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## Wetlands in Kakadu National Park

# WETLANDS IN KAKADU NATIONAL PARK – THE MANAGEMENT SETTING

**P WELLINGS**

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**ABSTRACT**

*This paper outlines the history of the establishment of Kakadu National Park and the arrangement where the Park is jointly managed by Aboriginal traditional owners and the Australian Nature Conservation Agency. The paper describes how management objectives are defined and the influences that effect the implementation of wetland management programs in the Park. Major considerations influencing wetlands management programs in Kakadu are discussed. These include:*

- *the Park's international, national and local conservation significance*
- *the Realpolitik of managing for conservation on Aboriginal Land*
- *the imperative of the Park's joint management arrangement*
- *the role of Kakadu as a major tourism resource*
- *the adequacy of management resources*
- *the rapidity of change*
- *the marrying of long term objectives with immediate 'dramas'*
- *the need for information*

**Keywords:** Kakadu National Park, Aboriginal people, management plans, tourism, weeds, hunting

## 1 The setting

Kakadu National Park is located in the wet-dry tropics of north Australia, 120 km east of Darwin. The park covers an area of about 20 000 km$^2$ and is the largest terrestrial national park in Australia. It was declared in stages over the period 1979–1991 and was the first place in Australia where Aboriginal Land (land in which legal title is held by indigenous land owners) was specially leased to a nature conservation agency (now the Australian Nature Conservation Agency) for the purposes of joint management for conservation.

The significance of Kakadu's heritage values has been recognised by the inclusion of the park in the list of World Heritage properties established under the international Convention Concerning the Protection of the World Cultural and Natural Heritage. Kakadu National Park is one of only seventeen sites across the world listed for both it's natural and cultural values.

Seasonally inundated wetlands make up approximately 13% of the park area and the importance of Kakadu's wetlands and waterfowl habitats has been recognised by the listing of these areas under the Convention on Wetlands of International Importance (the Ramsar Convention).

A feature of the park is that it includes a complete major river system, the South Alligator River. The conjunction of major landforms in the area has produced an ecological diversity that has been described as both representative and unique (Braithwaite & Werner 1987). Detailed

descriptions of the park and its values are contained in ANPWS and DASET (1991) and Graham et al (1994).

## 2 The joint management of Kakadu National Park

Management of the park aims to conform to internationally accepted principles underlying the definition and management of national parks, but also has to take into account the ownership and continuing occupation of land in the park by its indigenous Aboriginal occupants. Contemporary Aboriginal owners of much of Kakadu are the direct descendants of people who have lived in the region for at least 50 000 years (Roberts et al 1990).

Today approximately 250 Aboriginal people live in a number of small communities (commonly referred to as 'outstations') within the park. Present day Aboriginal traditional owners of land in the park require that they have the opportunity to both maintain their cultural traditions, including traditional responsibility for management of their land, and to pursue contemporary interests.

Kakadu has been described as a community based conservation project where it is intended that indigenous land owners have the opportunity to fully participate in the management of their lands for conservation purposes (Hill & Press 1992).

The concept of the 'joint management' of land for conservation purposes is regarded by the Australian Nature Conservation Agency as an important initiative and a concept that is fundamental to the successful management of the park.

## 3 The establishment of Kakadu National Park

Plans for a national park in the Kakadu region date from 1965 but little substantial progress in establishing a large national park took place until a decade later. This coincided with a shift in Commonwealth government policy from one of promoting the assimilation of Aboriginal people into the mainstream non-Aboriginal community to one of recognising Aboriginal peoples right to self determination and the maintenance of their own cultural identity.

A government inquiry at the time also promoted the concept of land rights for Aboriginal Australians and suggested that '.. a scheme of Aboriginal title, combined with national park status and joint management, would prove acceptable to all interests ...' (Woodward 1973).

The discovery of substantial uranium deposits in the Kakadu region in the early 1970's also led the Commonwealth government to establish a major inquiry into Australia's participation in this industry and the implications of development of uranium mines in the Kakadu area. This inquiry recommended that uranium mining be allowed to proceed, that a large national park (Kakadu National Park) be established and that Aboriginal people in the region be granted title to land that could, in turn, be incorporated in the new national park (Fox et al 1977).

One early concern of the Aboriginal claimants to land in the Alligator Rivers Region was that they would not be able, on their own, to adequately manage and look after the land in the face of growing and competing pressures. It was hoped that by joining with the (then) Australian National Parks and Wildlife Service in managing the land as a national park would assist in meeting these challenges (Hill & Press 1994).

Title to approximately one third of the land within Kakadu National Park is held by Aboriginal traditional owners with a further substantial area of land under claim. It is the continuing policy of the Australian Nature Conservation Agency that the commitment to liaison and

consultation with Aboriginal people regarding the management of the park extends over the whole park area, not just Aboriginal Land within the park.

Leases between the Director of National Parks and Wildlife and the traditional owners of Aboriginal Land in the park contain special provisions to provide for:

- a commitment to world standard management procedures
- the maintenance of traditional occupation (residency) and usage rights
- employment training programs for traditional owners
- a commitment to providing employment opportunities for Aboriginal people
- support for Aboriginal business enterprises
- annual rental payments
- benefits from Park revenue

In the 1993/94 financial year financial benefits to traditional owners from rental payments and share of park revenue amounted to AUD $540 000.

## 4 The role of the Kakadu National Park Board of Management

In 1989 a Board of Management was established for the park. The legislative mandate for the Board (the *National Parks and Wildlife Conservation Act* 1975) describes the Board's functions as including:

- in conjunction with the Director (of National Parks and Wildlife), the preparation of Plans of Management
- the power to make management decisions consistent with the Plan of Management
- in conjunction with the Director, the monitoring of the management of the Park
- in conjunction with the Director, the formulation of advice to the Minister about all aspects of future Park development

The Board has a responsibility equal to that of the Director of National Parks and Wildlife to advise the Minister concerning park policy and management. In the event that the Board and the Director cannot agree the Minister may take steps to resolve the disagreement, ultimately by arbitration.

The current Kakadu National Park Board of Management comprises 14 persons, including ten adult Aboriginal people nominated by the traditional owners of the Park. The Aboriginal owners of the Park have majority representation on the Board and the Chairperson is (by convention) selected from the Aboriginal members. This arrangement reinforces the status of Aboriginal traditional owners as the landlords (lessors) of much of the park area.

## 5 The Park Plan of Management

The *National Parks and Wildlife Conservation Act* 1975 specifically requires that due regard is given to the interests of traditional owners (and other Aboriginal people with interests in the park) in the preparation of Plans of Management. Current practice is for the Plan to be reviewed every five years and during these reviews a Consultative Committee, comprising representatives of members of the park's Aboriginal community, is established to advise the Board of Management and the Director on Aboriginal perspective's on park management issues.

The current Plan of Management (ANPWS 1991) articulates four over-riding principles that govern the management of the park:

#### Aboriginal Rights

As freehold landowners of much of the land in the park the Aboriginal people of Kakadu have rights and expectations, including the right to hunt and forage, which they may wish to exercise from time to time.

#### Natural and cultural heritage

The conservation of the natural and cultural features of the Park is regarded as fundamental to its management.

#### Tourism

While recognising an obligation to encourage public appreciation and enjoyment of the Park, the provision of access to the Park by visitors must not be at the expense of, or allowed to take priority over, the preceding.

#### Communication of Park values

The promotion of a continually developing program to communicate Park values to visitors is an integral part of management.

# 6 Day to day involvement of Aboriginal people in park management

Hill and Press (1992) have described the opportunities provided for the direct involvement of Aboriginal people in day to day decision making and liaison as the 'backbone' of the success of the joint management arrangement in the park. Thirty five percent of the 60 odd staff in the park are Aboriginal people, most of whom have a traditional cultural attachment to the landscape. All park staff are encouraged to develop and maintain relationships with the local community so that, in effect, all staff share in the responsibility to liaise with the local community.

# 7 Issues affecting the management of wetlands in Kakadu National Park

## 7.1 The Park's significance

The park's prominence on the world stage is benefitting the long term protection of the park. It's World Heritage status results in annual reporting to the UNESCO World Heritage Centre on the progress of management programs and Commonwealth legislation provides a specific mandate for the protection of world heritage values.

The park's international, national and regional significance also engenders wide community support for the park and provides an incentive for appropriate government funding.

## 7.2 The imperative of the joint management arrangement

Given the legal status of Aboriginal Land in the park, the park lease agreements, the composition and role of the Board of Management, the commitment to employment of Aboriginal people in the park and a general policy commitment to the principle of joint management it is essential that this process works effectively.

This requires a focus on shared values, a preparedness to understand different value systems, a willingness to negotiate and openness in communication between staff of the ANCA and traditional owners of Aboriginal Land in the park.

## 7.3 The importance of economic benefit

An important 'bottom line' is that the Australian Nature Conservation Agency continues to appreciate that the economic value of wetlands is a critical value to Aboriginal owners. Economic value here is meant in its widest sense, including the value of wildlife as food. It is not meant to deny that wetlands have other less tangible, but nevertheless important, values. Conservation will be aided in the long term by a strong commitment to protecting the resource and its economic value to traditional owners.

It is also important to consider here the notion that Aboriginal traditional owners are 'not passing through' as is so often the case with other people who come to live in, use and care for the Kakadu landscape. The on-going residency of Aboriginal people within the park, and their guarantee of access within the park for foraging, landscape management and other cultural activities, assists in maintaining commitment to the land and in maintaining competency in understanding ecological processes in the landscape. This is especially so in the wetlands.

The reality of Aboriginal people's legal title to wetlands in Kakadu requires that the on-going economic value of wildlife and habitats in these places **to Aboriginal people** is nurtured and maintained.

## 7.4 Hunting in the park

That Aboriginal people should be able to exercise a right to hunt and gather biological resources in protected areas remains a controversial issue in Australia. Some community based conservation groups regard traditional hunting in reserved areas as a serious threat to biodiversity (House of Representatives Standing Committee on Environment, Recreation and the Arts 1993). The Kakadu experience has been that allowing this cultural tradition to be maintained helps sustain community interest in the health of the environment and knowledge about wildlife populations. In Kakadu it is often Aboriginal people who most quickly alert park authorities of problems and perceived threats to wildlife populations and urge appropriate management response. An example of this has been the Aboriginal peoples strong concern about the threat of invasive weed species, particularly in biologically rich riverine and wetland environments within the park.

The Kakadu experience has also been that if the local community are given the means of exerting authority over the management of hunting by members of their community that they are ready to exercise this authority and impose sanctions on those who disregard expected standards of behaviour.

## 7.5 Tourism

Kakadu is a major Australian tourism icon. Expenditure on visits to Kakadu National Park accounts for more than 25% of all tourism expenditure in the Northern Territory (Knapman 1990) and the park is considered to be an important attraction which also sustains and supports visitation to other parts of Australia. Tourism to Kakadu (currently 240 000 visitors per annum) is expected to experience continuing strong growth as the direct result of assertive marketing programs by both government and the private sector.

At present environmental impacts of tourism are restricted to specific localities where these can be managed in accordance with normal park management principles.

Wetland areas are a major attraction for park visitors and the tourism driven economic significance of wetlands already assists in justifying expensive wetland management programs.

Tourism also provides opportunities to increase community awareness about the importance of wetlands, current threats to wetlands and the need for on-going conservation programs.

## 7.6 The regional context

The region that Kakadu is located in is one where land use change continues at a rapid pace. Current activities include tourism, mining, pastoralism, Aboriginal land use, military use and conservation. There is a need to ensure that regional wetland management programs are complementary, particularly in the context of mobile wildlife and invasive plant species. There is also a need to ensure that 'good neighbour policies' are enacted for common purposes, that information is shared and that resources can be pooled to meet common needs.

## 7.7 Resourcing

The adequacy of resources and the prioritisation of those that are available is, as always, an on-going problem. Limitations on funding requires disciplined reasoning regarding priorities, ie what are the real problems that have to be addressed? A particular problem in relation to weed species is defining when a weed is a problem and which weeds are more of a problem than others. In Kakadu we are also very interested in not just reacting to problems as they appear but in preventing problems occurring in the first place, ie through wash down of high risk weed seed carrying vehicles.

Other resourcing issues in Kakadu include the potential advantages of park use fees in funding management work, maximising the use of external funding programs and ensuring that essential landscape conservation work is not put at risk by the demands of tourism (visitor) management.

It has also been the Kakadu experience that employing the right people for the job and then looking after them in the job is also critical in ensuring maximum value from management programs. Much management work, particularly weed control, can be repetitive, lonely and difficult. Success can also be very elusive. People who develop and exercise special skills and can maintain enthusiasm in face of the apparent obstacles remain the linchpin to success.

## 7.8 The rapidity of change

The need to be flexible and responsive has proved to be important in Kakadu. Park wetland management programs have included a focus, to varying degrees, on all of the following in just one decade, grazing impacts of feral water buffalo, saltwater intrusion into *Melaleuca* forests, premature drainage of freshwater swamps, 'invasion' of woody shrubs on floodplain margins, control of *Mimosa pigra*, management of *Salvinia*, management of para grass, experimentation with fire regimes, management of tourism, the potential impacts of global warming and effects of mining activity. We expect a future challenge will be responding to the appearance of the cane toad!

## 7.9 Long term objectives and short term crises

It is evident in Kakadu that we have to be ever mindful of the relative significance of short term crises as opposed to our long term conservation objectives. It is often easy in a busy workplace to be distracted by immediate dramas at the expense of what might be more important in the long term.

### 7.10 The need for information

Like all managers, we need quality information to help define what we should be doing, how we do it and to measure the success of our efforts. Only limited in-house funds are available for research work and our current priorities are focussed on apparent management problems and possible solutions. We are fortunate though, that within the Aboriginal community in Kakadu there is also a wealth of information about ecological processes at both the species and community levels. Tapping into this body of knowledge provides great support to current conservation managers. It is a dilemma in Kakadu that much of this valuable resource information is based within an oral tradition and given current social circumstances is highly vulnerable to permanent loss. It is a park priority to collect, in an organised way, the collection of this valuable and often irreplaceable information.

## 8 Summary

The Kakadu experience reflects over a decade of experimentation with the concept of the joint management of a large regional national park with indigenous land owners. In the Kakadu context this means an arrangement where Aboriginal people, with a lifestyle and culture based on the traditional harvesting of wildlife resources, jointly manage the park with mainstream park management professionals.

Wetlands are of particular importance in the Kakadu landscape given their significance both for wildlife conservation and their value as an economic 'engine room' for both Aboriginal traditional owners and tourism.

In managing these wetlands the following challenges have to be addressed:

- being clear about our long term objectives
- being wise in allocating priorities
- meeting our information demands
- recognising change and responding appropriately
- being responsible in meeting resourcing demands
- employing, and where necessary developing, 'best practice' methodologies
- ensuring that Aboriginal traditional owners can maintain Kakadu and its wetlands as a cultural landscape

The wise management of wetlands in Kakadu National Park is a great challenge but one that is both exciting and special given the park's joint management arrangement and the tremendous landscape we have to work in.

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# WETLAND MANAGEMENT ISSUES IN KAKADU NATIONAL PARK

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**ABSTRACT**

*This paper focuses on current wetland management issues in Kakadu National Park, particularly in relation to habitats and wildlife. This includes an outline of management objectives as defined in the Park's Plan of Management and a description of current management programs. The major issues discussed include the management of alien plants, the management of feral animal populations, the monitoring of landscape change and the rehabilitation/restoration of habitats. Issues relating to the management of recreational fishing and the saltwater crocodile,* Crocodylus porosus, *are also discussed. The paper concludes by discussing current research needs relating to the management of wetlands in the park.*

**Keywords:** weeds, crocodiles, Mimosa, Salvinia, buffalo, pigs, fire, Kakadu National Park

## 1 Introduction

The current Plan of Management (ANPWS 1991) sets out a range of objectives and issues which require addressing. The major issues affecting wetlands are identified as follows:

- Flora management, particularly the management of exotic plants
- Fauna management, particularly the management of feral animals, saltwater crocodiles and recreational fishing
- Habitat management, particularly with respect to issues such as fire management, rehabilitation of areas affected by saltwater intrusion and maintenance of water quality
- Research and monitoring requirements

This paper sets out to briefly cover the major current issues affecting wetlands management in the Park.

## 2 Flora management - weeds

Cowie and Werner (1987) in their report to ANCA reported that over 300 exotic plant species are cultivated at settlements and communities, and of these, 87 species (or 6% of the local flora) were considered to be naturalised. Some of these weeds which have adversely affected habitat in some areas of the Top End, for example *Mimosa*, *Salvinia* and para grass, are very high on the agenda of weed management programs within Kakadu.

### Mimosa

*Mimosa* is a thorny scrub which can perennially produce thousands of seeds in ideal growing conditions. The seeds can remain dormant in the ground for a number of years before

germinating. Since the discovery of *Mimosa* in the Park in the early 1980s and the concerns expressed by the Gagadju Association (and subsequent involvement with eradicating some infestations at that time) ANCA has kept the park virtually free of *Mimosa*, unlike the major infestations which occur on the 'borders' of Kakadu in wetland systems to the east and west. These massive spreading infestations require that ANCA at least maintains the current commitment to the program. The number of known treated infestations in the Park is approximately 160. Each of these plots requires ongoing management.

### Salvinia

*Salvinia* is a free-floating aquatic fern which reproduces vegetatively. It was first discovered in the Park on the Magela Creek (downstream of Mudginberri Billabong) in 1983. Early attempts to remove it failed and due to a very fast reproduction rate and seasonal flooding *Salvinia* rapidly spread downstream throughout the Magela system. Subsequent infestations have been found on the East Alligator River and the Nourlangie Creek system. Despite considerable efforts (manual, mechanical and chemical) by ANCA to eradicate the weed, *Salvinia* is now well established on some waterways in the Park. Current control practice includes spraying strategically important waterways (eg upstream of road crossings) with the herbicide AF100. A field trial of the impacts of AF100 on aquatic organisms found that herbicide application posed no significant ecological hazard (Finlayson et al 1994).

In 1991, CSIRO commenced a three year study on biological control of *Salvinia* within Kakadu (Julien & Storrs 1993a & b). This involved study of the biological control agent *Cyrtobagous salviniae* and its effect on the Park's *Salvinia* infestation. *Cyrtobagous* was found to have a considerable effect on free-floating infestations, especially by the late dry season, but seasonal flooding and inability of the weevil to access all *Salvinia* infested areas has restricted its effectiveness, particularly where the weed survives in moist/damp areas devoid of surface water. Every effort where practicable will be made to prevent the further spread of *Salvinia*.

### Para Grass

Para grass *(Brachiaria mutica)* is a highly invasive pasture weed which can reproduce from rhizomes and seeds. It was first introduced to the East Alligator area as pastoral fodder for domestic livestock at the Oenpelli Mission. Oenpelli is situated about 20 km east of Kakadu in Arnhem Land. Major infestations of para grass now exist in the Park on the East Alligator River Floodplains (near Ubirr and Cannon Hill) and extensively on the Magela Creek system. In recent times (post 1960s) para grass was introduced to Munmarlary (J Lord pers comm), 4 Mile Hole (F Pocock pers comm) and Number 2 Goose Camp (F Woerle pers comm) for pastoral and rehabilitation purposes. Where practicable, park staff are attempting to eradicate isolated infestations to prevent further spread to 'clean' areas. It poses a significant threat to the South Alligator system.

### Other Weeds

A large number of other weeds occur in the Park. Cowie and Werner (1987) identify the major of these as having the potential to modify habitats they invade. A large number of these occur on wetland systems, or their margins, in the Park (eg *Senna* spp., *Calopogonium mucunoides, Parkinsonia aculeata, Pennisetum* spp., *Malachra fasciata*).

## 2.1 Developing a weed management strategy

Given that weed management in the Park consumes both large amounts of staff time and financial resources, the Park has embarked on developing a weed management strategy as a means for identifying and prioritising issues. An Officer has been appointed to undertake this task over a twelve month period, and a report is presented as part of these proceedings.

# 3 Fauna management

## 3.1 Feral animals

### Buffalo

Asian Water Buffalo were introduced to Northern Australia from Timor in the 1820s to 1840s by the early British settlers (ANPWS 1991). With the demise of the early settlements buffalo spread rapidly across the wetlands of Murgenella, Alligator Rivers, Mary and Adelaide Rivers. By the mid 1970s thousands of buffalo occupied the woodlands and floodplains of the Kakadu region (ANPWS 1991).

In the Alligator Rivers Region buffalo were exploited for their hides. This started in the early 1900s and lasted up until 1956 (ANPWS 1980). In more recent times buffalo were slaughtered for environmental reasons, pet meat and human consumption, along with some live export to Asian countries.

Since the declaration of Stage 1 of Kakadu in 1979, buffalo primarily have been removed in large numbers by commercial operators and aerial culling carried out by ANCA staff. From 1980–1990, it is estimated approximately 100 000 buffalo were removed from the Park (ANPWS 1991).

In the mid 1980s ANPWS was issued a destocking notice which required eradication of all unfenced feral livestock (buffalo and cattle) in the Park by the year 1997 as part of the national Brucellosis and Tuberculosis Eradication Campaign (BTEC). This program involved the use of animals fitted with radio transmitting collars. Combined with aerial culling this very successful technique has reduced the present number of buffalo and cattle in the Park to about 200 (+/- 100) animals (Pat Carrick pers comm February 1995).

Throughout the buffalo era Aboriginal residents of the region have a long association with the buffalo industry and the animal as a food resource. Traditional Owners want to maintain a manageable free-roaming herd within the Park upon completion of the BTEC program. The Gagadju Association also runs a small domesticated herd of approximately 500 buffalo behind electric fencing in the Park. Animals slaughtered from the farm are used to supply meat to the Aboriginal communities within the Park.

Exhaustive sampling and testing (as part of BTEC) of feral livestock in the southern section of the Park has now ceased. Continual testing over the last two years failed to find any cases of bovine disease. Livestock entering the Park from the adjacent southern properties have been provisionally declared disease free.

### Pigs

Pigs were first introduced at the early British settlements and like buffalo spread rapidly across the Top End wetlands. Since 1979 Kakadu Park staff have conducted an opportunistic feral pig culling operation. The *Mimosa* weed program was an exception, whereby pigs, cattle and buffaloes were required to be destroyed on sight in the vicinity of known *Mimosa* plots. This is still a mandatory requirement given the potential for pigs to spread *Mimosa* seed over a large area. However, the approach to pig control in the past has been fairly general according to day to day operational priorities.

At times very large numbers of pigs (>200-400) have been removed by using aerial culling methods (helicopters), particularly where there a large concentrations feeding on heavily vegetated floodplain channels and spring rain-forest patches at the end of the dry season.

An attempt to count and establish a survey methodology for pigs using aerial survey was conducted but failed due to lack of pigs being sighted, despite their obvious presence from the visible damage and previous on-ground observations made by staff (Caley & Palmer 1992).

In more recent times pigs have been commercially harvested in the Park by operators approved by Traditional Owners and Park Management. Despite the efforts of park staff and commercial operators in reducing pig numbers, high level of pig damage still continue on an annual basis to many different habitats within the Park, particularly springs, rain-forest patches and floodplain sedgeland areas.

## 3.2 Native fauna

### Saltwater crocodiles

Two species of crocodiles exist in Australia; the Estuarine or Saltwater crocodile *(Crocodylus porosus)* and Freshwater crocodile *(Crocodylus johnstoni)*; both are common in the wetland habitats of the Park. Aboriginal people and crocodiles have shared the Kakadu region for a long period of time. The co-existence of crocodiles and Aboriginal people before modern settlement was one of mutual predation and mutual respect. Both posed activity constraints on each other. Aboriginal people were killed and eaten as opportunities presented themselves to crocodiles *(Crocodylus porosus)*. People *understood* the risks. Early explorers to the Top End region recorded that many of the waterways were 'infested' with crocodiles. This is deeply inbedded in local nomenclature (eg Alligator Rivers, Alligator Billabong, etc).

In recent times (pre 1945) crocodiles have been exposed to commercial harvesting for their hides. Other reasons for killing crocodiles (by poison baiting, hooking and nest destruction) involved cattlemen reducing stock predation. Despite this type of hunting pressure crocodile numbers remained high until after World War II. Then, the adoption of spotlight shooting for commercial hunting of crocodiles, coupled with a good return for hides and a surplus of adventurous hunters, brought a rapid decline in crocodile numbers (D Lindner pers comm). Due to the decimation of crocodile populations both species were given protection in the late 1960s and early 70s. Since then there has been a rapid increase in the observable population of crocodiles (Palmer 1992). This is particularly evident on the tidal and inland waterways (eg Yellow Waters - late dry season) of Kakadu.

# 4 Habitat management

## 4.1 Fire management

Fire has been used as a land management tool for a long period of time by Aboriginal residents of the Alligators Rivers Region and has been associated with the development of wetland habitats throughout their late Holocene evolution (Jones 1985). This included burning a variety of habitats progressively throughout the year. Since 1979 ANCA has tried to replicate these past burning regimes as near as possible.

## 4.2 Water quality

A water quality testing exercise was conducted to ascertain the effects of chemicals (body cosmetics etc) used by visitors at Gunlom, a heavily used swimming area in the south of the Park (Rippon et al 1994). Results suggested that during intensive day use the chemical level in these areas does not adversely affect water quality.

Tests have been undertaken on the herbicide, AF100, used for the control of the water weed *Salvinia*. As described previously it appears that this herbicide, when applied in an appropriate

manner, has little observable ecological effect on non-target organisms (Finlayson et al 1994). It has been Park policy not to use residual herbicides on *Salvinia* in waterways in the Park. Unfortunately, treatment of *Mimosa* stems and seed banks requires the use of hexazinone (eg VELPAR), a residual herbicide (with a half life of 4 weeks on soil) which will affect non-target vegetation if carelessly applied.

### 4.3 Rehabilitation

Further assessment and rehabilitation of some wetlands areas is necessary where tidal channels are encroaching into aquatic wetlands and associated vegetation. Comparisons of 1970s, 80s and 90s aerial photography suggests that some areas were exposed to high levels of impact from buffalo activity. This resulted in natural levee banks being broken down, which led to poor freshwater retention of wetlands and subsequent inundation by saltwater of these areas during the following dry season. Some waterways have recovered with the aid of artificial levee banks being constructed and the removal of buffalo. Other areas have not recovered sufficiently through natural processes and, as a result, tidal channels and mangrove communities have encroached extensively into what were previously freshwater habitats. This has decimated aquatic vegetation, particularly large forests of *Melaleuca* trees. Large stands of stumps remain in what were previously healthy stands of paperbark forest. Some encroachment has extended for a few hundred metres to some kilometres beyond their natural boundaries as a result of levee bank destruction.

Immediate action is required to halt further unnatural freshwater loss of these affected areas and subsequent tidal encroachment during the dry season. The best short-term measure would be to build earth walls across the tidal channels. Artificial levee banks constructed elsewhere in the Park on similar problems have resulted in a remarkable recovery to freshwater habitats halting the threat of freshwater loss and saltwater intrusion.

## 5 Research and monitoring

In this section, I will deal only with research and monitoring issues that bare directly on fauna. The list below is not exhaustive, but provides examples of the types of management issues involved. Issues concerning the development of a weed management strategy and the development of other long-term monitoring programs in the Park relevant to wetlands management, are considered by other speakers.

### 5.1 Waterbirds

Bayliss and Yeomans (1987) described the significance of the parks wetland system as follows:

> 'Kakadu National Park encompasses all the major wetlands of the Alligator Rivers Region and is of World Heritage Standard.....The most impressive feature of these wetlands is the incredible abundance and diversity of waterbirds.'

As well, Kakadu's wetlands are listed on the Convention on Wetlands of International Importance (Ramsar) and various waterbird species seasonally resident in Kakadu are listed on three international agreements (JAMBA, CAMBA, Bonn Convention). Throughout the year, large numbers of birds abound on the Park's wetlands. This includes ducks, egrets, brolgas, waders, ibises, cormorants, bird of prey and amongst others, the mass congregation of Magpie geese later in the dry season.

A number of studies have been undertaken on waterbirds in the Park (Morton et al 1980, Bayliss & Yeoman 1987, Schultz 1989, Bamford 1990, Dostine & Skeat 1992).

### Magpie geese

The wetland systems of Kakadu are continually occupied by magpie geese throughout the seasonal changes of the year, although numbers may fluctuate markedly according to movement to and from areas outside the Park. Bayliss and Yeoman (1987) estimate that magpie geese in the region (Kakadu) vary between 600 000 in the wet to 2.5 million in the dry according to breeding and refuging.

Considerable research and monitoring has been conducted on the magpie goose populations of the Top End. This includes annual aerial survey counts across the northern wetlands (including Kakadu) which are conducted by the Conservation Commission of the Northern Territory (CCNT). These surveys are incorporated into other ongoing research of geese conducted by the CCNT. These studies are being carried out on wetland areas outside the Park. As well, other studies on Magpie goose nesting habitat preference have been undertaken at CSIRO's Kapalga Research Station (Corbett 1993).

Magpie geese are also a highly sought food source of the Park's Traditional Owners. Eggs are harvested late in the wet season and the birds are actively hunted later in the dry (July – October).

The Gagadju Association have initiated trials on non-toxic bird shot and are investigating bismuth as an alternative to lead for hunting of wildfowl on the Park's wetlands.

## 5.2 Crocodiles

In the 1990s Kakadu may well achieve a total recovery in its crocodile numbers. It may still be a population of young animals, but it is essentially a full grown population (D Lindner pers comm). It is important that a crocodile survey and monitoring program be maintained to monitor any trends (size structures, distribution, etc) that may be occurring.

### Crocodile survey program

Since 1979 a crocodile monitoring program has been undertaken in Kakadu National Park according to the Plan of Management (ANPWS 1991). The program has comprised the following elements:

- Spotlight surveys of tidal systems and inland waterways
- Management of problem crocodiles
- Survey and monitoring of crocodiles near visitor use areas eg boat ramps where problems may arise from human/crocodile interaction

In 1992 an attempt was made to collate all data concerning crocodile management in Kakadu National Park between 1977 and 1988 (Palmer 1992). The data were analysed and it was recommended that some refinements be made to the Park's crocodile survey methodologies relating to the tidal and inland freshwater systems. Following a recent assessment, this program will be resumed this year.

### Problem crocodiles

Crocodiles now present an ongoing issue of concern to Park management and one which, because of the frequency of interactions with humans, even if irregular in occurrence is a routine work hazard rather than a chance of a novel adventure for field staff. The responsibility prescribes unique assessment and action procedures. This needs to be undertaken under set guidelines with respect to the following objectives according to the Plan of Management (ANPWS 1991); ie monitor potential human/crocodile situations that may occur in relation to:

- personnel working in Kakadu

- visitor use areas
- fishing activities
- Aboriginal outstations and hunting areas
- other likely interaction activities

In broad summary, Kakadu management has responsibility for maintaining a large predator species population in a near as possible to its *natural wild state while protecting a visiting and resident prey species from predation at all times.*

## 5.3 Pigs

There is clearly a requirement for a coordinated approach to be taken toward assessing the impact of pigs and the numbers that currently exist in the park. A coordinated pig impact assessment program would require assessment of pig activity in some of the following ways:

- level of pig damage occurring
- habitat and vegetation affected and time of year
- concentration of pigs in worst affected areas
- mapping and grid referencing pig activity
- recording instances of disease

As a result of any program carried out and the extent of pig activity, consultation between Traditional Owners and management will need to determine the level of control required. Another point that warrants serious attention is the potential for pigs to carry and transmit a number of exotic diseases. This factor needs to be considered seriously when determining the acceptable level of pig concentrations within the Park.

## 5.4 Buffalo and cattle impact

Upon completion of the BTEC program ANCA will need to continue regular monitoring of buffalo and cattle populations in the park for disease. A level of vigilance is required so as to guard against future incidence of exotic diseases. Given the past history of buffalo impact in the region, particularly on wetlands, it is imperative that the current fortuitous situation of having low population densities of feral buffalo and cattle be maintained. Survey and monitoring of buffalo and cattle populations is also necessary to determine acceptable numbers which will:

- not impact significantly on the habitat resources of the Park
- accommodate Traditional Owners' requests for retaining small free-roaming herds as a food resource

## 5.5 Recreational fishing

Recreational fishing in the Park targets particularly the barramundi. Fishing effort is concentrated on the South Alligator and East Alligator River systems, particularly downstream of Jim Jim Billabong on the South, and downstream of Cahill's Crossing on the East Alligator River (Duff 1989). A recent population assessment of barramundi in Yellow Waters indicates that while recruitment in this species is annually episodic, the local barramundi population is healthy and vigorous, with approximately 60% of the entire estimated population of 6000 in 6 kms of billabong being less than one year old (Griffin 1993). Ongoing monitoring of

recreational fishing pressure is an evident priority. Similarly, no assessments are available of the effects of *Salvinia* on natural systems pre- or post-buffalo days; this is another area worthy of investigation.

# 6 Conclusion

Kakadu's wetlands provide an immense management challenge on a range of issues. Some of these issues are being effectively tackled at the present time. For example, the *Mimosa* program has been an unqualified success, and buffalo numbers are currently very low, at a density of one beast per 50 km$^2$. In fact, Kakadu's wetlands are in relatively great shape by comparison with adjacent areas in the local and international region. Other problems remain, eg Para grass and other aquatic weeks, pigs, cats, and some areas of salinisation warranting rehabilitation. As well, there is always the need to obtain more useful information, with research and monitoring programs targeting both short-term crises and long-term issues.

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