A GOAL MAINTENANCE SYSTEM FOR THE MANAGEMENT OF THE KRUGER NATIONAL PARKS RIVERINE ALIEN VEGETATION: DEVELOPING A PROTOCOL AND A PROTOTYPE

by

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Executive Summary

Introduction

Management requires explicit operational goals, the means to know if those goals are being achieved, and institutional structures that can adapt management techniques and protocols to new goals, information and data (Christensen, 1997). Auditing the effects of management decisions in the context of the management goals is necessary to evaluate the extent to which those goals are being met (Rogers and Biggs, 1999).

Goal Maintenance System

A Goal Maintenance System (GMS) is a tool to help managers understand, manage and improve operations. It is a means of monitoring and auditing progress, to check how well the organisation is meeting its conservation goals, and to reveal when improvements to operations are necessary. The protocol developed in this study provides a disciplined, systematic approach to enable the development of a GMS (Chapter Two) which encourages commitment from all stakeholders. However, each organisation is unique and so should follow its own path in developing a Goal Maintenance System.

Prototype GMS for the control of Riverine Alien Vegetation

Invasive alien plants are considered to be the single most important threat to the biodiversity of the Kruger National Park (Braack, 1997). Alien species, particularly plants, are increasing in abundance and frequency in the KNP with 214 species recorded to date. Some of these invasive plant species, such as *Lantana camara* and *Opuntia stricta* have already invaded thousands of hectares of land, forming impenetrable thickets in places. Alien aquatic weeds (*Azolla, Eichornia, Pistia* and *Salvinia*) have also formed dense mats on various water bodies throughout the KNP.

The Kruger National Park Rivers Research Programme decided to focus attention on alien vegetation along riverine areas in developing a protocol for the GMS. Although the development of the Alien Vegetation GMS is still in progress, the available details are presented in Chapter Two.

Acknowledgements

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CHAPTER ONE

Project Origin and Purpose

1.1 Introduction

Ecosystem management has been defined as management driven by **objectives** and **explicit goals**. It is made adaptable by **monitoring** and research based on the best available understanding of the ecological interactions and processes necessary to sustain ecosystem composition, structure and function (Christensen, 1997). Management requires explicit operational goals, the means to know if these goals are being achieved, and institutional structures that can adjust and adapt management techniques and protocols according to new goals, information and data (Christensen, 1997).

Auditing the effects of management decisions in the context of the management goals is necessary to evaluate the extent to which those goals are being met (Rogers and Biggs, 1999). A Goal Maintenance System (GMS) is a tool to help managers to understand, manage and improve the functioning of the organisation. It is a means of monitoring and auditing progress, to check how well the organisation is meeting its conservation goals, if it is meeting its goals, and if and when improvements to operations are necessary. Participants in an activity need to know what outcome is expected, where their work contributes to a particular goal, what progress is being made, and what to do if results are not occurring as they should (DOE, 1995).

A major strategy of the Kruger National Parks Rivers Research Programme (KNPRRP) has been to develop a consultative management process (Figure 1.1) in which interactions between stakeholders, managers and researchers are facilitated. A protocol for an objectives hierarchy was developed to service this management process (Refer to Rogers and Bestbier, 1997 for details). A comprehensive objectives hierarchy for the management of the Kruger National park was developed using this protocol (Braack, 1997; Rogers and Bestbier, 1997). Effective measurement of goal attainment (monitoring/auditing) must be an integral part of the management process (Kaplan and Norton, 1993) to ensure that the organisation 'stays on track'.

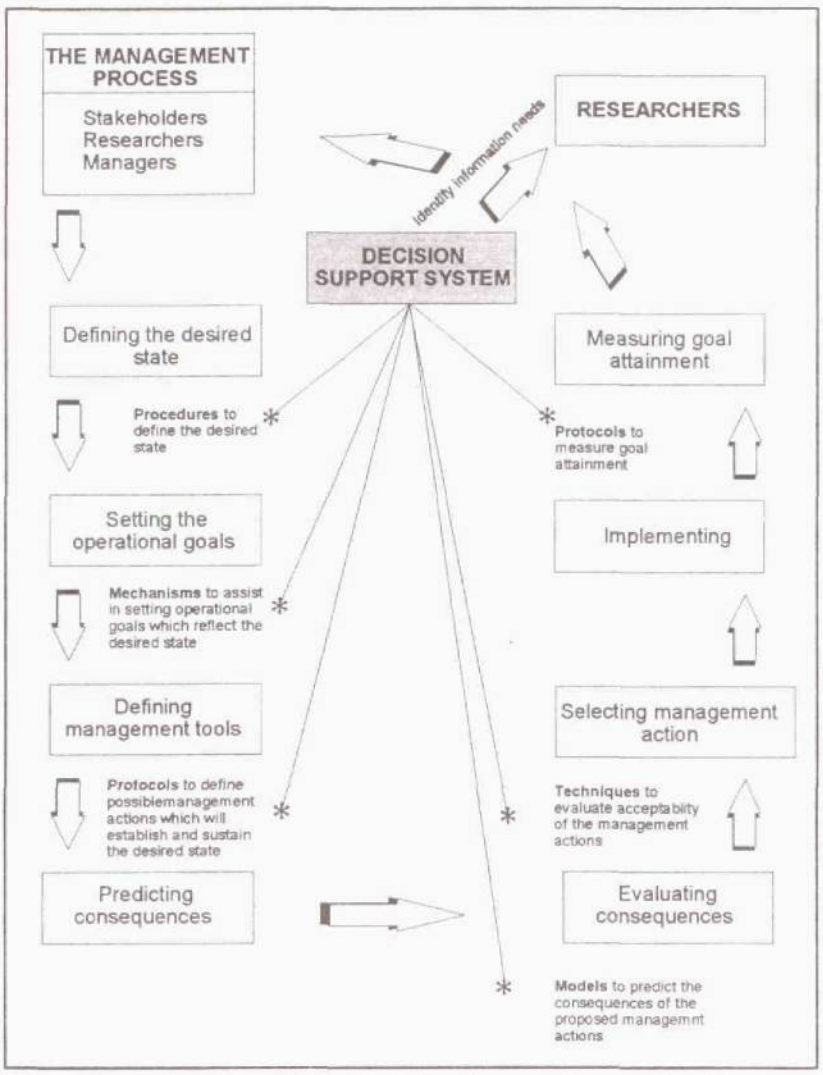


Figure 1.1. Elements of the Decision Support System for the Kruger National Park Rivers Research Programme and their relationship to the management process (after Breen *et al*, 1994).

The next step is to operationalise the objectives hierarchy. To do this, a system needs to be developed to ensure that once goals have been set and accepted, they are met, revised, audited and, when necessary, reintegrated into the management process. This is called the Goal Maintenance System (GMS). Although Rogers and Bestbier (1997) developed a very basic protocol for a GMS (Figure 1.2), it was not comprehensive enough to be useful in operationalising an objectives hierarchy (refer to Section 1.2). The purpose of this project was to address this need, and to develop the basic protocol further to provide managers and scientists with a system for cross referencing their intentions and actions.

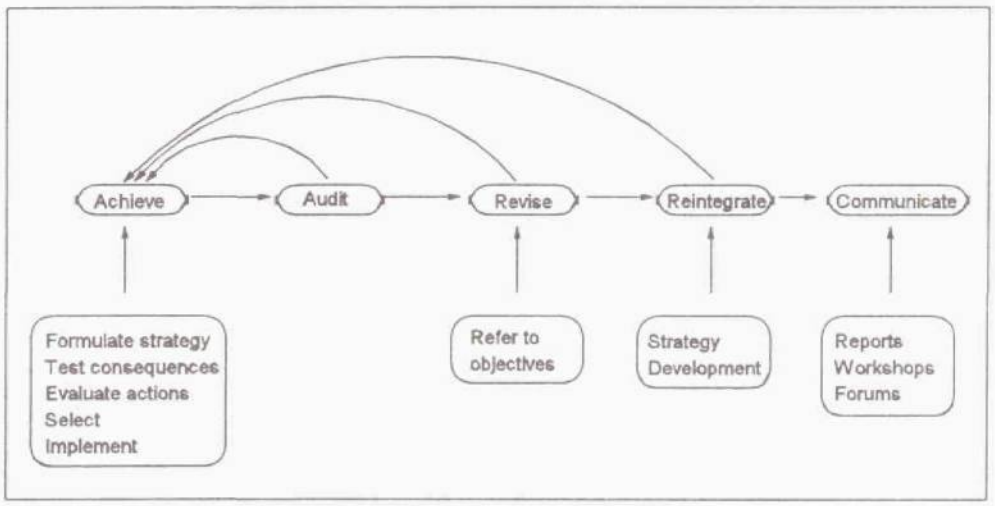


Figure 1.2. Goal Maintenance System (from Rogers and Bestbier, 1997).

1.2 The Objectives Hierarchy concept

The objectives hierarchy serves as a focal point for an organisation's actions and for defining and communicating priorities. The objectives hierarchy begins at the coarsest level with the organisation's "vision" for management (Rogers and Bestbier, 1997). The protocol provides a step-by-step process (Figure 1.3) for decomposing the vision into a series of "objectives" of increasing focus, rigour and achievability. The finest level of the hierarchy is defined by achievable goals which may be either "institutional goals" or "conservation goals". Institutional goals define achievable targets for managing institutional structures and processes. Conservation goals define endpoints for ecosystem management. The higher level vision and objectives serve upper management levels with statements of strategic intent, while the low level goals provide on-the-ground managers with specific, spatially and temporally bounded targets. These specific ecological endpoints are termed Thresholds of Potential Concern (TPCs) (Rogers and Bestbier, 1997).

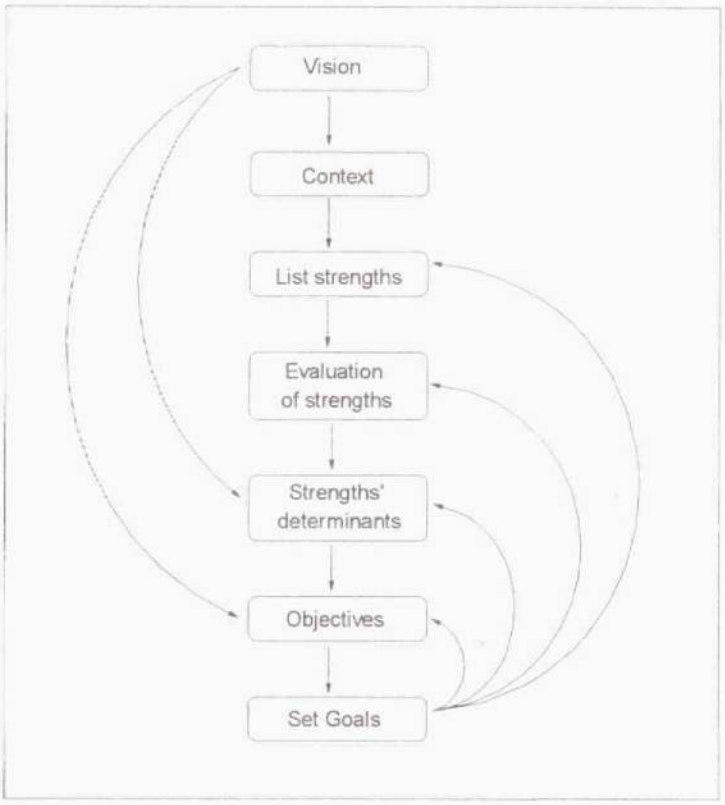


Figure 1.3 Protocol for developing an objectives hierarchy by translating the vision into operational goals (after Rogers and Bestbier, 1997).

TPCs are described by a range of spatially and temporally bounded "criteria" which indicate system response to the main potential agent of change (Rogers and Biggs, 1999). TPCs represent statements or hypotheses of limits of acceptable change in ecosystem structure, function and composition. TPCs might initially be established at somewhat arbitrary levels if the information base is limited. However a corollary to their use is that they must be integrated into a well structured monitoring programme where they act as "red flags" or "amber lights" which direct management. Integrated monitoring, research, and modelling track the criteria relative to the TPCs and audit whether management action or recalibration of the TPC is needed (Rogers and Biggs, 1999).

A structured monitoring/auditing programme is therefore needed to assess changes in the TPC criteria and to feed the data back to the managers and scientists. A Goal Maintenance System provides an iterative internal auditing system to promote interaction between managers. In addition, the GMS encourages feedback between managers and scientists by ensuring that once

acceptable goals have been set they are **met**, **revised**, **audited** and, when necessary, **reintegrated** into the management process. Proper documentation of decisions taken and the reasoning behind them provides the institutional memory needed to keep future management "on track".

1.3 Objectives of this project

The general aim of this project was to develop a protocol for a GMS to service conservation management. To achieve this aim the following specific objectives were pursued:

1. Develop a system to audit the attainment of the KNP's alien vegetation goals.

2. Develop a protocol for designing and developing a goal maintenance system for conservation management.

1.4 Approach to developing the protocol

The approach adopted in this project was :

Objective 1. *Develop a system to audit the attainment of alien vegetation control/eradication goals within the KNP.*

- Decide which species will be monitored.
- Document the flow of information between KNP personnel responsible for alien vegetation management, including what information they receive, what information they need and for what purpose.
- Review the KNP's current strategies and approaches to measuring performance and goal attainment, and identify the KNP's key shortcomings taking local conditions into consideration.
- Using the outcome of the above, design and refine, with numerous iterations, a prototype goal maintenance system for the management of alien vegetation in the KNP to ensure feedback into the objectives hierarchy.

Objective 2. *Develop a protocol for designing and developing a goal maintenance system in conservation systems.*

- Use literature and the outcomes of objective one to formalise, with hindsight, the sequence of events and processes used in developing the goal maintenance system.

CHAPTER TWO

A Prototype Goal Maintenance System for the Management of Riverine Alien Vegetation in the KNP

2.1 Introduction

Invasive alien plants are considered to be the single most important threat to the biodiversity of the Kruger National Park (Braack, 1997). Aliens species, particularly plants, are increasing in abundance and frequency in the KNP with 214 species recorded to date. Some of these invasive plant species (*Lantana camara* and *Opuntia stricta*) have already invaded thousands of hectares of land, forming impenetrable thickets in places. Also, alien aquatic weeds (*Azolla, Eichornia, Pistia* and *Salvinia*) have formed dense mats on various water bodies throughout the KNP.

In the past there was no formal procedure for the management of alien vegetation in the KNP. If the rangers noticed alien vegetation, they would record it in their diaries, which were sent to scientific services once a month. The information which they recorded was anecdotal, and lacked specific detail (such as the exact location and density of the invasion). This method has proved unsatisfactory, and a step-wise procedure for setting and achieving goals is needed to ensure that alien vegetation is controlled within the KNP.

The Kruger National Park Rivers Research Programme decided to focus attention on alien vegetation along riverine areas in developing a protocol for the GMS. Each organisation is unique and so follows its own path for developing a Goal Maintenance System (GMS). However, the following protocol can enable the creation of a GMS by providing a disciplined, systematic approach. Commitment to the GMS from the various stake-holders, such as managers, scientists and non-government organisations, is essential.

The protocol outlined here (Figure 2.1) is specifically for conservation goals. It will need slightly different interpretations for institutional goals, although the principles embodied in the steps remain the same for both types of goals.

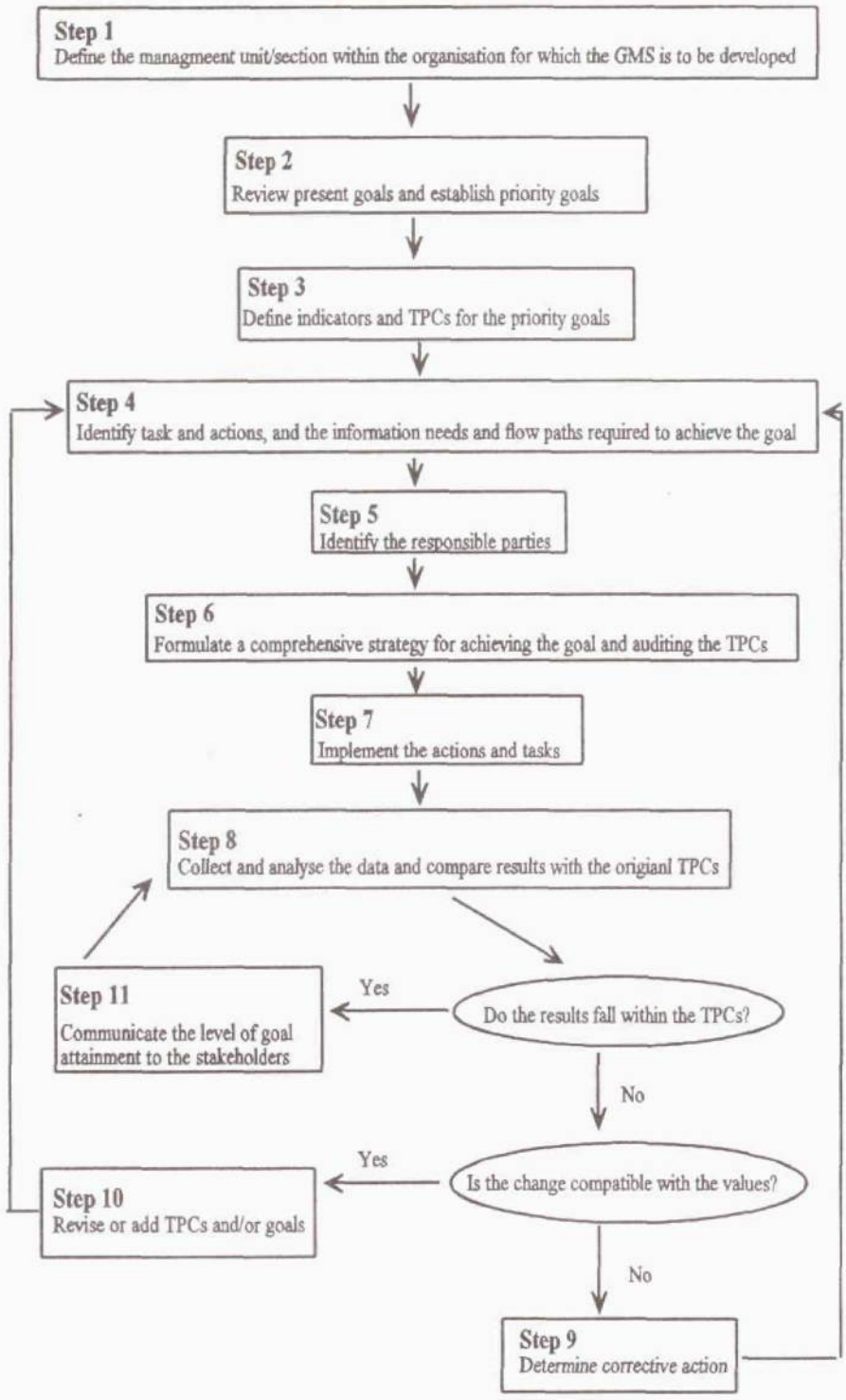


Figure 2.1 Protocol for developing a goal maintenance system

2.2 Developing a Goal Maintenance System

The protocol provides a step-by-step process for developing a GMS. Where appropriate, key questions to prompt thinking about the type of output required at each step is provided. The output at each step relates specifically to managing alien vegetation in the KNP. The prototype alien vegetation GMS was developed in conjunction with personnel from the Alien Biota Section, Scientific Services, and Regional and Sectional rangers.

1. Define the management unit/section within the organisation for which the GMS is to be developed

Protocol Steps

Identify, or define, the management section within the organisation for which the GMS is needed eg alien vegetation control unit. This may be an individual or a team of workers.

This step is especially important in large organisations as there are many different functions performed by various units/sections.

KNP Output

Within the KNP, the **Alien Biota Section** was pinpointed as being a good starting point for developing a goal maintenance system, as alien vegetation is considered to be the number one threat to biodiversity in the KNP. The responsibility for alien vegetation management falls mainly within this section.

Output:

Clear definition of section/unit.

2. *Review present goals and establish priority goals*

Protocol Steps

Conduct interviews with individuals within the section to obtain their input on the section's objectives hierarchy and their proposals to operationalise the objectives hierarchy. This builds commitment and clarifies expectations. The key question for managers to ask is:

Why are we doing this work?

In the light of this self assessment review the goals that have been set and, if necessary, change the goals.

Establish which are the priority goals, systematically balancing resource constraints and effort to decide what needs to be done and how.

Output:

List of goals of the section/unit.
A revised list of the priority goals.

KNP Output

The objectives and goals for the alien vegetation management (Figures 2.2 and 2.3) were reviewed in light of the 'core' business of the alien biota section, which is eradicating and preventing the spread of alien biota. The goals as they stand were deemed acceptable for the purposes of this project and no significant changes were made at the time (mid 1998).

The priority goal for the management of alien vegetation is to:

"Plan, develop, implement and monitor attainment of specific control programmes to counter each threat identified."

The following species were identified as target species for developing the prototype GMS: *Lantana camara, Opuntia stricta* and aquatic alien plants (*Azolla, Eichornia, Pistia* and *Salvinia*). *Lantana camara* is mainly found in riverine areas and can form impenetrable thickets. *Opuntia stricta* is found throughout the park, not only along riverine zones.

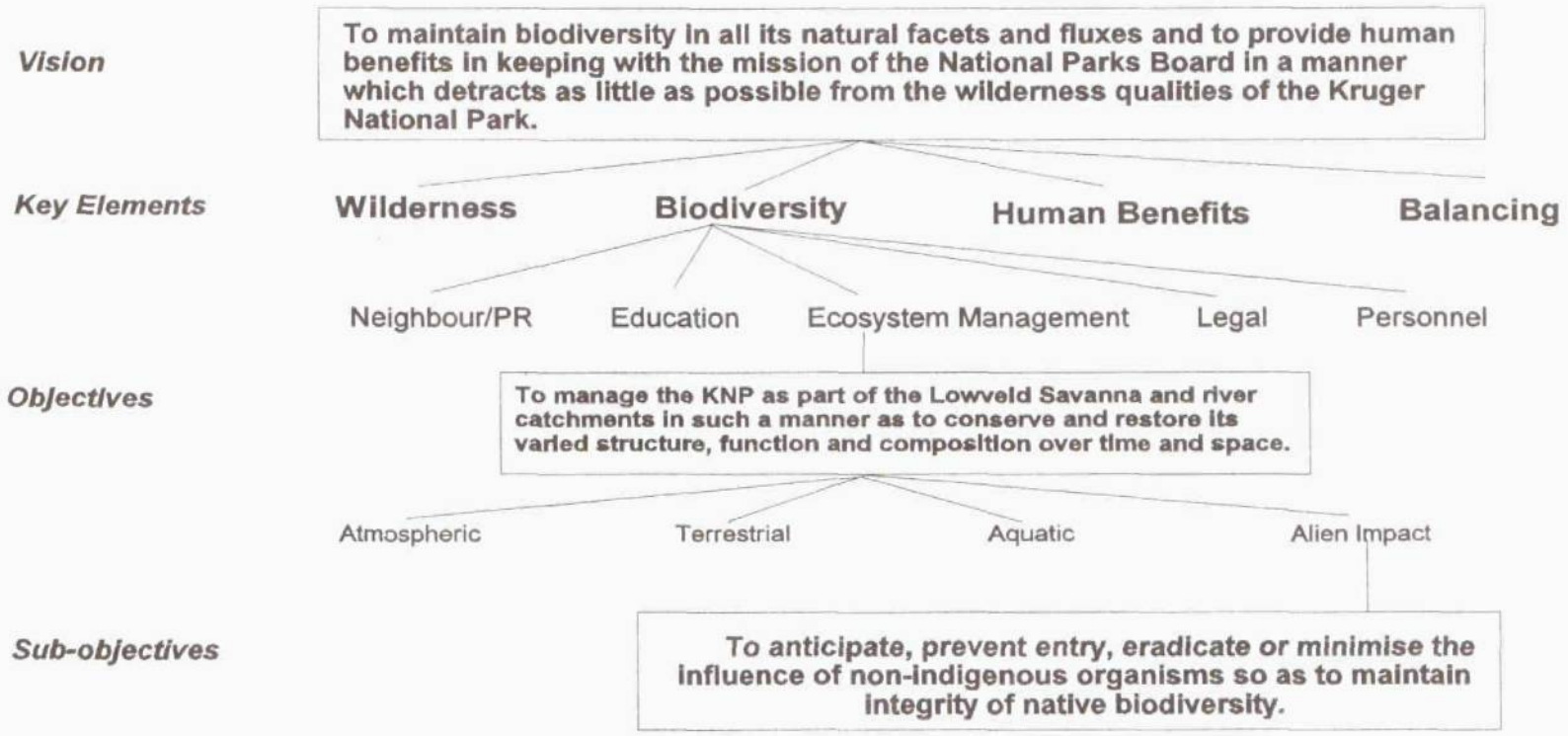


Figure 2.2 Abridged objectives hierarchy of the KNP, highlighting the alien biota control objectives (after Braack, 1997)

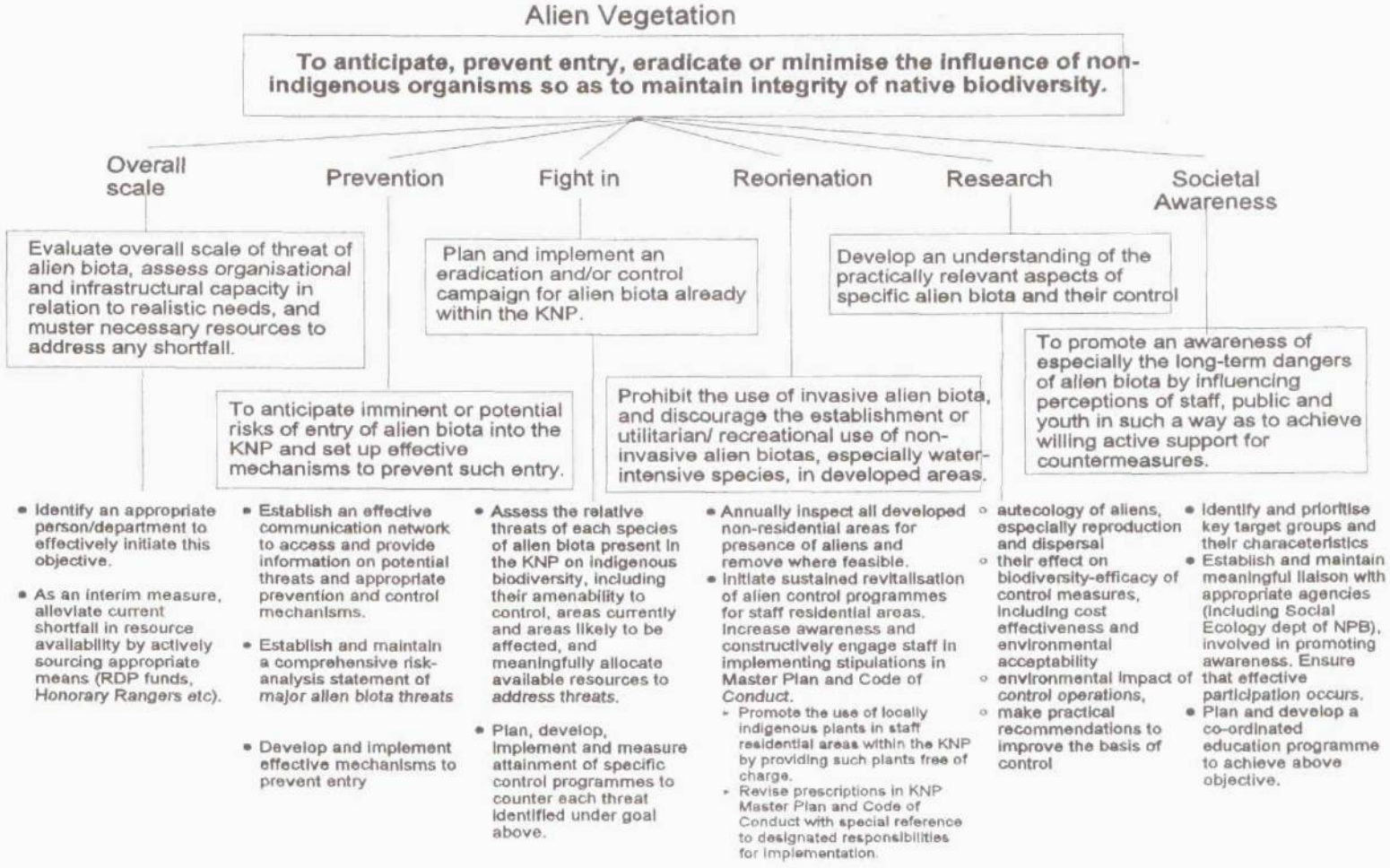


Figure 2.3 Objectives hierarchy for the control of alien biota (after Braack, 1997)

3. Define indicators and TPCs for the priority goals

Protocol Steps

Scientifically rigorous, spatially and temporally bounded targets of ecosystem condition must be specified for conservation goals. These targets are termed TPCs and act as amber lights to warn managers of possible unacceptable environmental change (Rogers and Bestbier, 1997; Rogers and Biggs, 1999). They form the basis of the auditing component of the GMS, as they are invariably hypotheses of limits of acceptable change in ecosystem structure, function and composition. As such their validity and appropriateness are always open to challenge, and they must be adaptively modified as understanding of the systems being managed improves (Rogers and Biggs, 1999). Refer to Box 1 for more details on how to define TPCs.

Output:

Comprehensive TPC tables.

Box 1: Setting TPCs (Rogers and Bestbier, 1997)

1. Define the criteria (indicators) to be measured.
2. Define the spatial and temporal scales of measurement.
3. Describe the sampling method and techniques.
4. State the upper and lower levels of the Threshold for Probable Concern (end point).
5. Provide the rationale for selection of the criteria and TPC.
6. Prioritise and rationalise the derived TPCs to provide a manageable monitoring programme.

KNP Output

Thresholds of probable concern (TPCs) are the same for all of the species (Table 2.1). Additional information can be obtained from the Scientific Services Home Page:

http://www.parks-sa.co.za

Table 2.1 Abridged table of thresholds of probable concern for monitoring the control of alien vegetation in the Kruger National Park.

Measurement Criteria	**Measurement Units**	**Measurement Scale**	**Thresholds of probable concern**	**Rationale**
Distribution	Hectares/point occurrence	Landscape scale annually.	Any new species recorded, or an extension of range (contiguous or non-contiguous).	Prevention is better than cure. Earlier detection results in lower costs.
Density/ frequency	Plant cover or sample frequency	Annual	When density increases by two or more classes.	To detect changes and reviewing priority status.
Rate of spread	Hectares	Annual	When the number of new units infected is greater than the number of blocks cleared.	To determine efficiency of control measures.

4. Identify the tasks and actions, and the information needs and flow paths required to achieve the goal

To improve the chances of meeting the goals we need to understand the operational structure that underlies the effort (DOE, 1995). A flow diagram is an invaluable tool and the best way to understand a process (DOE 1995). Flowcharting the entire process of achieving a particular goal, down to task level, sets the stage for developing a GMS. All parties who are involved should participate in creating the flowcharts. As participants, you can later count on their support to make the GMS work (DOE, 1995).

To generate useful information, planning for good data collection proceeds along the following lines (DOE, 1995):

What TPC/hypothesis is being addressed?

How will the correct answers be recognised and communicated?

What type of data does auditing of the TPC require?

What data analysis tools are envisioned?

How will the results be communicated to the relevant parties?

Where are the raw data to be collected?

How will the data be collected, how often and by whom?

Where in the process can these data be obtained?

Who in the process can provide these data?

How can these data be collected from people with minimum effort and chance of error?

What additional information is needed for future analysis?

When this project began there were very rudimentary processes in place to report on alien eradication and presence (Figure 2.4). The sectional rangers were to report in their diaries what they accomplished on a daily basis. Anecdotal information was also included, such as sighting of kills or rare birds. In this way the presence of some alien vegetation was recorded. However, this did not provide the scientists with any quantitative feedback that they could use to refine their measurements and assess the extent of the threat. Another shortcoming was that there was no alien vegetation researcher within the park.

The rangers' diaries were sent to scientific services once a month and were captured digitally according to various categories such as fire outbreaks, animal sightings and alien vegetation. This information was then printed out and distributed to the managers and scientists involved in the respective categories. The alien vegetation printout was therefore handed to the alien biota manager once a month. The alien biota manager assessed the information to determine if any action was necessary, especially if a new alien species had been reported.

The existing system of data collection was inadequate because only anecdotal information, and no specific data were recorded by the rangers who undertook alien clearing. Much of the control of alien plants was therefore based on *ad hoc,* crisis management. A more systematic method of managing alien vegetation was therefore needed. A new management plan is suggested below (KNP output and Figure 2.5).

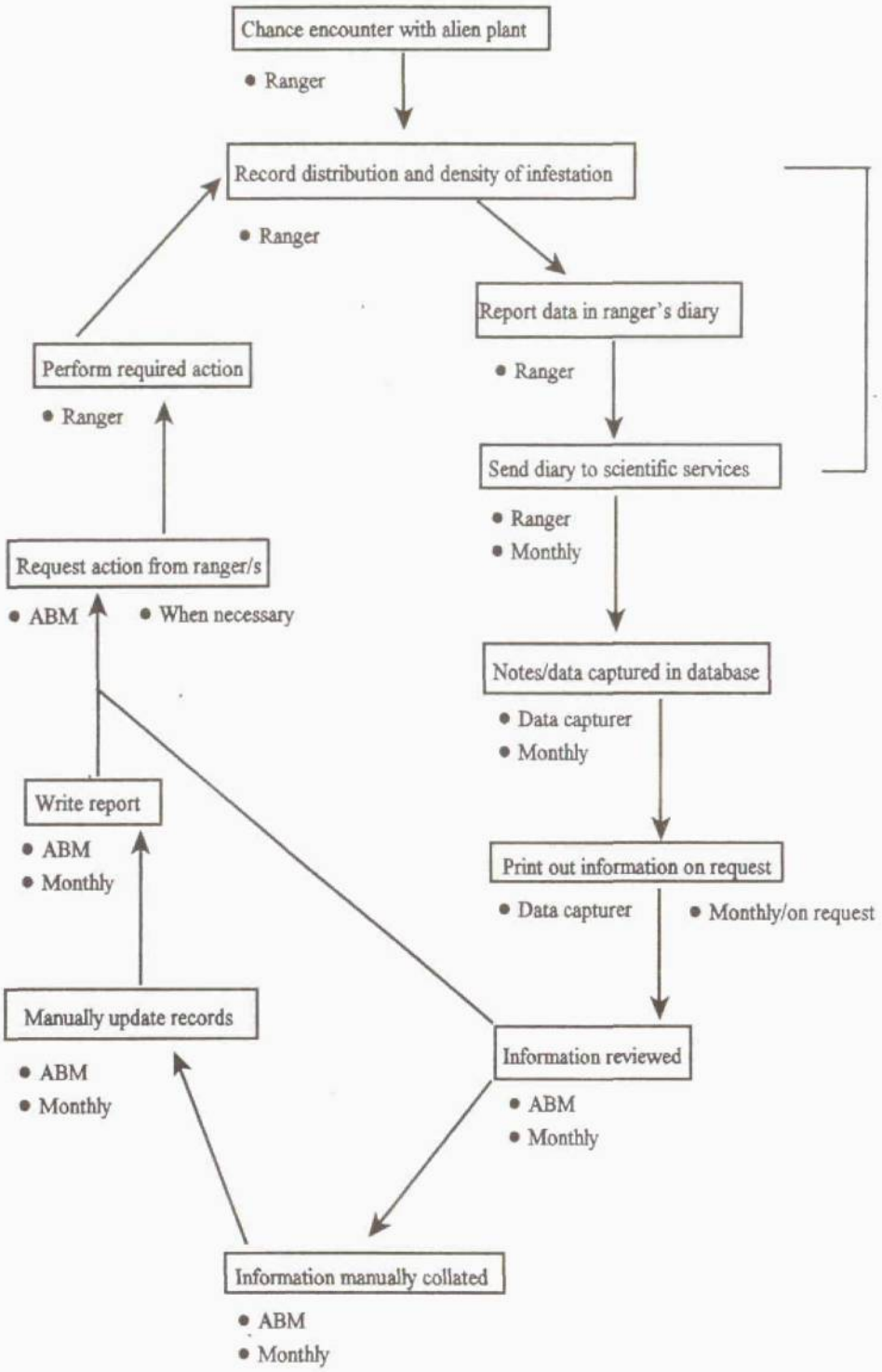


Figure 2.4 Previous pathway of alien vegetation information flow

(ABM = Alien Biota Manager)

Protocol Steps

Identifying the actions that must be taken to achieve the goal is a key step for institutional change. The key questions to ask at this stage are:

What needs to be done to achieve the goal and how should it be done?

What is being done at the moment? How is it being done at the moment?

What needs to change in order to do it properly and how should it change?

Identify the information and the pathways of information flow needed to achieve the goal and to audit the TPCs. Review how data are collected and how the information is transferred to the responsible parties (see step 5).

At this step much thought is required about the information needed to achieve the goal. The key question is:

"What do I/we want to know about this goal?".

The key issue then becomes:

"How is the required information generated?"

Output:

A list of key processes and information, and a flow diagram of information flow to achieve and audit the goals.

KNP Output

The following list of actions is required to "Plan, develop, implement and monitor attainment of specific control programmes to counter each threat identified":

Identify infested areas by systematically surveying the landscape.

When infested areas are encountered record their coordinates using a GPS.

Record and map their overall distribution.

Record the density of the infection.

Send a comprehensive standardised report to the alien biota manager (eg Figure 2.6).

Digitise the distribution, and add densities to the database.

Formulate an eradication plan using the above information.

Select tasks and milestones according to time, manpower, equipment and financial constraints.

Determine whether the rate of spread is greater than the rate of clearing.

Act accordingly.

Figure 2.5 illustrates the information flow needed for the successful control of alien vegetation.

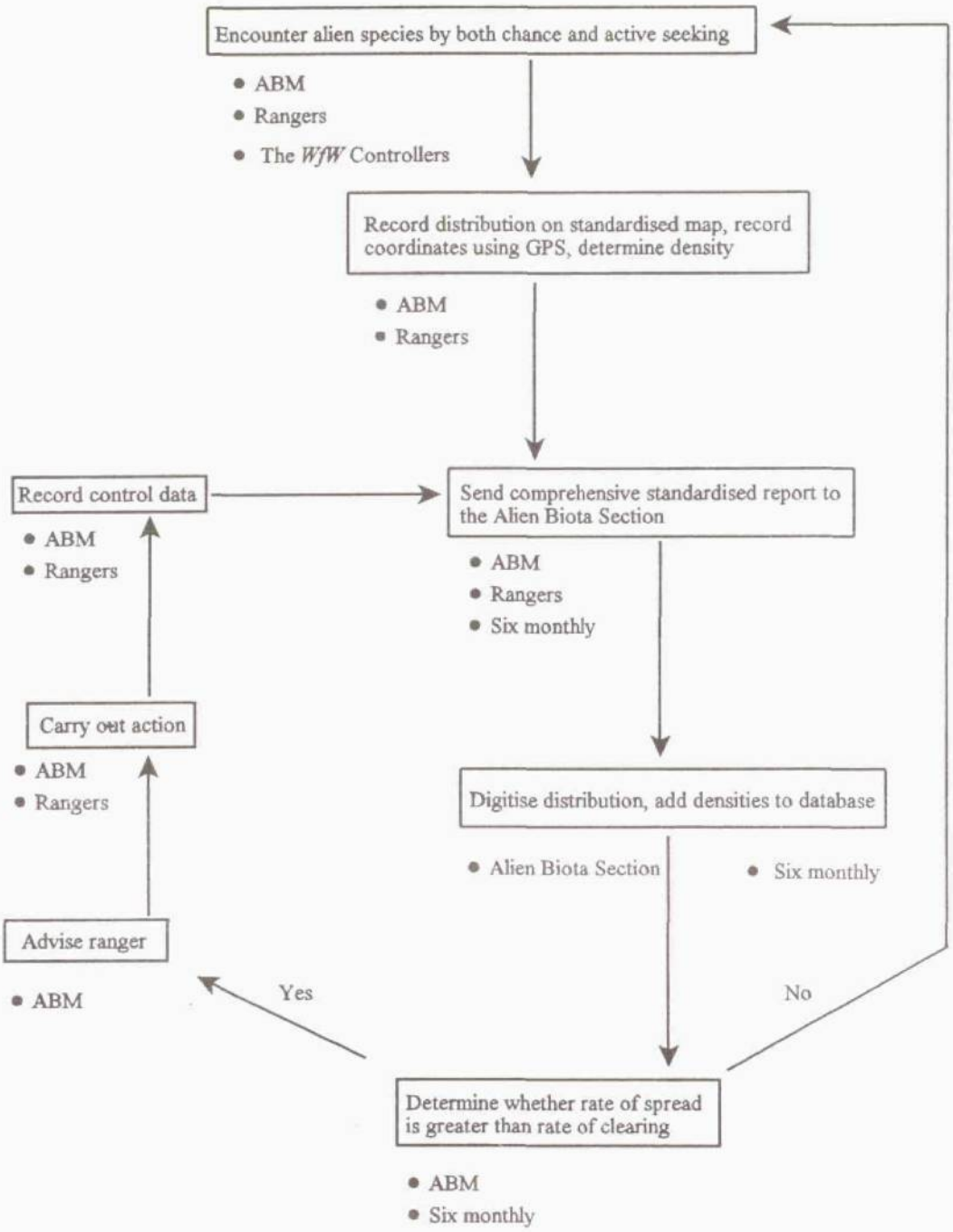


Figure 2.5 The information flow necessary to achieve goal maintenance

ALIEN PLANT DISTRIBUTION

SECTION: SKUKUZA
SECTION/FIELD RANGER:
_____
DATE: _____
SPECIES: *Opuntia*
Tick appropriate block.
CLEARED/TREATED ☐
UNCLEARED/UNTREATED ☐
IF CLEARED/TREATED INDICATE TREATMENT_____

Please use the following key to indicate the density of *Opuntia* on the grid.

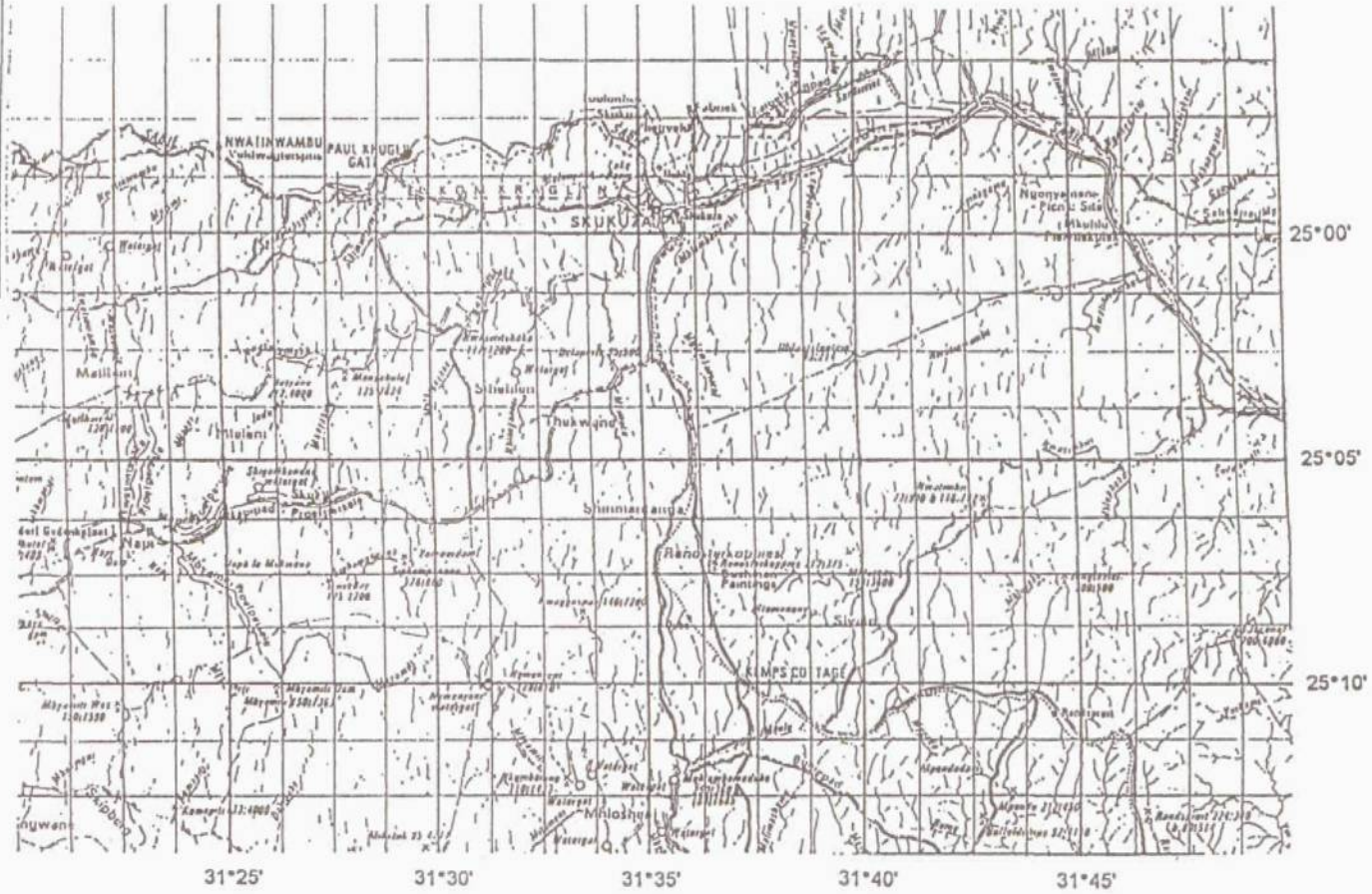
Code	Density
1	Very low
2	Low
3	Medium
4	High

Where possible divide the grid block into four. E.g. ☐ → ⊞

Fill in each sub-block with the density code. E.g. 1|2 / 2|4

If you have GPS coordinates for particular stands of *Opuntia*, or single plants, please indicate on the sheet as well.

Please return this sheet, with the control data sheet, to Alien Biota section.



SKAAL 1 : 250 000 SCALE

Meter 0 4 000 8 000 12 000 16 000 Metres

Landmyl 0 2 4 6 8 10 Statute Miles

Figure 2.6 Example of a report which the ranger at Skukuza should complete for the species *Opuntia stricta*

5. *Identify the responsible parties*

Protocol Steps

The results of the data collection must be communicated back to the responsible worker and/or decision maker, so that they can take appropriate action. Thus a basic feedback loop must be defined to ensure effective and efficient operation.

At this stage define people/parties responsible for:
Collecting data,
Analysing and reporting the data,
Comparing the data to the goal,
Determining if corrective action is needed,
Making operational changes to ensure the attainability of the goal.

Output:

A list of people and their areas of responsibility.

KNP Output

Within the KNP, the following people should be responsible for:

Collecting data - sectional rangers and the alien biota manager.

Analysing and reporting actual performance - alien biota manager.

Comparing the actual to the goal - alien biota manager.

Determining if corrective action is needed - alien biota manager.

Making changes to ensure attainability of goal - alien biota manager, regional rangers and sectional rangers.

6. *Formulate a comprehensive strategy for achieving the goal and auditing the TPCs*

Protocol Steps

Consolidate the results from the above steps and formulate a comprehensive strategy to achieve the goals and audit the TPCs. Define and select actions, tasks and milestones appropriate for achieving the goals and measuring the TPCs. Evaluate the actions relative to the goals. Is the effort warranted and is it within resource constraints?

Output:

A comprehensive strategy for achieving the goal and measuring the TPCs.

KNP Output

The first step in formulating a strategy for eradicating alien vegetation and monitoring the TPC of spread exceeding control was to determine where the aliens are distributed and in what densities. This is fundamental to the development of any plan and to the development of a GMS.

A system whereby the distribution of aliens within the KNP can be mapped was devised and was tested in the Lower Sabie section with the assistance of Flip Nel and the rangers from Malelane and Tshokwane. Grided A4 maps of the KNP's sections were sent to each of the sections, and the rangers were asked to map the known distribution of the alien species and estimate densities within their section (Figure 2.6)

The distribution of aliens removed along riverine areas has been mapped by the regional rangers at a scale of 1:250 000, and is currently being digitised by the alien biota section. The vision is to develop an alien vegetation GIS system which will provide the alien biota manager, rangers, and scientists with up-to-date status reports and data on the control of alien vegetation, and which will reveal whether the TPCs are being approached or exceeded.

7. Implement the actions and tasks to achieve the goal

Mobilise resources to implement the tasks and actions to achieve the goals.
Check that the actions for achieving the goals have been implemented as prescribed according to the set deadlines/timeframes.

OUTPUT: Implemented plan
This is not yet complete for the management of alien vegetation in the KNP.

8. Collect and analyse the data and compare the results with the original TPCs

Collect the data for the TPCs and feed them back to the relevant people. The data are then captured and analysed using the predefined data analysis tools.

The results from the analysis of the data are compared to the original TPCs, to determine if the TPC has been reached. Once the comparison against the TPC has been made, there are several alternatives to follow (Rogers and Biggs, 1999):

1. If the results fall within the TPC, continue monitoring. The data collection cycle continues. Go to Step 11.
2. If they fall beyond the TPC then the cause, degree and nature of change is assessed relative to the values embodied in the higher level objectives and vision statement:
    a) If the change is <u>not</u> compatible with the values, appropriate action must be taken to address the cause of change. Go to Step 9.
    b) If the change is compatible with these values feed the information back to the researchers for them to test its validity. Go to Step 10.

OUTPUT:

1) A list of data. Data should be checked for accuracy and reliability as they are being collected.
2) Presentation of the data in an appropriate form, eg report, to relevant parties such as high level managers and stakeholders.

3) Decision based on results.

9. Determine what corrective action is needed and make operational changes

Determine what actions are required to address the cause of change in the TPC. Formulate an action plan to address the cause of change and implement it.

OUTPUT: Action plan to implement operational changes.
Implementation of action plan.

10. Revise or add TPCs and/or goals

If the change in the TPC is compatible with the values of the organisation's objectives hierarchy feed the information back to the researchers for them to test its validity. Changes then need to be made to bring the TPC back in line with the objectives hierarchy.

Goals will normally only be changed if a change occurs at a higher level in the Objectives Hierarchy. This rule reduces the chance of goals being changed as a result of a change in staff or their enthusiasm (Blackmore, 1995).

Goals (and TPCs) could be modified when:

1. There is strong motivation that a goal has been poorly or loosely defined,
2. There is a change in the understanding of the potential of the reference system being managed, or
3. The full implications of the goal where not clearly understood (Blackmore, 1995).

New goals could be generated when:

1. Previous goals have been achieved.
2. The work processes change.
3. Policy/objectives change.

If goals have been revised or new goals generated ensure that they are harmonious with the existing goals and objectives. Note that the *ad hoc* addition of goals without careful reintegration will erode the integrity of the goal orientated process.

OUTPUT: New goals, new TPCs or no change.

11. Actively communicate the goals and their attainment to the stakeholders

Goals, TPCs and their attainment need to be actively communicated so that people at all levels of management are aware of the status of the ecosystem and their role within it.

Reports, workshops, meetings and fora are effective means of communication.

2.3 Conclusion

This prototype is still in its infancy and requires much refinement and further development. It is critical that someone "champion" and thus facilitate its implementation and further development. The commitment of the regional and sectional rangers is also critical, as they should provide much of the necessary data and are involved in the hands-on implementation of the plan to control and ultimately eradicate aliens.

To conclude, the GMS should provide a means of auditing goal achievement and ultimately feed back to the evaluation of the policies of the KNP to ensure effective and efficient ecosystem management.

CHAPTER THREE

A Protocol for Developing a Goal Maintenance System

The second objective of the study was to develop a protocol for developing a goal maintenance system to be used for the management of various components of the system. The steps are the same as those described in Chapter Two, although in the protocol they are more general and do not relate to a specific problem (such as the control of alien vegetation). They can therefore be used to develop a goal maintenance system for any aspect of conservation (Figure 3.1).

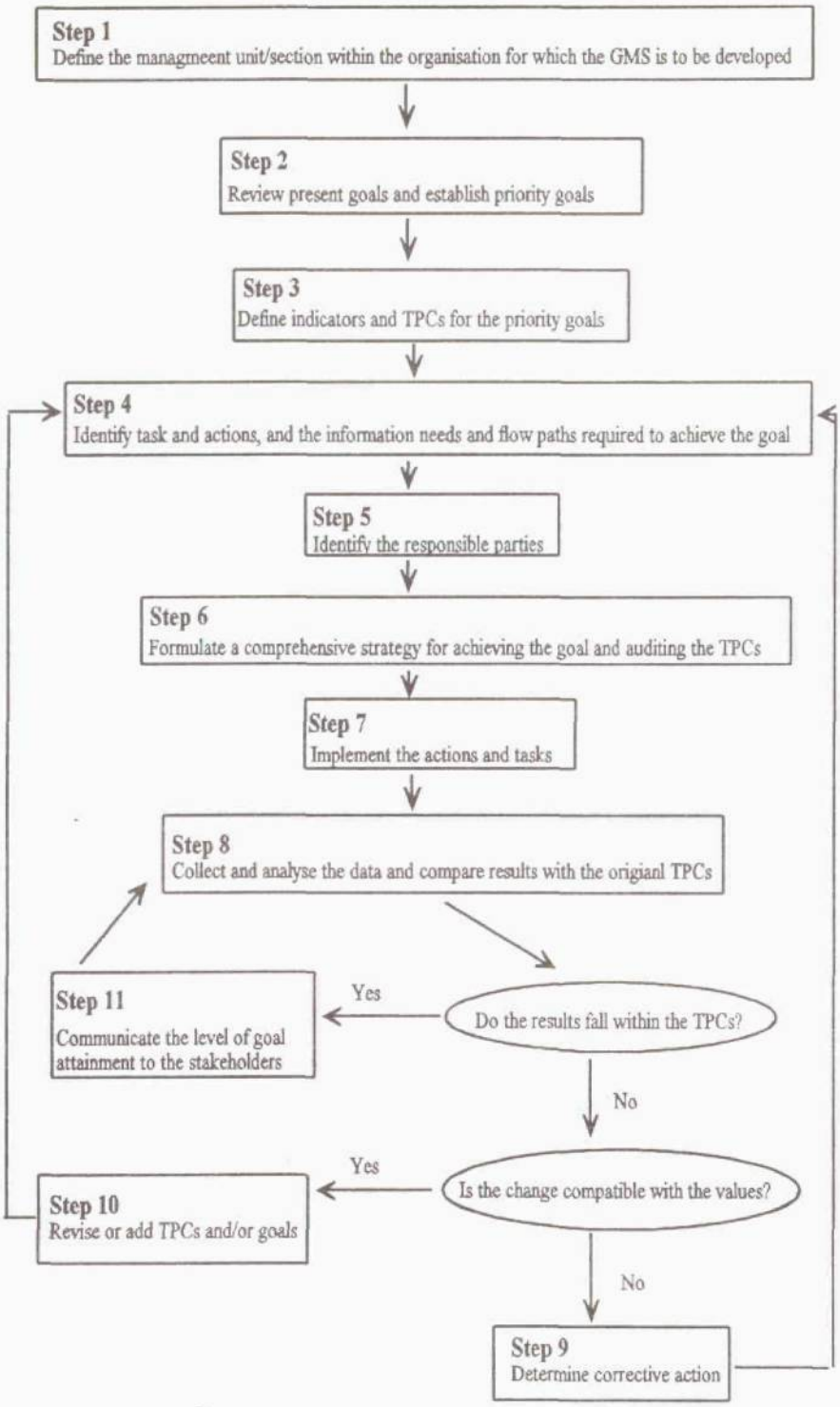


Figure 3.1 Protocol for developing a goal maintenance system

1. Define the management unit/section within the organisation for which the GMS is to be developed

Identify, or define, the management section within the organisation for which the GMS is needed eg alien vegetation control unit. This may be an individual or a team of workers.

This step is especially important in large organisations as there are many different functions performed by various units/sections.

OUTPUT: Clear definition of section/unit.

2. Review present goals and establish priority goals

Conduct interviews with individuals within the section to obtain their input on the section's objectives hierarchy and their proposals to operationalise the objectives hierarchy. This builds commitment and clarifies expectations.

The key question for managers to ask is:

Why are we doing this work?

In the light of this self assessment review the goals that have been set and, if necessary, change the goals.

Establish which are the priority goals, systematically balancing resource constraints and effort to decide what needs to be done and how.

OUTPUT: List of goals of the section/unit.

A revised list of the priority goals.

3. *Define indicators and TPCs for the priority goals*

Scientifically rigorous, spatially and temporally bounded targets of ecosystem condition must be specified for conservation goals. These targets are termed TPCs and act as amber lights to warn managers of possible unacceptable environmental change (Rogers and Biggs, Rogers and Bestbier, 1997). They form the basis of the auditing component of the GMS, as they are invariably hypotheses of limits of acceptable change in ecosystem structure, function and composition. As such their validity and appropriateness are always open to challenge and they must be adaptively modified as understanding of the systems being managed improves (Rogers and Biggs, 1998).

Setting TPCs (Rogers and Bestbier, 1997):

1. Define the criteria (indicators) to be measured.
2. Define the spatial and temporal scales of measurement.
3. Describe the sampling method and techniques.
4. State the upper and lower levels of the Threshold for Probable Concern (end point).
5. Provide the rationale for selection of the criteria and TPC.
6. Prioritise and rationalise the derived TPCs to provide a manageable monitoring programme.

See insert for more details on how to define TPCs.

OUTPUT: Comprehensive TPC tables, such as Table 3.1

Table 3.1 TPCs based on changes in spatial and temporal patterns of regeneration and mortality of various species which occur along the Sabie River (from Rogers and Biggs, 1999)

Measurement criteria	Measurement units	Measurement scale	Thresholds of probable concern
Population structure of key species from each of 6 vegetation units *Breonadia salicina* *Ficus sycamorus* *Phragmites mauritianus* *Trichilia emetica* *Combretum erythrophyllum* *Spirostachys africana*	Size class frequency distribution	Temporal: every 3 years and events greater than 1:25 years Spatial: all representative reaches except: *B. salicina* pool-rapid reaches only *C. erythrophyllum* alluvial reaches only *S. africana* macro-channel banks only	*B. salicina*: negative *J*-curve population structure in pool-rapid channel types Other trees: recruitment at least once in 10 years; mortality threshold uncertain *P. mauritianus*: directional increase in areal extent (20 years prediction)

4. Identify the tasks and actions, and the information needs and flow paths required to achieve the goal

Identify the actions that must be taken to achieve the goal.

The key questions to ask at this stage are:
What needs to be done to achieve the goal and how should it be done?
What is being done at the moment? How is it being done at the moment?
What needs to change in order to do it properly and how should it change?

To improve the chances of meeting the goals we need to understand the operational structure that underlies the effort (DOE, 1995). A flow diagram is an invaluable tool and the best way to understand a process (DOE 1995). Flowcharting the entire process of achieving a particular goal, down to task level, sets the stage for developing a GMS. All parties who are involved should participate in creating the flowcharts. As participants, you can later count on their support to make the GMS work (DOE, 1995).

Identify the information and the pathways of information flow needed to achieve the goal and to audit the TPCs. Review how data are collected and how the information is transferred to the responsible parties (see step 5).

At this step much thought is required about the information needed achieve the goal.
The key question is: *"What do I/we want to know about this goal?"*.
The key issue then becomes: *"How is the required information generated?"*

To generate useful information (DOE, 1995), planning for good data collection proceeds along the following lines:

What TPC/hypothesis is being addressed?
How will the correct answers be recognised and communicated?
What type of data does auditing of the TPC require?
What data analysis tools are envisioned?
How will the results be communicated to the relevant parties?

Where are the raw data to be collected?

How will the data be collected, how often and by whom?

Where in the process can these data be obtained?

Who in the process can provide these data?

How can these data be collected from people with minimum effort and chance of error?

What additional information is needed for future analysis?

OUTPUT: A list of key processes and a flow diagrams of how these key processes interact to generate the desired output/product.
List of information needed and a flow diagram of information flow to achieve and audit the goals.

5. Identify the responsible parties

The results of the data collection must be communicated back to the responsible worker and/or decision maker, so that they can take appropriate action. Thus a basic feedback loop must be defined to ensure effective and efficient operation.

At this stage define people/parties responsible for:

- Collecting data,
- Analysing and reporting the data,
- Comparing the data to the goal,
- Determining if corrective action is needed, and
- Making operational changes to ensure the attainability of the goal.

OUTPUT: A list of people and their areas of responsibility.

6. Formulate a comprehensive strategy for achieving the goal and auditing the TPCs

Consolidate the results from the above steps and formulate a comprehensive strategy to achieve

the goals and audit the TPCs. Define and select actions, tasks and milestones appropriate for achieving the goals and measuring the TPCs . Evaluate the actions relative to the goals. Is the effort warranted and is it within resource constraints?

OUTPUT: A comprehensive strategy for achieving the goal and measuring the TPCs.

7. Implement the actions and tasks to achieve the goal

Mobilise resources to implement the tasks and actions to achieve the goals.
Check that the actions for achieving the goals have been implemented as prescribed according to the set deadlines/timeframes.

OUTPUT: Implemented plan

8. Collect and analyse the data and compare the results with the original TPCs

Collect the data for the TPCs and feed them back to the relevant people. The data are then captured and analysed using the predefined data analysis tools.

The results from the analysis of the data are compared to the original TPCs, to determine if the TPC has been reached. Once the comparison against the TPC has been made, there are several alternatives to follow (Rogers and Biggs, 1998):

1. If the results fall within the TPC, continue monitoring. The data collection cycle continues. Go to Step 11.
2. If they fall beyond the TPC then the cause, degree and nature of change is assessed relative to the values embodied in the higher level objectives and vision statement:
    a) If the change is <u>not</u> compatible with the values, appropriate action must be taken to address the cause of change. Go to Step 9.

b) If the change is compatible with these values feed the information back to the researchers for them to test its validity. Go to Step 10.

OUTPUT:
1) A list of data. Data should be checked for accuracy and reliability as they are being collected.
2) Presentation of the data in an appropriate form, eg report, to relevant parties such as high level managers and stakeholders.
3) Decision based on results.

9. Determine what corrective action is needed and make operational changes

Determine what actions are required to address the cause of change in the TPC. Formulate an action plan to address the cause of change and implement it.

OUTPUT: Action plan to implement operational changes.
Implementation of action plan.

10. Revise or add TPCs and/or goals

If the change in the TPC is compatible with the values of the organisation's objectives hierarchy feed the information back to the researchers for them to test its validity. Changes then need to be made to bring the TPC back in line with the objectives hierarchy.

Goals will normally only be changed if a change occurs at a higher level in the Objectives Hierarchy. This rule reduces the chance of goals being changed as a result of a change in staff or their enthusiasm (Blackmore, 1995).

Goals (and TPCs) could be modified when:

1. There is strong motivation that a goal has been poorly or loosely defined,
2. There is change in the understanding of the potential of the reference system being

managed, or

3. The full implications of the goal where not clearly understood (Blackmore, 1995).

New goals could be generated when:

1. Previous goals have been achieved.
2. The work processes change.
3. Policy/objectives change.

If goals have been revised or new goals generated ensure that they are harmonious with the existing goals and objectives. Note that the *ad hoc* addition of goals without careful reintegration will erode the integrity of the goal orientated process.

OUTPUT: New goals, new TPCs or no change.

11. Actively communicate the goals and their attainment to the stakeholders

Goals, TPCs and their attainment need to be actively communicated so that people at all levels of management are aware of the status of the ecosystem and their role within it.

Reports, workshops, meetings and fora are effective means of communication.

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