internal report **278**

Wetland inventory and monitoring: Tools for management in Australian tropical wetlands

CM Finlayson

March 1998

supervising scientist

Wetland inventory and monitoring: Tools for management in Australian tropical wetlands

CM Finlayson

Environmental Research Institute of the Supervising Scientist

Locked Bag 2, Jabiru, NT 0886, Australia (maxf@eriss.erin.gov.au)

****

Observer, Ramsar Convention Scientific and Technical Review Panel

Coordinator, Wetlands Inventory and Monitoring Specialist Group, Wetlands International

****

Abstract

An inventory and monitoring program for detecting biophysical change in the wetlands of Kakadu National Park in northern Australia has been established. The Park is renowned for its conservation values, but is under threat of major change as a consequence of weed and feral animal invasion, pollution, and predicted sea level rise and climate change. In order to determine the likely extent and rate of such change an inventory and monitoring program for the wetlands has been designed. An inventory of existing baseline information is being established and will be expanded through the use of remote sensing techniques. Monitoring of specific biophysical features will be undertaken in relation to threats to the wetlands and will be underpinned by the baseline information contained within the inventory.

The inventory and monitoring program was developed in close cooperation with all interested parties. Land managers, owners and users have been included in the process from the outset. From these activities a model for developing a wetland monitoring program has been outlined. The components of the model are: establishment of technical expertise; consultation; identification of causes of change; information collation and coordination (inventory); collaboration and partnership; design and implementation; audit; management actions; and communication.

The successful use of such a model is dependent on the strategies by which each of the components is addressed. It is important to stress that the model is supported by the thoroughness with which the inventory information is collated and made available for users.

Introduction

Over the last decade there has been a remarkable change in community-wide recognition in Australia of the value of wetlands. This has seen the development of various governmental policy initiatives, such as the release of the Wetlands Policy of the Commonwealth

Government of Australia. Further, the Sixth Meeting of the Conference of the Convention on Wetlands (Ramsar Convention) was held in Brisbane, Australia in 1996. This policy and resolutions from the conference encouraged the development of appropriate inventory and monitoring techniques for ensuring the wise use of wetlands. They also promoted the involvement of local communities in wetland monitoring and management programs.

However, translating these policy initiatives into action has not been simple. Much of the wetland monitoring in Australia has not been effective. Insufficient resources have been allocated to long-term programs and many programs have suffered through inadequate planning and insufficient adherence to scientific principles.

The need for an effective inventory and monitoring program in Australia's tropical wetlands was recognised in an assessment of the vulnerability of the wetlands of Kakadu National Park in the Northern Territory to climate change and sea level rise. This was an important assessment. It postulated that Kakadu's famed freshwater wetlands are under immediate threat, and also highlighted that management responses are hampered by poor collation and coordination of existing data (ie inventory) and inadequate procedures for obtaining further relevant data (ie monitoring). As a consequence a monitoring node has been developed to provide better information for managing the wetlands, particularly those in the coastal zone.

This paper describes the inventory and monitoring program being developed in Kakadu National Park. As an introduction the biophysical features of the wetlands of the Park and the major threats to them are briefly described.

The region

The area being considered is referred to as the wet-dry tropics of northern Australia. Basically this corresponds to the northern-most part of the continent (fig 1). It has an annual rainfall of 600-1600 mm spread over 4-7 months.

The biophysical features of the wetlands have been described and the major threats or management problems have been identified. The wetlands in the 20 000 km^2 Kakadu National Park are well known and have received recognition under the World Heritage and Ramsar Internationally Important Wetlands Conventions.

Kakadu lies to the east of Darwin and abuts the vast and little disturbed area of the Northern Territory known as Arnhem Land. It comprises the 28 000 km^2 catchments of the East Alligator, West Alligator and South Alligator Rivers (fig 2). Public attention was drawn to the region after the discovery of four large uranium deposits in 1969–70. The Park covers 20 000 km^2 and is managed by Parks Australia North (part of Environment Australia).

The wetlands

The main wetland types in Kakadu National Park include coastal salt marshes, mangrove swamps, and freshwater floodplains.

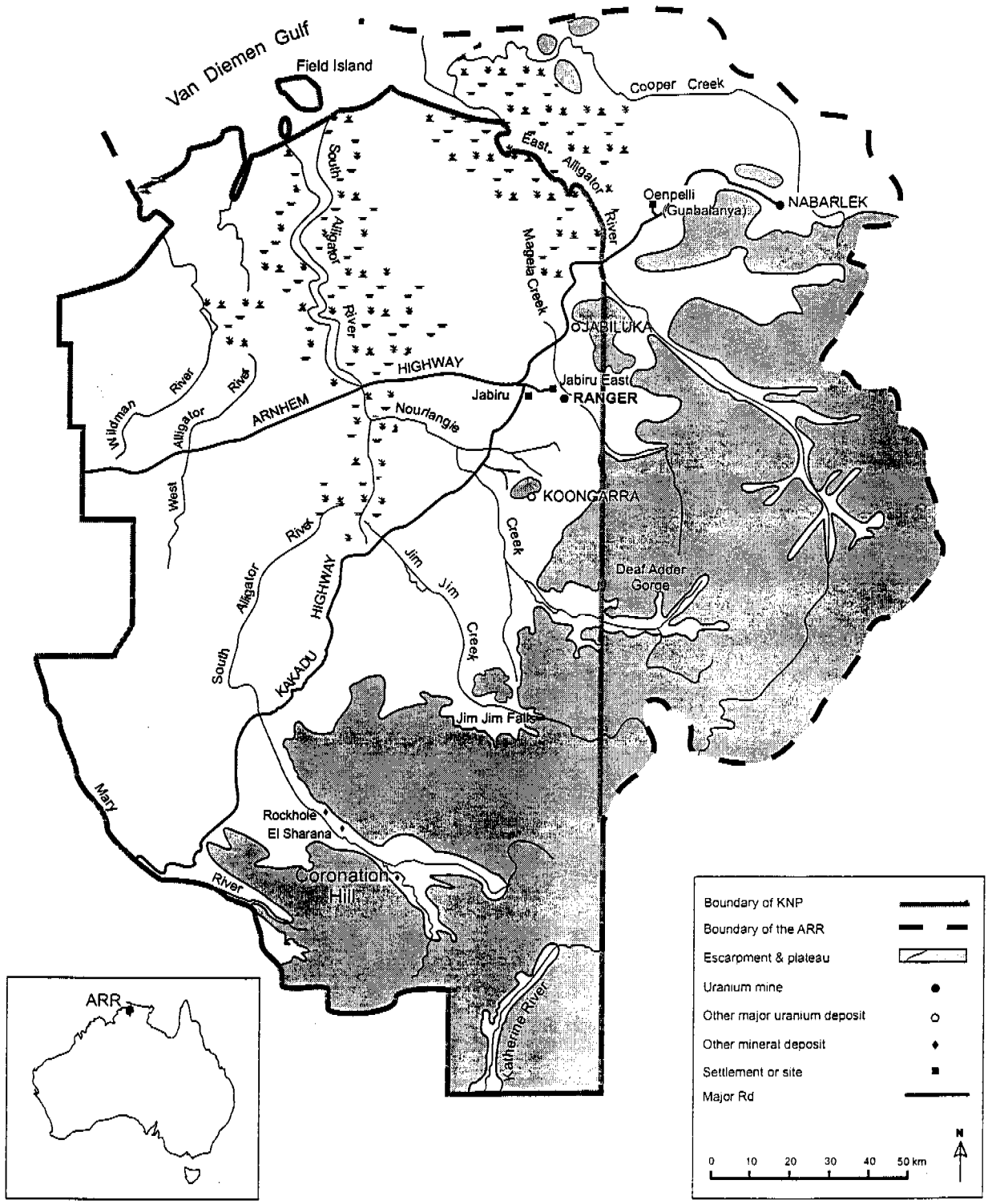

Figure 1 Map of the Alligator Rivers Region in northern Australia

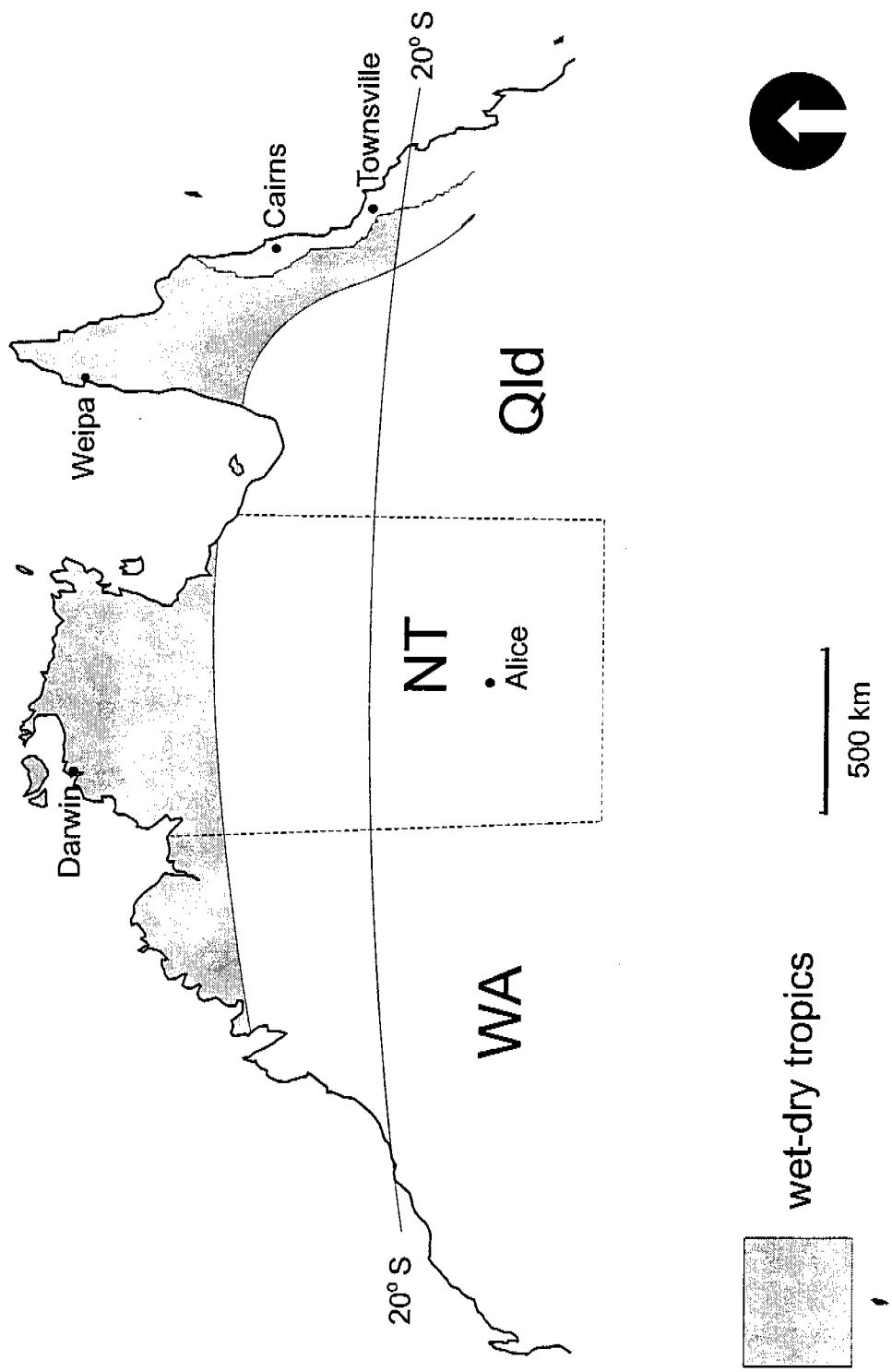

Figure 2 Location of the wet-dry tropics in northern Australia

Coastal salt marshes and flats

These include intertidal salt marshes and supra-tidal salt flats that can extend some 30-40 km inland. They are characterised by macro-tides (often 5–7 m range) that rise and fall across broad expanses of mudflats or sparse seagrass meadows.

Plant diversity is not high. Salt-flats without vegetation are common and are found alongside many of the coastal mangrove communities. Information on the fauna of these marshes and flats is sparse with the exception of migratory shorebirds. The birds also utilise the mud flats that are exposed at low tide and are important staging sites for the migratory birds.

Mangrove-swamps

Mangroves do not cover a large area, but they are floristically diverse. Extensive stands occur along rivers. There are 18 mangrove species commonly found in the region. Generally they occupy a narrow fringe along the river banks. Near the mouth this may be more than 50 m wide, but it soon decreases to a discontinuous fringe little more than 10 m wide. Along much of the river this fringe is reduced to a line of scattered trees.

Differences in the frequency of tidal inundation along the coast results in a clear zonation of mangroves. While the zonation pattern in the mouth of the Alligator Rivers is similar to that on the coast - *Sonneratia, Rhizophora, Ceriops, Avicennia* - the occurrence and elevational range of species changes often. The salinity of the water is a major factor determining the distribution of mangrove species.

The mangrove fauna, especially the macro-invertebrates, are not as well known as the flora. The larger animals are better known, but not necessarily in a quantitative manner. The saltwater or estuarine crocodile (*Crocodylus porosus*), a number of snakes, lizards, geckos, skinks and turtles plus mammals such as the fruit and insect-eating bats and water rats and feral buffaloes, pigs and cattle utilise mangrove habitats. The best known animal species is the estuarine crocodile.

Floodplains

The floodplains cover about 150 000 ha and are greatly influenced by the northern climate and hydrology. Permanent waterholes occur on the floodplains and have fairly uniform physico-chemical conditions during periods of stream flow and a progressive increase in solute concentrations during the Dry season. Most parts of the floodplain dry out during the Dry season.

More than 220 plant species have been found on the floodplains. Major vegetation communities include: Melaleuca open forest and woodland; Melaleuca open woodland; Nelumbo (Lotus lily) swamp; Oryza grassland; Hymenachne grassland; Pseudoraphis grassland; Hymenachne-Eleocharis swamp; mixed grassland and sedgeland; Eleocharis sedgeland; and open-water community. All of these communities undergo large seasonal changes in biomass and species composition. An outstanding feature of the floodplain vegetation is the variation in floristic composition and foliar cover during the Wet and Dry seasons. The success of the majority of species relies on mechanisms that enable them to survive the Dry season drought.

The floodplains have a relatively low mean nutrient availability. They are, however, dynamic with plant standing crops developing very rapidly at the start of the Wet season and sensing and decomposing at the beginning of the Dry season.

The floodplains hold high numbers of animals. These include freshwater and saltwater crocodiles, other large reptiles such as the file snake and freshwater turtles, freshwater fish, freshwater mussels and a wide assortment of water birds. This represents a high standing biomass. Large long-lived animals exploit the wetlands by using a high level of mobility and/or by having mechanisms that allow them to withstand periods of little or no nutrient intake. Many animals are faced with food shortages, at least on a seasonal basis.

The freshwater wetlands and adjacent grasslands and riparian woodlands contain about 115 species of birds. The numerically dominant species on the floodplains are the magpie geese, wandering whistling-ducks, intermediate egrets and glossy ibises. The large Jabiru stork is common as is the brolga crane. There are also an additional 18 species of migratory birds, although few are resident. Movement of waterbirds is very pronounced with species migrating between wetlands on a seasonal basis.

Freshwater fish include surface feeding species (eg the checkered and black-striped rainbow fish), scavengers (eg black bream and sharp-nosed grunter), omnivores (eg fork-tailed catfish) and a few highly-specialised species (eg archer and primitive archer fish). The barramundi is a large species that breeds in seawater at the mouth of the rivers and then either stays in the salt water or swims upstream to the fresh water. Fish migration occurs during the Wet season.

Threats to the wetlands

The usage of wetlands along the coast of the Northern Territory is diverse and has intensified in recent years. This has led directly to increased environmental threats and management issues. The major management issues and threats to the wetlands are introduced weed species, such as mimosa, salvinia and pastures grasses, in particular paragrass; introduced feral animals, such as pigs, buffaloes and horses; salinisation; and potential pollution, especially from mining. The introduced cane toad is also seen as a potential threat. The management issues and threats to the wetlands are listed in table 1.

Importantly, the wetlands are under the serious threat due to sea level rise and climate change. This includes the effects of rising sea levels (inundation and salinisation) and also that from higher or more intense storm activity (flooding and erosion) in the catchment.

Some of the major threats in the park have been successfully controlled. The best example is the intensive control program for mimosa — an ongoing 'search and destroy' program. The virtual elimination of feral buffaloes from the wetlands is another example. Both of these programs are ongoing and well resourced.

The diversity and extent of these threats and management issues has resulted in the collection of a large amount of information and data. Unfortunately, much of this is not collated and stored in an easily accessible inventory.

Table 1 Management issues and threats to the wetlands of Kakadu National Park

Threats	Invasive weeds — mimosa, salvinia, paragrass and new entrants
	Inappropriate fire regimes
	Feral animals, especially pigs and the cane toad
	Salinisation and drainage of freshwater
	Potential pollution from uranium mining
	Sea level rise and climate change
Issues	Poorly managed tourism
	Balancing private and public interests within the park
	Aboriginal peoples' desire to explore new ways of deriving benefits from their land
	Poaching and law enforcement
	Prioritisation of resources for management activities

Managing the wetlands

Managing the wetlands of Kakadu National Park is a complex affair, where direct field experience is being supported by the collation, storage and use of a vast information resource. This information has been collected over many years and is constantly being extended through monitoring and research. The basic components of the inventory and monitoring programs are outlined below.

The inventory program

The basic step in establishing a wetland inventory is agreement on a suitable classification scheme. The purpose of wetland classification is to standardise and define the terms being used to describe various wetland types. A uniform set of terms is needed. The important point in classifying wetlands is not the detail of the classification, but the usefulness of the classification for management purposes. Within Kakadu a very broad and simple ecosystem classification was used — coastal salt marshes and flats, mangrove swamps and floodplains. A more detailed habitat classification has not been needed.

Much of the information required for wetland management can be collected in a directory or inventory of wetlands. A directory and inventory are used to compile the same type of information, but the former is limited to current information and may not be comprehensive. An inventory includes steps to obtain more information and present a comprehensive coverage of sites. Thus, a directory may lead to an inventory. In reality, the terms are used interchangeably.

The information collected through wetland inventories is the first step in assembling an information base for wetland management. In fact, Contracting Parties to the Ramsar Convention undertake to compile an inventory as part of the process of developing and implementing a national wetland policy. A well planned inventory should provide managers and policy makers with the information base that they require to manage individual wetlands or threats and to also place the conservation value of wetlands within the context of land use priorities.

An effective inventory must be available to, and understood by, all those who manage wetlands. Thus, it must be framed in a manner suitable for management purposes. Additionally, to remain useful it must be regularly reviewed and updated. Information

categories often used in wetland inventories are shown in table 2. Many of the categories do not relate directly to biophysical information, but are management oriented.

An analysis in Mediterranean countries concluded that the objectives of a wetland inventory were to:

- identify where wetlands are, and which are priority sites for conservation
- identify the functions and values of each wetland
- establish a baseline for measuring change in a wetland
- provide a tool for planning and management

In order to achieve these objectives the following recommendations were made:

- use standardised methods for classification, data collection/storage, delineation and mapping
- incorporate qualitative and quantitative data to provide a baseline for monitoring wetland change and loss
- facilitate analysis of loss of wetland functions
- be regularly updated
- be easily disseminated and made available to wetland managers, decision-makers and the general public

For the above to be achieved careful planning and testing of techniques is required. A secure funding source is needed and all changes to protocols should be well documented and assessed. Critically, any limitations on the use of the information should be made apparent at the outset.

Table 2 Information categories used in the 1989 Asian wetland directory

Category	Information
Title/Location	Name of wetland/Coordinates/Name of town
Area/Altitude/ Biogeographical region	Area/Height above sea level/Biophysical
Wetland type/ Description of site	Generalised classification/Water regime/quality
Climatic conditions	General features
Principle vegetation	Description of aquatic vegetation
Land tenure/Conservation measures	Land ownership and nature protection
Land use	Current and future land uses
Disturbances and threats	Current and future threats
Economic and social values	Value for local people
Fauna/Flora	Special communities or species
Research and facilities	Research and education programs and facilities
References	Relevant reports

The monitoring program

In a general sense, environmental monitoring addresses the broad issue of change or lack of change through time and at particular places.

> ***Monitoring*** *is based on surveillance and is the systematic collection of data or information over time in order to ascertain the extent of compliance with a predetermined standard or position.*

The effectiveness and complexity of monitoring varies considerably. An effective monitoring program is not necessarily complex nor expensive. Effectiveness is gauged by the relevance and timeliness of the data or information collected rather than the complexity of design. Simple approaches to monitoring can be very effective and inexpensive.

Monitoring is a process, which provides information for management purposes and should be supported by a management structure and a well developed inventory. The management structure provides the support for the program and the inventory provides the broad baseline against which change can be judged and management actions decided.

Wetland monitoring has received more and more attention in recent years as awareness of the extent of wetland degradation and loss has increased. Such is the concern at the extent of global wetland degradation that more and more effort is being directed towards developing effective management processes and responses to problems. In many instances this effort is being held back by a lack of relevant information, such as that contained in an inventory and collected through monitoring.

A framework for assisting with the design of a monitoring program is presented in figure 3. The framework applies to all forms of monitoring but it does not provide a recipe for specific techniques. It presents a series of steps that will assist with designing a monitoring program suitable for individual situations.

The framework contains the following headings: identify the problem or issue; set the objective; establish the hypothesis; choose the methods and variables; assess the feasibility and cost effectiveness; conduct a pilot study; collect the samples; analyse the samples; report the results; evaluate the project. After evaluation the program may be continued, altered or terminated. These steps are described in table 3.

Monitoring is needed to prevent further unchecked exploitation and degradation of wetlands. Thus, there is a need to assess the impact of human development and minimise ecological change. Success in such programs will depend on our ability not only to detect and monitor changes in the quality of wetlands, but also to provide early indications of likely change and thereby take action to prevent this change from occurring.

The Ramsar Convention has recognised the need to design effective monitoring programs and has adopted the abovementioned framework.

Table 3 Summary of key points to consider when using the Ramsar Convention framework for designing a wetland monitoring program.

Identify the problem or issue	State clearly and unambiguously State the known extent and most likely cause Identify the baseline or reference situation
Set the objective	Provides the basis for collecting the information Must be attainable and achievable within a reasonable time period
Establish an hypothesis	Supports the objective and can be tested
Choose the methods & variables	Specific for the problem and provides the information to test the hypothesis Able to detect the presence of and assess the significance of any change Identifies or clarifies the cause of the change
Assess the feasibility & cost effectiveness	Determine whether or not it can be done regularly and continually Assess factors that influence the sampling program: availability of trained staff; access to sampling sites; availability and reliability of specialist equipment; means of analysing and interpreting the data; usefulness of the data and information; means of reporting in a timely manner Determine if the costs of data acquisition and analysis are within the budget
Conduct a pilot study	Time to test and fine-tune the method and specialist equipment Assess the training needs for staff involved Confirm the means of analysing and interpreting the data
Collect the samples	Staff should be trained in all sampling methods All samples should be documented: date and location; names of staff; sampling methods; equipment used; means of storage or transport; all changes to the methods Samples should be processed within a timely period and all data documented: date and location; names of staff; processing methods; equipment used ; and all changes to the protocols
Analyse the samples	Sample and data analysis should be done by rigorous and tested methods The analyses should be documented: date and location; names of analytical staff; methods used; equipment used; data storage methods
Report the results	Interpret and report all results in a timely and cost effective manner The report should be succinct and concise and indicate whether or not the hypothesis has been supported and contain recommendations for management action, including further monitoring
Evaluate the project	Review the effectiveness of all procedures and where necessary adjust or even terminate the program

The monitoring model

The vulnerability assessment of Kakadu's wetlands to climate change and sea level rise highlighted the need to undertake further monitoring within the region and to also make far greater use of existing information. Further, the importance of local government and communities in the management and monitoring processes was stressed. These issues have been addressed with the establishment of a monitoring node.

The goal of the monitoring node is to develop a regional capacity to measure and assess variation in biophysical processes and land-use on the floodplains of the region. This involves four components

1. *Information review and management*
2. *History of land use and environmental change*
3. *Assessment of past biophysical change*
4. *Floodplain survey and monitoring*

A number of individual monitoring programs are being developed and established on a cooperative basis with other agencies. These are all part of an overall inventory of the wetlands that will provide managers with historical and current information on the wetlands. The inventory is not static, it is linked to the monitoring programs and actively used by the managers.

In developing the Kakadu monitoring node a number of processes have been adopted and lessons learnt. These have included making full use of existing information (in an inventory) and resources and talking to land owners and users. On the basis of these experience it is recommended that the following steps are included when developing a complex monitoring program:

- Establishment and empowerment of an expert monitoring centre
- Consultation with and empowerment of key stakeholders, including the local community
- Identification of major processes and causes of ecological change
- Collation and coordination of available data and information
- Identification of potential collaborators and partners
- Design and implementation of technical monitoring programs
- Audit and, if necessary, termination of monitoring programs
- Provision of feedback to stakeholders, partners and community groups

The critical points with the above general procedure is the involvement of community and stakeholder groups and the maintenance of an inventory. The monitoring being planned in Kakadu includes a sophisticated program of remote sensing in order to assess environmental changes over the large area of wetland within the park and in adjacent catchments. This work is being supported by extensive ground truthing of the topography, vegetation and water. This continued collection of information will be added to the inventory and support the monitoring program.

Summary

Wetland management in Kakadu National Park is being supported by active and ongoing wetland inventory and monitoring programs. A monitoring node has been established to encourage the involvement of community and stakeholder groups in the program. Information collected from new monitoring programs and further sampling programs will be added to the inventory on a continual basis.

The development and maintenance of the inventory is considered an important part of the management process necessary to combat the various threats to the wetlands. Great care is being taken to ensure that the monitoring programs are effective and can contribute useful information for managers. Thus, inventory and monitoring are considered part of the ongoing management processes — they are not being treated as individual one-off events.

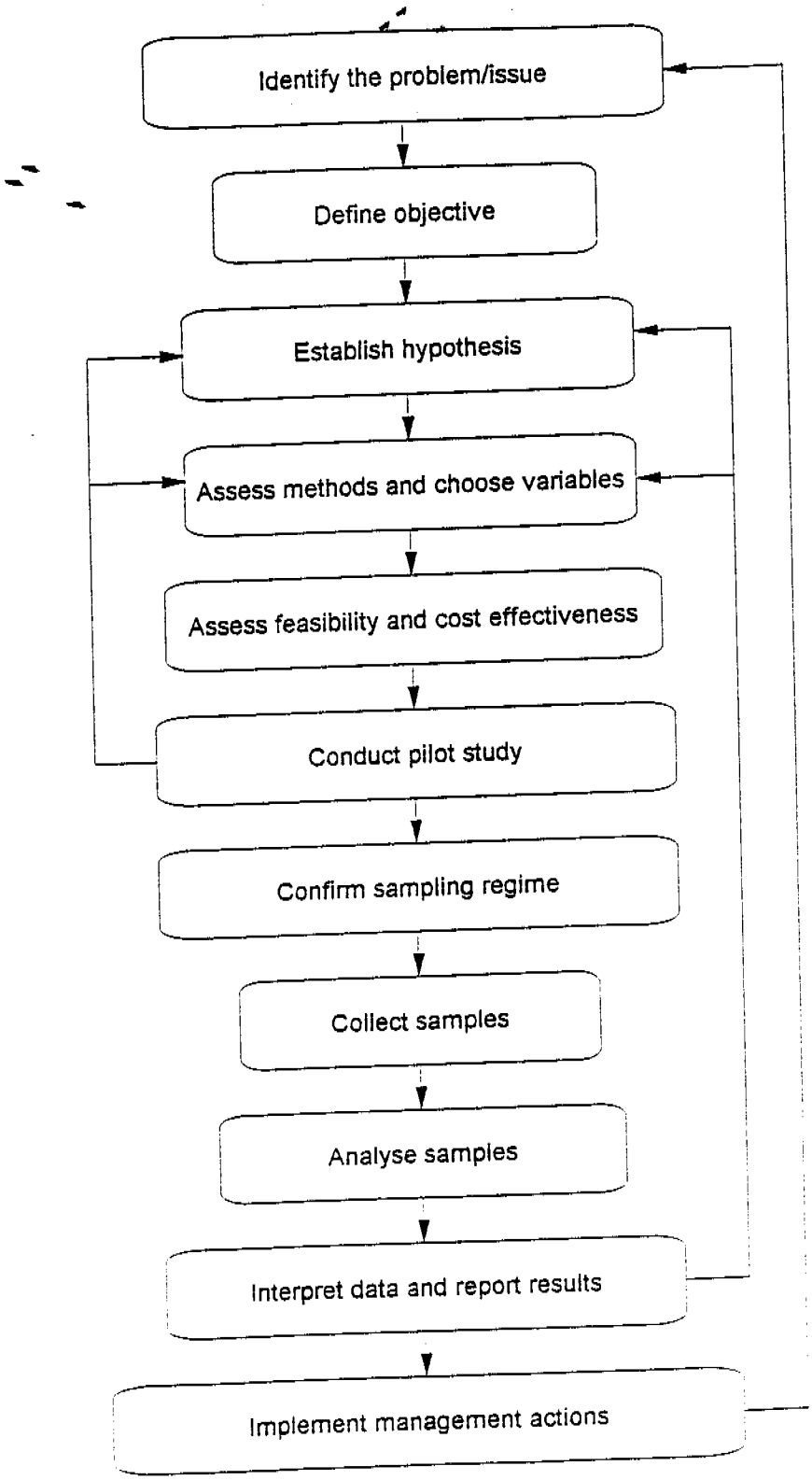

Figure 3 A framework for designing a wetland monitoring program

Further reading

Finlayson CM & van der Valk AG 1995. Classification and inventory of the World's wetlands. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Finlayson CM & von Oertzen I 1996. Landscape and vegetation ecology of the Kakadu Region, northern Australia. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Storrs MJ & Finlayson CM 1996. Overview of wetlands of the Northern Territory. Supervising Scientist Report 116, Jabiru, Northern Territory, Australia.