standardising photopoints:
• Align markers north to south to avoid excessive sun or shadow, and to make it easy to remember which direction to take the photo if the markers are removed.
• Try to include a distinctive object in each photo, such as a tree or fence post, that will be there each time.
• Use the same camera and film type (or the same settings on a digital camera), and take the photos from the same height (rest the camera on the stake), with the same zoom settings.
• Take photos as frequently as required to reflect changes at the site, but ensure that photos are taken at the same time each year to make valid comparisons.
• Label each photo with the date, location, and the reason for taking the photo (e.g. annual monitoring, before and after weed removal).

Measuring density

Density is defined as the number of individual plants per unit area – for example 100 plants per hectare. Density is a good measure of population size, as populations will respond to most control treatments by a change in the number of individuals (of various age classes), rather than a change in vigour or plant size.

Measuring density in age classes will reflect more accurately the changes caused by the control treatments. It is a good idea to determine the density of juvenile and mature

plants separately, as the removal of mature plants is generally followed by the germination of many seedlings.

For example, before treatment, the density may be 500 mature plants and 100 juveniles (total 600 plants) per hectare. Six months after the initial treatment, the density may be 50 mature plants and 650 juveniles (total 700 plants) per hectare. Follow-up control is carried out 12 months after the initial control. After 18 months, the density may have dropped to 0 mature plants and 300 juveniles (total 300 plants) per hectare. If only total numbers of plants were counted, the dramatic effect of the initial treatment on the population would not have been captured.

Plot counts

Density can be measured simply, by marking out three or more plots ('quadrats') of 10 m x 10 m (100 square metres). The plots should be randomly located over the site, and the more plots there are, the more precise the results will be. Count the number of plants (in each age class) in each plot, and determine the average. Multiply the average number of plants per 10 m x 10 m plot by 100 to get the number per hectare (one hectare is 10,000 square metres). For plants straddling the boundaries of the plot, count all individuals along two contiguous sides, and do not count the individuals that straddle the other two sides.

Plot transects

Plots are often placed along sample lines called transects. Transects are commonly 100 m long, and are placed 10–50 m apart, parallel to each other. Using multiple transects will give results that are more representative of the entire site. Plot size will depend on the species being measured. For shrubs such as boneseed, 2 m x 2 m plots may be appropriate. Smaller plots (50 cm x 50 cm) would be needed for measuring native seedling regeneration. Keep the plots the same size on each subsequent monitoring occasion, so that results are comparable.

Monitoring of native regeneration can be done by counting all the species in each plot. Alternatively, one or two key native species may be chosen as the target species to be monitored. Record the number of individuals of the target species within each plot. Average the number of individuals of each species in each plot (over all transects), and convert to a density measure (i.e. individuals per square metre or individuals per hectare).

Measuring cover

Sample point method

Counting individual plants is only possible for scattered or light infestations, as separating individual plants is very difficult in dense infestations. An easier method for measuring dense populations is to determine percentage cover using the sample point method.

Use a tape-measure and a narrow pole to measure sample points along a transect. Place the pole next to the tape at set distances along each transect, and record a 'hit' if the pole touches a plant, or a 'miss' if the pole does not touch a plant. The proportion of sample points with a 'hit' is an estimate of the cover. Using more sampling points gives one more precise results.

Alternatively, walk between two fixed points (e.g. two stakes or other permanent features) and record a 'hit' if a plant is present within a metre at a given step interval. Distances and intervals can be varied to suit the site.

A field manual has been developed by the Bureau of Rural Sciences to standardise the mapping of WONS. A field manual for surveying and mapping national significant weeds (McNaught et al. 2006) lists the attributes that should be recorded when surveying weeds, and describes various methods of determining weed density. Copies of the manual are available from the Australian Weeds website (www.weeds.org.au).

Appendix 2: Examples of invasive plant management programmes with monitoring and surveillance components used in New Zealand

Management programme	Management objective	Monitoring and surveillance plan
Biodiversity Pest	(i) Protect biodiversity values by eradicating all pest plants, prior to seed set each year. (ii) Reduce to levels sufficient to ensure protection of biodiversity in high-value environmental areas.	(i) Monitor areas where operations have been carried out to determine whether populations have been reduced to levels which do not threaten biodiversity values. (ii) Regularly inspect land at risk of infestation to determine pest presence and density. The frequency of inspection will depend on the proneness of the area to the pest plant. (iii) Progressively identify high value environmental areas and prioritise the need for control programmes in consultation with land occupiers and community groups.
Boundary control	Control spread from adjacent properties to land clear of, or being cleared of pest plant.	Undertake monitoring and investigations (monitor the effectiveness of control work that has been undertaken). Carry out surveillance for pest plant on land at risk of infestation.
Containment	(i) Reduce adverse effects on properties with neighbouring infestations. (ii) Prevent infestation of neighbouring uninfested properties. (iii) Reduce the pre-existing	Undertake audit/performance monitoring of pest populations after control work. Undertake investigations aimed at detecting any new pest infestations outside the containment area.

	seedbank on infested properties. (iv) Encourage progressive control of scattered pest plants by occupiers through agreed pest management programmes. (v) Reduce density and/or distribution in the long term. (vi) Achieve self-sustaining populations of biocontrol agents.	Inspect, at least once annually, and monitor properties with known infestations to establish extent of infestations and identify any remedial action that needs to be taken. Identify new sites of pest plant through incidental reports by biosecurity officers or the public. Annually inspect local nurseries for the sale of pest plants. Carry out inspections to determine if occupiers have destroyed all pest plants, before they produce seed, each year.
Limited control	Reduce adverse effects through improved awareness and management.	Undertake surveillance and monitoring.
Population control	No increase in populations across the region; with decreased levels in targeted areas.	Undertake monitoring.
Potential pest	Prevent potential pest plant becoming widely established.	Survey potential pest plants, wherever they occur in the region to gather information on their effects and distribution.
Progressive control	Reduce density and/or distribution with priority given to controlling isolated or satellite populations.	Inspect properties suspected of having pest plant. (ii) Carry out surveillance for pest plant. (ii) Undertake monitoring and investigations.
Restricted pest	Ensure restricted pests known to be present in the region are not knowingly spread by sale, propagation or distribution.	Regularly inspect places from which plants are being sold, propagated or distributed to determine the presence of

	Prevent the establishment of restricted pests known not to be present in the region.	restricted pests.
Suppression	No establishment in the canopy at more than 10% of sites inspected during the previous year.	Annually inspect a selection of properties with known infestations of pest plant.
Surveillance	Prevent establishment. Understand distributions, impacts and control options so that individual pests may be reassigned to other categories at next review. Voluntary control by land occupiers assisted by way of approved Council programmes. Collect information and keep records relating to the distribution, density and impacts of Surveillance Pest Plants.	Record and monitor infestations.
Total control/eradication	Achieve zero density by year x. Eradicate currently known populations by year x. Immediate control leading to eradication of new occurrences. Reduction in density and range on a targeted, planned basis. No increase in distribution Prevent reproduction (no mature or seeding plants).	Monitor the distribution and density of pest plant in the region. Inspect properties with known or suspected infestations of pest plant. Undertake monitoring, surveillance and destruction. Monitor the effectiveness of control work that has been undertaken. Carry out inspections to ensure all plants have been destroyed where occupiers carry out control of pest plant. Monitor for the presence of pest

	plants on properties surrounding known sites. Owing to the long-term viability of some seeds, monitoring should continue at all sites from which pest plant has been eradicated. Work with the community to inform occupiers of identification and control techniques.

Appendix 3: The 15 modules as outlined in The Weed Control Monitoring Standard Operating Procedure (SOP) (Department of Conservation 2001).

Module 1:	An introduction to the Standard Operating Procedure
Module 2:	An introduction to monitoring weed control.
Module 3:	Selecting Programmes for Monitoring and setting objectives
	Result Monitoring
Module 4	Deciding on methods for results monitoring
Module 5:	Organising fieldwork and data management
Module 6:	Marking and mapping infestations
Module 7:	Principles and standards for population sampling in result monitoring
Module 8:	Fieldwork for sampling
Module 9:	Photopoints
Module 10:	Analysing and evaluating result monitoring data
Module 11:	Weed control trials
Outcome Monitoring	
Module 12:	A method for outcome monitoring
Module 13:	Organising fieldwork and data management for outcome monitoring
Module 14:	Fieldwork for outcome monitoring
Module 15:	Analysing and evaluating outcome monitoring data

APPENDIX 4: The steps and accountabilities involved in planning, co-ordinating and delivering monitoring as outlined in New Zealand's Weed control Monitoring Standard Operating Procedure.

Steps	Key Points	Responsibility
	Monitoring of 1/3 of weed control programmes in the Conservancy is no longer a requirement, but is still a useful target.	Conservator
Step 1 Select programmes to monitor	Select priority weed control programmes for monitoring and ensure that adequate resources are allocated. Check the suitability of the weed control programmes that have been selected for monitoring by submitting them for review with appropriate people e.g., The Technical Support Officer (weeds) and peers. Enter the weed monitoring programme(s) you have decided on into the national Weed Control Monitoring Projects spreadsheet (wgncr-24615).	Weed Programme Manager (in the Area Office) and / or Conservancy Technical Support Unit
Step 2 Set monitoring objectives	Set measurable objectives for monitoring. Check the suitability of the monitoring objectives by submitting them for review by appropriate people e.g., Technical Support Officer (weeds) and peers	Weed Programme Manager (in the Area Office) and / or Conservancy Technical Support Unit

Step 3 Design monitoring	Choose a standard method for monitoring and refine this according to the objectives and the given weed control programme. Use the specification sheets to make sure you have covered all the information needed for monitoring. Allow about half a day in the field to pilot the chosen sampling method. If necessary, the method can be adjusted, providing it follows the principles outlined in this SOP. Include a plan for how data will be recorded, analysed, stored and used. Get the monitoring design reviewed by appropriate people e.g., Technical Support Officer (weeds) and peers Seek approval for the monitoring design from the Area Manager as part of the work plan approval process.	Weed Programme Manager (in the Area Office) and / or Conservancy Technical Support Unit
Step 4 Collect monitoring data	Carry out fieldwork and collect monitoring data. Record any details that will help re-measurement, e.g. plot location. For field assistance or advice at any stage of the weed control and monitoring programme, see TSOs, CAS or RDI.	Weed Programme Manager
Step 5 Manage data entry and storage	Store collected data as soon as possible after data collection and ensure that it is both safe and retrievable. If data collection and storage methods differ from what was planned, details shall be recorded so that monitoring is repeatable and understandable.	Weed Programme Manager (in the Area Office) and / or Conservancy Technical Support Unit

Step 6 Analyse data and evaluate objectives	As soon as possible after data collection, analyse the data to determine whether targets and objectives were met. For data analysis, evaluation and presentation of results, seek advice from peers, TSO (weeds), CAS, or RDI.	Weed Programme Manager (in the Area Office) and / or Conservancy Technical Support Unit
Step 7 Write report	Present the results and recommendations in a report, preferably in the same financial year that weed control was carried out. Also outline the monitoring objectives and how data were collected, analysed and stored in the report. Send the report to the Area Manager, or the TSM when it is produced by the TSU. Review of the methods and results of monitoring and weed control by peers, TSO (Weeds), CAS, RDI. Share the methods and results amongst people involved in weed management throughout DOC.	Weed Programme Manager (in the Area Office) and / or Conservancy Technical Support Unit
Step 8 Adjust weed control practice	Use the monitoring to inform and improve weed control. Modify the monitoring if needed.	Weed Programme Manager (in the Area Office) and / or Conservancy Technical Support Unit

Appendix 5: Objectives of the Invasive alien species section in the Kruger National Park

Alien Impact Objective

To anticipate, prevent entry, eradicate or minimise the influence of non-indigenous organisms so as to maintain the integrity of native biodiversity.

Sub-objectives

Strategic objective: Evaluate the overall scale of threat of alien species, assess organisational and infra-structural capacity in relation to realistic needs, and muster necessary resources to address any shortfall.

Prevention objective: To anticipate imminent or potential risks of entry of alien species into the KNP and set-up effective mechanisms to prevent such entry.

Eradication objective: Plan and implement eradication and/or control campaigns for alien species already within the KNP.

Prohibit/discourage objective: Prohibit the use of invasive alien species and discourage the establishment or utilitarian/recreational use of any alien species. In rest camps the only alien species currently allowed are *Dactylocenium australis*, *Stenophratum dimidiatum* and *S. secundatum* as lawn species.

Research objective: Develop an understanding of the practically relevant aspects of specific alien species and their control, usually in the following areas:

- Autecology of alien species, especially reproduction and dispersal
- Their effect on biodiversity
- Efficacy of control measures, including cost effectiveness and environmental acceptability
- Environmental impact of control operations and practical recommendations to improve the basis of control.

Awareness objective: To promote an awareness of especially the long-term dangers of alien species, by influencing perceptions of staff and public in such a way as to achieve willing active support for counter measures.

Appendix 6: List of project managers that were interviewed in this project

Name	Interviewed	Area	Contact details
Dinah Cloete	√	Northern Cape - (Viooldrift)	(027) 718 2678
Elize Pienaar	√	Free State - (Modder River)	(053) 831 2273/8359 082 4156773
Timothy Jack	√	Western Cape - (Assegaaibosch)	(021) 876 206
James Jansen	√	Eastern Cape - (Sand/Bulk)	(043) 701 0336 076 2267 423
Myles van der Byl	X	KZN (Richmond)	(033) 239 1301 084 499 7751
Charles Ngwenya	√	Gauteng - (Soshanguve)	(012) 392 1400 083 341 6375
Henry Segone	√	NWest - (Koster and Buffelshoek)	(018) 642 3535 082 807 5655
Curtis Mabaso	√	Mpumalanga - (Vygeboom)	082 908 4803
Werner Roux	√	Limpopo - (Mokolo Project - now area manager)	(014) 717 4912 082 469 4341
Garth Brook	X	SANPARKS - (Clarens Training Centre)	(012) 426 5000
[4]*Raymond Pretorius (Assistant project manager)	√	Western Cape (Calvinia)	(027) 341 8100
*Patrick Jeftas	√	Western Cape (Citrusdal)	084 548 2572

[4] Additional project managers interviewed