Biodiversity Audit - bioregional case study

Tiwi-Cobourg bioregion, Northern Territory

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Disclaimer

This report discusses conservation management options in a broad way with the aim of illustrating issues for comparable bioregions elsewhere in Australia. There has been no formal consultation process with stakeholders in this exercise, and this exercise is not a mechanism for implementation of any conservation initiatives for this bioregion.

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SUMMARY

This report provides a review of the Tiwi-Cobourg bioregion, noting in particular its conservation values, current reserve system, threatening processes and other factors which may affect conservation management. It then considers a range of options for enhancing that management.

The Tiwi-Cobourg bioregion is 9964 km^2 of entirely Aboriginal-owned land. It is sparsely populated (total population of about 2750 individuals). There are few land-based industries, and the overall economic basis of the bioregion is extremely limited. There is one conservation reserve in the bioregion: Garig Gunak Barlu National Park (on Cobourg Peninsula), whose area of 2207 km^2 comprises about 22% of the bioregion. This reserve includes samples of only four of the 11 vegetation types identified (at very broad scale) for the bioregion.

The bioregion has outstanding conservation values, including 44 threatened taxa (14 of which are listed nationally under EPBCA), a Ramsar wetland, at least 19 seabird colonies, nine endemic plant species, four endemic invertebrate species, ten endemic vertebrate subspecies, an endemic vegetation type, and an unusually extensive rainforest network. But the conservation value of this bioregion is by no means restricted to these isolated features. Rather, the value is due largely to the extent of largely unmodified lands providing succour for entire assemblages of species and allowing broad-scale natural processes to operate. Further, much of the bioregion is composed of islands, and even the mainland component is relatively isolated: this provides some security for many species from factors which have affected populations elsewhere on the north Australian mainland. Most of the bioregion is in generally good condition, but there are well-established large populations of some feral animals, and incipient populations of some highly destructive weeds. Fire regimes have changed (generally detrimentally) across most of the bioregion, in response to changing social patterns of the Aboriginal landowners.

A large forestry project (focusing on plantations of exotic timber species) is being developed on Melville Island, and will affect some biodiversity values there.

The future for conservation in this bioregion involves an enhanced reserve network, more resources for management of threatened species, and broad-scale off-reserve NRM. It is a simple desk-top exercise to draw maplines to encompass a comprehensive reserve network, but establishment of any additional reserves will require considerable partnership with Aboriginal owners, and explicit benefits to those owners. Currently, the threatened species occurring in this bioregion are generally not being managed or monitored. Most species would benefit from broad-scale land management, including greater security for rainforest patches, amelioration of the contemporary fire regime, elimination of the few existing noxious weed outbreaks and vigilance and quarantining against new outbreaks, and reduction in feral animals. Aboriginal ranger schemes must be an integral part of this land management effort. However, land management issues here are compromised by (i) lack of resources and employment opportunities; and (ii) the generally subtle and insidiuous decline in environmental quality. The latter factor means that there are few

conspicuous impacts which trigger ameliorative action. Hence, feral animals are widely viewed as relatively benign, with their economic (as foci for safari hunting tourists) and food values being seen to outweigh any environmental cost.

Compared to many other Australian bioregions, the Tiwi-Cobourg bioregion has generally retained high conservation values and requires relatively little resource contribution to maintain or enhance those values. However, even that meagre contribution is difficult to access because most of the conservation management resource is spent elsewhere on problems deemed to be more urgent or serious. The very limited economic base of this bioregion, and the lack of any substantial return to landowners from maintaining biodiversity, means that many landowners will support land-uses which provide some income but degrade biodiversity values. Many of these features are typical of the sparsely populated largely Aboriginal owned lands across much of centrala nd northern Australia.

THE REGION AND ITS ISSUES

Physical description

The Tiwi-Cobourg bioregion (Fig. 1) comprises four main components, Cobourg Peninsula (2207 km^2), Croker Island (310 km^2), and the two Tiwi Islands - Bathurst (1693 km^2) and Melville (5788 km^2) - with smaller islands associated with each of these. After Tasmania, Melville Island is Australia's second largest island, and Bathurst the fifth largest.

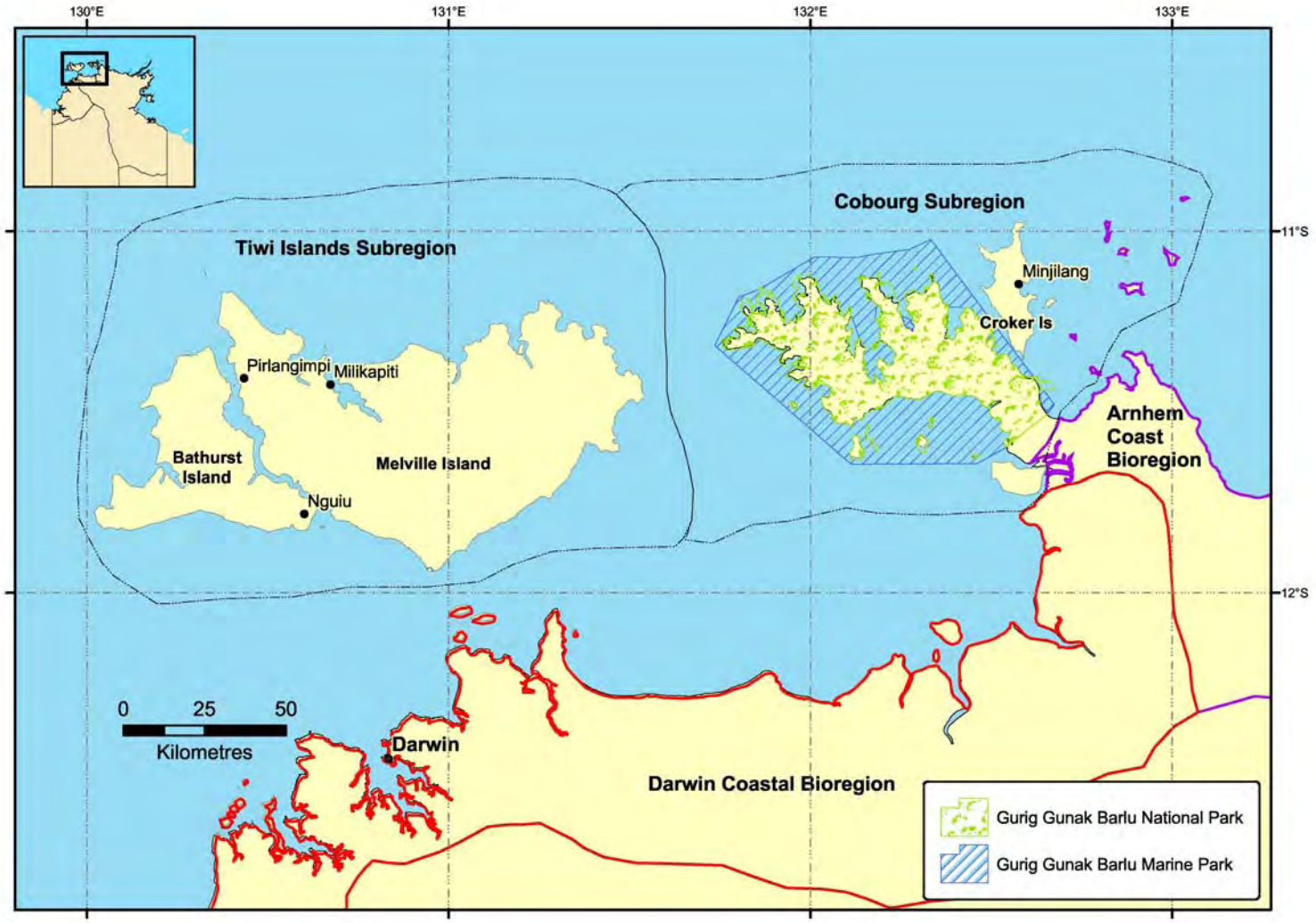
The total land area for the bioregion is 9964 km^2 comprising two subregions, P1 (the Tiwi Islands: 7349 km^2) and P2 (Cobourg Peninsula and Croker: 2615 km^2). The only land connection to any other bioregion is at the narrow (*ca* 10 km wide) isthmus at the base of Cobourg Peninsula, from which the Arnhem Coast bioregion extends to the south-east and the Darwin Coastal bioregion extends to the south-west.

The isolation of the Tiwi Islands and Croker is relatively recent. All were connected to the mainland up to between 12,000 and 8,000 years ago, when rapidly rising sea levels sundered the connection. The most isolated parts of the bioregion are a group of small islands (Grant, Lawson, McClure, Oxley, New Year islands: all <20 km^2) between 30 and 50 km north-east of Croker Island. There are also small islands close to Croker (Darch Island), Cobourg Peninsula (the Sir George Hope group, notably including Greenhill and Morse Islands) and the Tiwi Islands (Buchanan and Seagull).

Notwithstanding a highly convoluted coastline, especially on the north of Cobourg Peninsula, most of the bioregion is topographically simple and relatively low-lying. The highest point on the Tiwi Islands is 102 m, on Croker 57 m, and on Cobourg Peninsula 148 m. There are few large watercourses on Croker Island or Cobourg Peninsula, but Melville Island includes some substantial watercourses, with the largest being the Johnson and Jessie Rivers, extending up to about 40 km, of which about half is tidal.

The geology of the bioregion is described in detail in Hughes (1978) and Senior and Smart (1976). The main geological feature is the strongly weathered and lateritised Cretaceous and Tertiary sandstone plateaux. This rarely outcrops as cliffs or escarpment, except in some coastline areas on the north of Melville Island and Cobourg Peninsula. The lateritic land surface has been dissected and is largely buried beneath a thin Quaternary cover of sands, gravels and alluvium. These deposits are deeper in depressions associated with watercourses, and extend into small floodplains at Andranangoo Creek on Melville Island and on Croker Island. Beach sands have been sculpted into high dune systems along stretches of the southwestern coast of Bathurst Island, and recent sand deposits extend the coastline, especially around many of the smaller islands. Recent higher sea levels produced the drowned river valleys which are a conspicuous feature of the dissected northern coastlines of Melville Island and Cobourg Peninsula. Stranded beach dune areas, such as at Danger Point on Cobourg Peninsula, are indicative of even higher sea levels in the past. Mangrove swamps and tidal flats of the southern coastlines have been interpreted as signs of recent submergence of this part of the coastline (Senior and Smart 1976).

Figure 1. Tiwi-Cobourg bioregion, showing sub-regions, adjoining bioregions, main population centres, and major islands.



Climate in this bioregion is dominated by the extreme seasonality, with a short wet season between November and March delivering more than 90% of the annual rainfall. Total annual rainfall varies from about 1500 mm on Cobourg Peninsula to 2000 mm at the northern tip of Melville Island, the highest rainfall in the Northern Territory.

A high frequency of destructive cyclones is a feature of this bioregion (Lee and Neal 1984). Cyclonic events affect biodiversity and its management through major alteration of vegetation structure and patch dynamics, some occasional substantial mortality of particular species, damage to infrastructure and diversion of resources to repair (Marsh *et al*. 1986; Bowman and Panton 1994).

The area considered here is a terrestrial bioregion and excludes any detailed consideration of marine issues. In a coastal and island bioregion this segregation is somewhat artificial, but it is especially so here where the Aboriginal land owners identify themselves as "saltwater people", and treat marine and terrestrial management issues as almost inextricable components of a whole. Hence, in this account, some attention is given to marine issues where this clearly affects the conservation management of the terrestrial bioregion.

Vegetation

Eucalypt tall open forests, dominated by Darwin Stringybark *Eucalyptus tetrodonta*, Darwin Woollybutt *E. miniata* and Melville Island Bloodwood *Corymbia nesophila*, are by far the most extensive vegetation type across the bioregion, occupying around 77% of the Tiwi Islands, 93% of Cobourg Peninsula and 75% of Croker Island (Woinarski *et al*. 2000). These are among the best developed eucalypt forests in the Northern Territory, with canopy heights frequently exceeding 20 m, total basal area typically around 12 m^2/ha, and a high frequency (*ca*. 15/ha) of large trees (>40 cm dbh) (Fensham and Bowman 1992; Fensham and Kirkpatrick 1992). Understories in these forests are variable, depending upon soils, landscape position, and fire frequency. Common elements include annual and perennial *Sorghum* grass, *Cycas* spp., *Terminalia* spp. and *Acacia* spp. Ironwood *Erythrophleum chlorostachys* is a common, and *Callitris intratropica* a less common, subdominant tree species.

Coastal areas comprise a mosaic of vegetation types including saltflats, mangrove forests, saline grasslands on dunefields and strand woodlands typically dominated by *Casuarina equisetifolia* and *Scaevola taccada*. Particularly on the Tiwi Islands, where they comprise 11% of the islands' area, the mangrove forests extend inland along tidal watercourses (Messel *et al*. 1979).

The Tiwi Islands support a distinctive complex of low open shrubland (dominated by a mix of species including *Acacia aulacocarpa, A. difficilis, A. gonocarpa, A. latescens, Banksia dentata, Grevillea pteridifolia, Jacksonia dilatata, Lophostemon lactifluus, Planchonia careya* and *Syzygium eucalyptoides*) and grassland (Wilson and Fensham 1994). These "treeless plains" occur mainly in 11 large patches, with a total area of 183 km^2 (2.5% of the Tiwi land area) (Wilson and Bowman 1994; Woinarski *et al*. 2000). At the scale of the Northern Territory's 1:1,000,000 vegetation map (Wilson *et al*. 1990), they occur nowhere else other than on the Tiwi Islands.

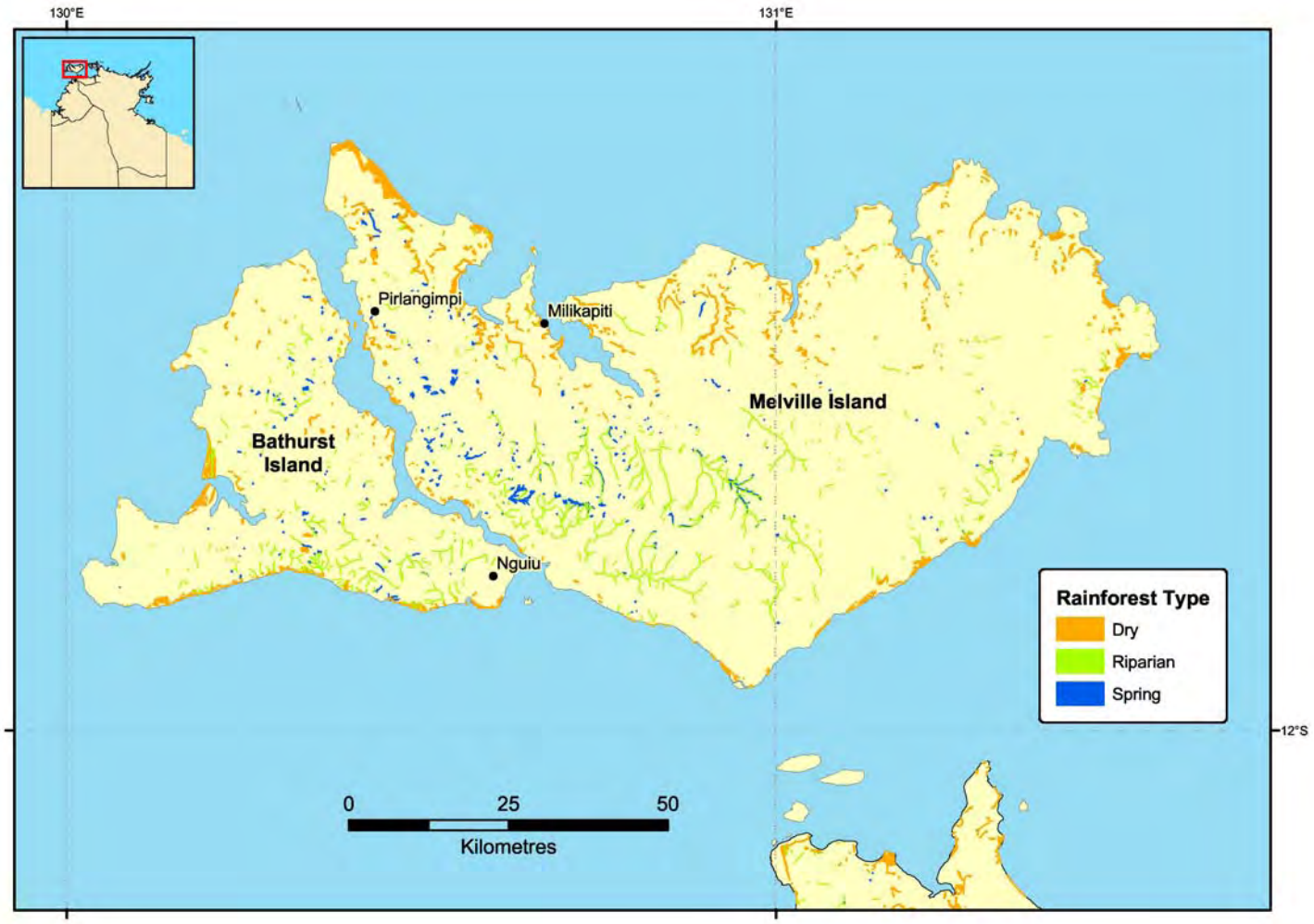
There is a higher proportional land area of monsoon rainforests in this bioregion than for any other bioregion in the Northern Territory. The rainforests on the Tiwi Islands alone constitute between 6 and 15% of the total rainforest estate in the Northern Territory (with this estimate depending upon the scale of the mapping used). Two of the seven large patches of monsoon rainforest mapped at 1:1,000,000 scale occur in the bioregion, at Cape van Diemen on the northwest tip of Melville Island (patch size of 36 km^2) and on the northern tip of Croker Island. However, most monsoon rainforest patches are isolated and small, with the mean size of "Group 3" (Russell-Smith 1991) (= "complex evergreen monsoon forest": Fensham and Woinarski 1992) rainforest patches being 1.1 ha, and mean size of "Group 5" (= "wet evergreen monsoon forest") being 0.8 ha. A total of 1261 separate rainforest patches have been mapped on the Tiwi Islands alone. There is great variation in floristics, structure and environmental position among the rainforest patches, in part summarised in a classification of rainforest types given in Russell-Smith (1991). In this bioregion, monsoon rainforest patches occur mainly in dry coastal thickets, around springs and seeps, and in riparian strips. The rainforests of this bioregion are generally markedly distinct in floristic composition from those elsewhere in the Northern Territory, as evidenced by the virtual restriction to the Tiwi-Cobourg bioregion of two of the 16 rainforest types identified for the Northern Territory by Russell-Smith (1991). Rainforest patches present particular conservation management challenges, because of the typically small sizes of individual patches, their susceptibility to disturbance, the highly idiosyncratic species composition of individual patches, the restriction of many species to rainforests, and because many rainforest species occur in very few patches (Fig. 2: Russell-Smith and Bowman 1992; Russell-Smith *et al*. 1992; Price *et al*. 1995).

Seasonally waterlogged areas across the bioregion support *Melaleuca* forests and woodlands and/or floodplain grasslands, sedgelands and swamps. On the Tiwi Islands, there are 77 km^2 of *Melaleuca* formations, and 173 km^2 of wet sedgelands and grasslands (Woinarski *et al*. 2000). The largest floodplains are on Andranagoo Creek (Melville Island) and on Croker Island.

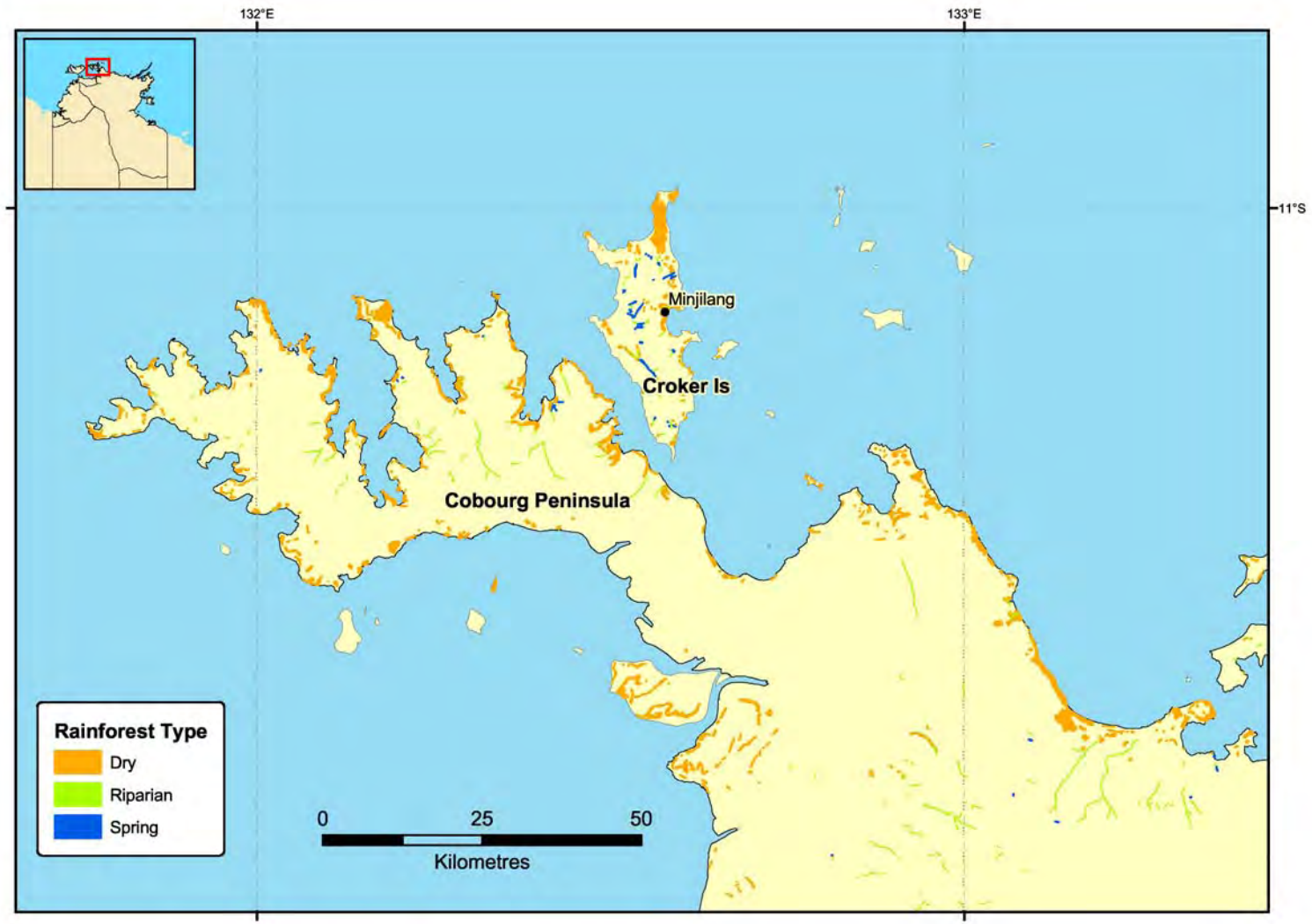
There are only relatively small areas of highly modified landscapes in this bioregion, although this may change rapidly in the near future. The total built-up area (settlements, airstrips, sewerage works, roads, etc.) is about 50 km^2 (<0.5% of the land area of the bioregion). Plantations of exotic timber species, dating back to the 1970s, comprise another 79 km^2, almost entirely on Melville Island. Thus, native vegetation still covers more than 98% of the bioregion's area.

Figure 2. Rainforest patches (a) on the Tiwi Islands, and (b) on Cobourg Peninsula and Croker Island.

(a)



(b)


132°E
133°E
11°S
Minjilang
Croker Is
Cobourg Peninsula
Rainforest Type
Dry
Riparian
Spring
0
25
50
Kilometres

Social issues and land use

The total population of the bioregion is about 2750, comprising about 2500 people on the Tiwi Islands (mainly in the towns of Nguiu, Milikapiti and Pirlangimpi), 50 people on Cobourg Peninsula and up to 200 people at Minjilang (Croker Island). Thus, population density for the bioregion is very low (0.27 individuals / km^2), as is typical for most bioregions which are predominantly Aboriginal lands.

The population centres are serviced mainly by light aircraft and coastal barges, with an experimental hovercraft service now being trialled between Darwin and the settlements of Nguiu and Pirlangimpi on the Tiwi Islands. Cobourg Peninsula is accessible by road from Darwin, but this is cut off for most of the wet season. There are track and minor road networks connecting most of the settlements and outstations.

The entire bioregion is inalienable Aboriginal lands held through the *Aboriginal Land Rights (Northern Territory) Act 1976*, under three titles: the Tiwi Aboriginal Land Trust, Cobourg Peninsula Sanctuary Land Trust and part of the Arnhem Land Aboriginal Land Trust. Within this legislative ownership system, lands are the responsibility of different clan groups: for example, the Tiwi Islands are divided into eight non-overlapping traditional estates (Yimpinari, Wulirangku, Mirrakawuyanga, Malawu, Munupi, Matiyupwi, Wurankuwu and Tikilaru). Individual clan groups have a primary responsibility for the management of their own estates, but issues affecting the Tiwi Islands or Tiwi people as a whole are addressed through the Tiwi Land Council. Similarly, there are four clan groups (Agalda, Madjunbalmi, Ngaindjagar and Muran) responsible for different parts of Cobourg Peninsula, and three for Croker Island (Malindarri, Namarrmouu and Gaduamingu). The Northern Land Council represents the interests of all clan groups on Cobourg Peninsula and on Croker Island.

Although there are some unresolved issues of interpretation and application, a range of Northern Territory legislation relating to natural resource management applies over land management issues on these Aboriginal lands. This includes the:

- *Planning Act*, which deals *inter alia* with development applications and environmental assessment;
- *Soil Conservation and Land Utilisation Act,* which deals *inter alia* with activities affecting soil resources and the prevention of erosion*;*
- *Water Act,* which deals *inter alia* with water resources and the prevention of pollution*;* and
- *Territory Parks and Wildlife Conservation Act,* which deals *inter alia* with threatened species and environments, feral animal control, commercial and sustainable use of species, and agreements to manage lands for conservation.

Cobourg Peninsula is subject to a markedly different land management process to that of the rest of the bioregion. In 1924, the Peninsula became the first flora and fauna reserve in northern Australia. The western part of the reserve was revoked in 1940, to become an Aboriginal reserve. This was resumed as sanctuary in 1962, and the status changed again in 1981. The *Cobourg Peninsula Aboriginal Land and Sanctuary Act (1981)* acknowledged the right of Aboriginal people to occupy and use land there, vested land in trustees for the Aboriginal traditional land owners, but also declared the land to be a national park held in perpetuity, with acknowledgement of the rights of traditional owners to participate in the

management of the national park. Accordingly, land management issues on the Cobourg Peninsula are now considered by a Board of Management, with a majority (and Chairman) of Aboriginal traditional land owners. Land use and conservation is guided by Plans of Management for the Garig Gunak Barlu National Park (formerly Gurig) National Park, with successive plans developed in 1987 and 1993, and a new plan currently in preparation. Aboriginal landowners are paid an annual fee for use of their land as national park. This was set at $20,000 in 1981 and increased annually by a percentage equal to the percentage increase in the average male wage in Darwin (Smyth 2001).

All lands in the bioregion are used to some extent for traditional purposes including harvesting and hunting of plants and animals, for food, medicine, art and cultural reasons. However, land management has evolved since pre-European times. Aggregation of the population to a few permanent settlements has disrupted traditional burning practices, and these have been further influenced by the development of road networks, a less intimate and immediate reliance upon bush tucker, and, in some cases, by gradual decay of knowledge about traditional land management.

Tourism is an important industry in parts of this bioregion, founded on the rich Aboriginal culture, abundant wildlife, good fishing and superb coastal landscapes. Tourism infrastructure comprises a luxury resort at Seven Spirits Bay on Cobourg Peninsula, a converted lighthouse and associated house at Cape Don (Cobourg Peninsula), a group of six bungalows and a campground near Smith Point on Cobourg Peninsula, a dry-season "safari-style" camp at Putjamirra on Melville Island, and a fishing lodge on the west coast of Bathurst Island and the west coast of Croker island. Aboriginal landowners are owners, partners, active participants, or royalty-earners in all of these ventures. There are also organised 1- or 2-day tours of Tiwi Islands. Most of these enterprises have had a somewhat erratic history and/or have changed hands repeatedly since inception. While most Aboriginal landowners appear to favour some tourism development, there is also a clear message that this needs to be controlled (Altmann 1988; Burchett 1991). For example, visitor numbers to Cobourg Peninsula are tightly regulated, with a maximum of 15 vehicles allowed entry at any time, and the area is inaccessible to vehicles for the duration of the wet season. Annual visitation is about 1500 tourists for Cobourg Peninsula and about 2500 for the Tiwi Islands (Fensham and Woinarski 1992; Blake *et al*. 1998).

Cobourg Peninsula provides a distinctive niche tourism market for safari game hunters, based especially on the large population of feral banteng *Bos javanicus*, on which royalties are paid to the Aboriginal landowners for each trophy animal.

Commercial art establishments (Tiwi Design Aboriginal Corporation, Jilamara Arts and Crafts Association Ngawa Mantawi, Munupi Arts and Crafts, Mgaruwanajirri) on the Tiwi Islands are a major source of employment and revenue. Wooden carvings, mostly using ironwood *Erythrophleum chlorostachys*, are a major component of this artwork.

The seas around this bioregion are significant fisheries, and also provide important sources of food for Aboriginal landowners. In addition to the existing fish and prawn industries, there is a major pearling venture based on two leased areas on Cobourg Peninsula and one on Croker Island, a recently established aquaculture venture (barramundi farming) on the Tiwi Islands and proposals for the development of trepang harvesting industries. These industries are not considered further here, as, although they may affect some terrestrial ecosystems locally, through land-based infrastructure, their management mostly relates to marine bioregions.

The major land use impact on the bioregion is commercial forestry. Localised harvest of native timbers (principally *Callitris intratropica* and *Melaleuca* spp.) occurred intermittently on the Tiwi Islands and Cobourg Peninsula from the time of European settlement up to about the 1960s. Subsequently, a major forestry industry developed on Melville Island, mostly involving *Callitris intratropica* and a range of exotic conifers (Forrest 1998). This enterprise has had a chequered history and has failed to reach the potential claimed by its initial proponents (Higgins and Phillips 1973; Lacey 1979; Anon 1978; Cameron 1985; Woinarski and Dawson in press). These plantations involved the clearing of 79 km^2 of native vegetation, mostly eucalypt tall open forest and treeless plains, mostly in the 1970s and 1980s. Subsequently, commercial forestry has been revived with recent proposals to establish a pulp industry based on short rotations of the exotic fast-growing *Acacia mangium* (ForSci 1999; First Management Corporation 1999). Initial clearing of two tranches each of about 2500 ha proceeded in 2000-01, and subsequent clearing of 30,000 ha was approved in 2001.

The Tiwi Islands was also the base for a major commercial buffalo-harvesting industry between 1890 and 1915, which continued fitfully at least into the 1990s (Forrest 1998). The Tiwi Islands also supported a short-lived export industry of skins of carpet pythons *Morelia spilota*, during the early decades of the twentieth century.

There is currently no commercial harvesting of bush tucker in this bioregion. However, there has been intensive bioprospecting investigations on the flora of this bioregion over the last decade, and one plant species is now being considered for pharmacological development.

Biodiversity information

Documentation of biodiversity in this bioregion has been patchy. Some significant gaps constrain conservation planning and biodiversity management.

In addition to the more targetted studies cited below, there are some incidental records published in Parker (1973), Storr (1977), Watts and Aslin (1981), Davis (1983), Thomson (1989), Horner (1991), and Strahan (1995), although the information in Davis (1983) and Strahan (1995) is unreliable.

Table 1. Knowledge status of biodiversity - the number and density of geo-coded plant and animal records for the Tiwi-Cobourg bioregion, compared to the Northern Territory as a whole.

area	plants		terrestrial vertebrates	
	no. records	*density (no/km^2)*	*no. records*	*density (no/km^2)*
Tiwi-Cobourg bioregion	30,395	3.05	10,067	1.01
Cobourg Peninsula	2,797	1.27	2,389	1.08
Croker Island	1,223	3.95	109	0.35
Tiwi Islands	26,375	3.59	7,569	1.03
whole NT	290,172	0.21	393,781	0.29

Cobourg Peninsula

Cobourg Peninsula has an unusually extensive historical record of biodiversity, for the period 1840 to 1880, courtesy mainly of the many collectors attracted to the early settlements there (principally Port Essington). Details of these collections and surveys are given in Specht (1964) and Calaby (1974). No substantial biodiversity information was then reported until the 1948 American-Australian Arnhem Land Expedition, during which fish (Taylor 1964), frogs and reptiles (Mitchell 1964) and mammals (Johnson 1964) were collected at Cobourg Peninsula.

Subsequently, a more comprehensive biological survey of Cobourg Peninsula in the 1960s and early 1970s (Frith and Calaby 1974) provided an important inventory benchmark for plants and terrestrial vertebrates, and included some information on changing status for some species. There has been little substantial research published on native terrestrial fauna of the Cobourg Peninsula since 1974, however some localised studies have considered dynamics of individual native mammal species (Begg *et al*. 1983; PWCNT 2000). Over the last 10 years, the coastal areas of Cobourg Peninsula and adjacent small islands have been sampled, mostly by aerial survey, for congregations of shorebirds, and for breeding colonies of seabirds and waterfowl, and breeding sites for marine turtles (Chatto 1998, 2000, 2001). Aerial survey has also been used to monitor feral mammals (Bayliss and Yeomans 1989), most recently in 2000.

The detailed account of plants of Coboug Peninsula in Frith and Calaby (1974) is now very dated, and there has been no subsequent attempt at floristic inventory. However, there have been several localised studies of vegetation dynamics and management, including some consideration of the impacts of fire and feral animals (Bowman *et al*. 1990; Bowman and Panton 1991; Bowman 1993); and some studies have included floristic inventory of rainforest patches on Cobourg Peninsula as part of a geographically broader survey (Russell-Smith 1991; Bowman *et al*. 1991; Bowman 1992).

The detailed information about plants known by the Aboriginal landowners of the Cobourg Peninsula has been compiled by Blake *et al*. (1998). This includes information on names and uses for 269 plant species from this area.

PWCNT maintains a Territory-wide atlas of all available geo-coded plant and terrestrial vertebrate records for the Northern Territory as a whole. For Cobourg Peninsula, there are 2797 records of plants and 2389 records of animals in this Atlas, a density of records substantially higher than that for the Territory as a whole (Table 1).

The finest scale vegetation systematic mapping for Cobourg Peninsula is the 1:1,000,000 vegetation map of Northern Territory (Wilson *et al*. 1990), which included only four vegetation types for the area. However, a vegetation map of uncertain derivation included in the 1987 Management Plan discriminated 9 vegetation types (eucalypt tall open forest and tall woodland; eucalypt mid-high open forest; rainforest; coastal dune complex (very tall grassland with scattered trees); coastal swamp and sand complex; freshwater wetland complex; mangrove and salt flat community; cypress pine tall open forest; and *Melaleuca* low open woodland) for the Cobourg Peninsula. A finer scale map (1:250,000 or 1:100,000) is under consideration for 2002.

There is some monitoring for biodiversity on Cobourg Peninsula. Since 1995, breeding populations of marine turtles have been sampled regularly on Greenhill Island, Black Point and Smith Point (Hope and Smit 1998). Populations of feral animals, especially banteng *Bos javanicus*, are counted periodically (most recently in 2001), and these counts are used to help set limits for safari hunting or as guides for culling. Commercial take, mostly by safari hunting, is also monitored. Permanent exclosure plots were established in 1988 (Bowman 1993; Panton 1993) to assess vegetation dynamics and especially the impacts of feral animals. However most of these plots have now been destroyed or discontinued.

A range of marine organisms has also been subject to recently established monitoring programs, but these fall outside the focus of this report.

Croker Island and surrounds

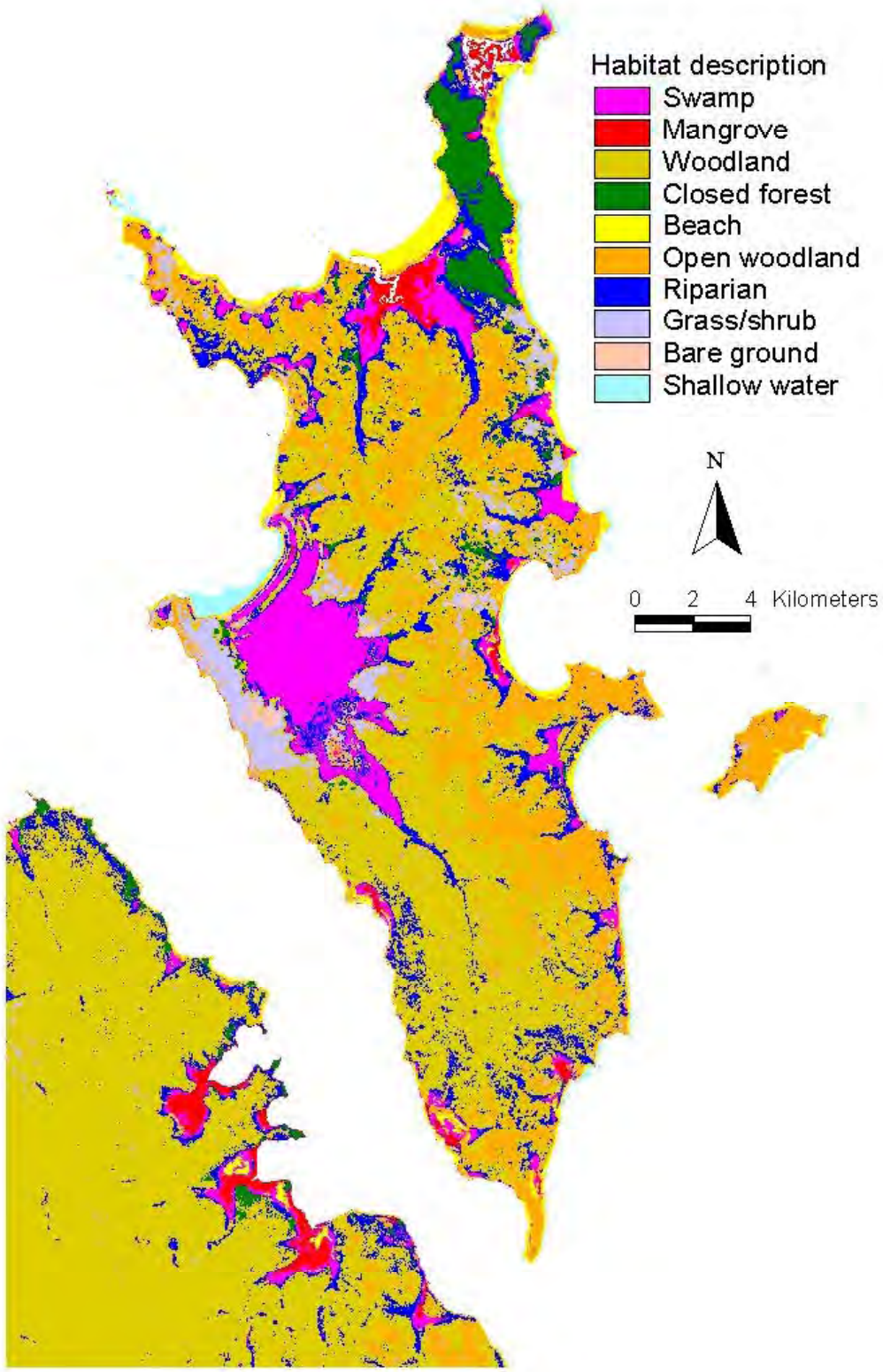
There is little biodiversity information recorded for Croker Island and adjacent islands (Table 1).

There has been no comprehensive sampling of terrestrial vertebrate fauna, other than a brief (<2 week) and currently undocumented survey in 2001, and some largely opportunistic and/or anecdotal records. The exception is that, as with the other components of this bioregion, there have been surveys of shorebirds, colonially-nesting waterfowl, colonial seabirds and breeding sites for marine turtles (Chatto 1998, 2000, 2001).

As for vertebrates, there has been no systematic sampling of vegetation of Croker and adjacent islands. However, some data have been collected as part of Territory-wide studies of rainforest patches (Russell-Smith 1991) and for field verification of the 1:1,000,000 vegetation map (Wilson *et al*. 1990).

For this study, we developed a vegetation map for Croker Island (Fig. 3), based mainly on interpretation of satellite imagery, some field verification, and use of previous mapping of rainforest and *Melaleuca* formations.

Figure 3. Vegetation map of Croker Island



Tiwi Islands

In comparison to the rest of the bioregion, there is a relatively large source of information about the biodiversity and conservation values of the Tiwi Islands (Table 1), mostly collated in Woinarski *et al*. (2000).

The islands were reasonably well sampled by early collectors (Holtze 1891; Thomas 1913, 1921; Mathews 1914; Zietz 1914ab), with occasional additional anecdotal records (Dodd 1935; Goodfellow 1935; Hayman 1936; Harney and Elkin 1943) up to the 1960s.

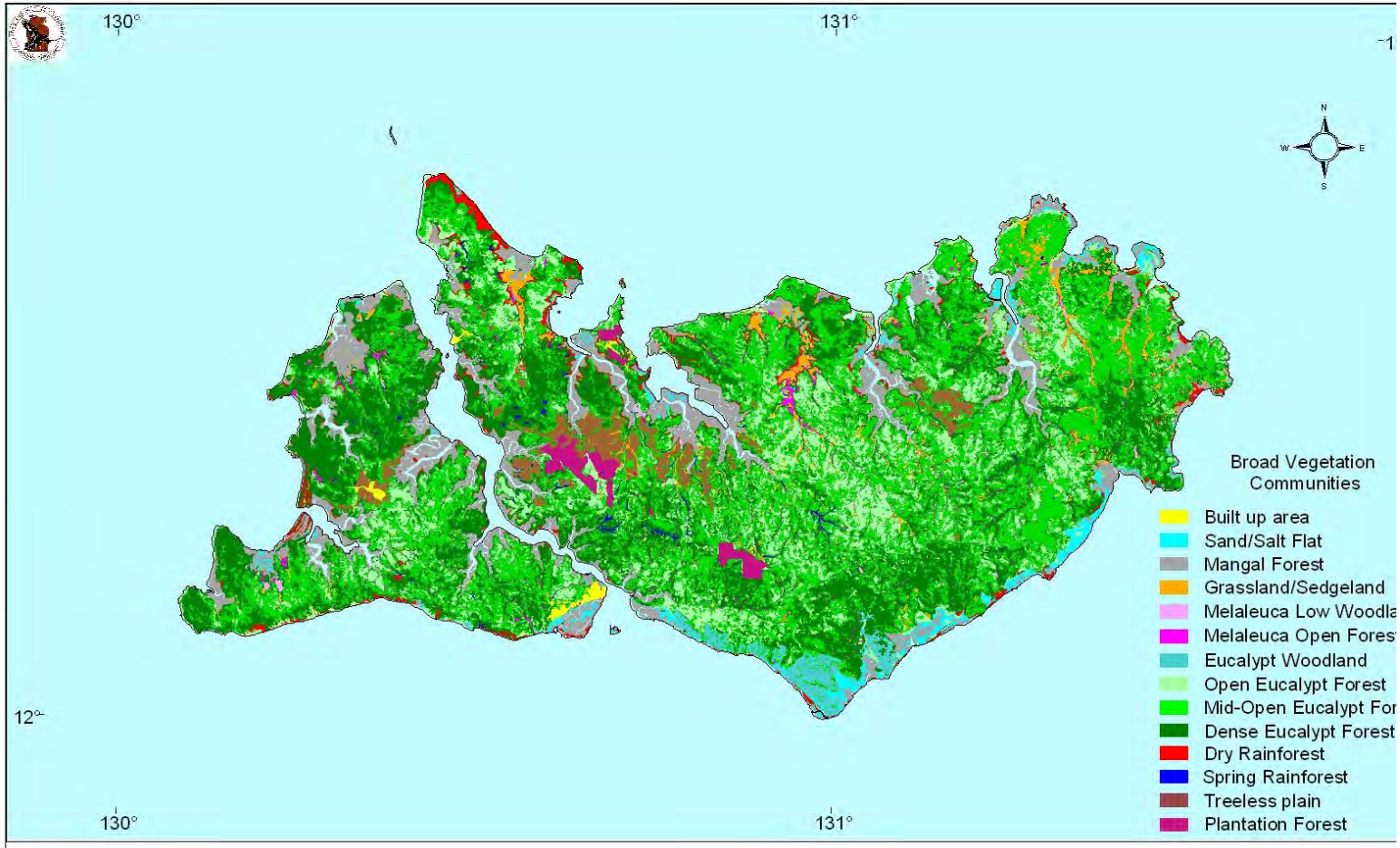
Then followed a series of intensive studies prompted by the development of plantation forestry (mainly native *Callitris* and exotic *Pinus*), including a series of environmental description and mapping studies, most notably fine-scale (1:50,000 or finer) mapping of land units of the Yapilika and Seventeen-Mile Plains areas of Melville Island (van Cuylenburg and Dunlop 1973; Wells and van Cuylenburg 1978), coarser-scale (1:100,000) mapping of land systems for the western half of Melville Island (Wells *et al*. 1978) and for parts of Bathurst Island (Olsen 1980). These reports include lists of plant species from the general study area.

The forestry industry also prompted some landmark studies of Tiwi vegetation ecology, most notably by Stocker (1968) at Karslake Peninsula, by Wilson on the dynamics of the eucalypt forest – "treeless plain" boundaries on western Melville Island (Wilson 1991; Wilson and Bowman 1994; Wilson and Fensham 1994); and by Fensham on patterning and regeneration of the eucalypt forests generally on western Melville Island (Fensham 1990*a*, 1994*a,b*; Fensham and Bowman 1992; Fensham and Kirkpatrick 1992). These studies remain the most substantial documentation of any aspects of Tiwi environments.

Russell-Smith (1991) included floristic inventories of 98 rainforest patches on the Tiwi Islands, as part of a survey of Territory rainforest communities generally. Subsequent work included information on Tiwi rainforests within Territory-wide consideration of the conservation status of rainforests (Russell-Smith and Bowman 1992; Price *et al*. 1995), the distribution of rainforest plants (Liddle *et al*. 1994), and the patterning of rainforest fauna (Menkhorst and Woinarski 1992; Gambold and Woinarski 1993; Reichel and Andersen 1996), as well as additional, more specific and extensive sampling of plants and animals within Tiwi rainforest patches (Fensham and Woinarski 1992), and consideration of the conservation status of one Tiwi rainforest plant (Fensham 1993*a*).

Other Tiwi vegetation types have received some, but less comprehensive, attention in the last few decades. Messel *et al*. (1979) described the characteristics and distribution of mangrove and riparian vegetation along parts of the Johnston River, Andranangoo, Bath, Dongau and Tinganoo Creek systems and Pulloloo and Brenton Bay Lagoons. Fensham (1993*b*) described a mosaic of *Melaleuca* forest, monsoon rainforest and strand (coastal) vegetation at a Holocene beach ridge system on the west of Bathurst Island. Wilson *et al*. (1990) described coarse-scale vegetation patterning, as part of a Territory-wide 1:1,000,000 vegetation map. As part of a Top End - wide study, Brocklehurst and Lynch (*unpubl*.) included the Tiwi Islands within a classification and map of *Melaleuca* vegetation communities, mostly from interpretation of imagery.

Figure 4. Vegetation map of Tiwi Islands



Datum: GDA94.
Projection: MGA52.
Communities derived from Landsat Imagery
Produced by the Bioregional Assessment Unit, PWCNT.

FIGURE 11 : Broad vegetation communities of the Tiwi Islands

Much of the above vegetation information was consolidated in a review of vegetation communities on the Tiwi Islands by Brocklehurst and Edmeades (1998), which included a composite vegetation map at 1:250,000 scale. This review was largely replicated in ForSci (1999), but refined into a map of broad vegetation communities in Woinarski *et al*. (2000) (Fig. 4).

To some extent arising from this vegetation inventory and ecological research, a number of recent papers have focused on taxonomic descriptions of Tiwi plant species (e.g., Hay 1992; Barker 1998).

There have been fewer detailed studies of the Tiwi fauna. Invertebrates in particular have been poorly sampled. The only systematic surveys published have been brief and relatively localised – Reichel and Andersen (1996) included samples from five Tiwi rainforests within their study of Top End rainforest ants; Watson (in Watson and Theischinger 1984) collected dragonflies and damselflies in June 1981; Suggit (in Anon 1998) collected macroinvertebrates at five freshwater sites on Melville Island as part of a national river health monitoring project; and Brown (1998) collected aquatic insects at 14 sites on Melville Island over a two-week period in 1996. A more comprehensive sampling of ants was conducted in 2000 and 2001, based on sampling >200 quadrats stratified across the range of environments present on Bathurst and Melville Islands (Woinarski and Andersen *in prep*.), but these data have not yet been written up. As evidence of the inadequacy of information on Tiwi invertebrates, Brown noted that 26 of the 81 aquatic insect species he collected "were either new or could not be identified to species with certainty".

Information on freshwater fish on the Tiwi Islands is similarly sparse. Before two weeks of sampling on Melville Island in October 1996, Larson (1998) noted "*almost nothing is known of the freshwater fish fauna of the Tiwi Islands. For example, only three freshwater fishes are recorded in the literature as occurring on Melville Island*." Her work recorded 49 fish species, although this tally included many estuarine species.

The terrestrial vertebrate fauna is now far better known, mostly through sampling of 185 quadrats stratified across the environmental range of Melville Island in 2000 (Woinarski *et al*. 2000) and about 100 quadrats on Bathurst Island in 2001 (Woinarski *et al*. *unpubl*.).

The frog fauna of Melville Island was previously described in some detail by Tyler *et al*. (1991), based on 10 days of sampling. Limited additional information was presented in Fensham and Woinarski (1992), Gambold and Woinarski (1993) and Woinarski (1998).

The reptile fauna known from the Tiwi Islands was listed in Fensham and Woinarski (1992) and Woinarski (1998), although this listing was based on little systematic research, most notably a survey of 17 Tiwi rainforest patches (Gambold and Woinarski 1993) and a two-week survey of freshwater and adjacent areas at four main sites on Melville Island (Horner and Griffiths 1998). There have also been surveys of the distribution and abundance of saltwater crocodiles *Crocodylus porosus* (Messel *et al*. 1979), and of nesting marine turtles (Chatto 1998).

The bird fauna of the Tiwi Islands was reviewed in Mason and Schodde (1997) and Woinarski (1998), based largely on collections in the first two decades of the twentieth century, more recent sampling of 17 Tiwi rainforest patches and their surrounds (Fensham

and Woinarski 1992), and a survey on Melville Island over two weeks in 1996 (Mason and Schodde 1997). Waterfowl, seabirds and shorebirds were sampled on the Tiwi islands in a series of aerial surveys by Chatto (2000, 2001, unpubl.)

The mammal fauna of the Tiwi Islands was reported in Fensham and Woinarski (1992) and Woinarski (1998), although this listing was based on little systematic research, most notably a survey of 17 Tiwi rainforest patches and their surrounds (Menkhorst and Woinarski 1992) and a two-week survey of freshwater and adjacent areas at four main sites on Melville Island (Horner and Griffiths 1998), as well as reasonably substantial collections made between 1900 and 1920 (Thomas 1913, 1921). There have also been some recent largely anecdotal accounts of individual mammal species on the Tiwi Islands (Magnusson *et al*. 1976; Kemper and Schmitt 1992; Woinarski *et al*. 1996).

The feral mammals of the Tiwi Islands (pig, water buffalo, horse and cattle) were surveyed as part of a Territory-wide aerial survey in 1985 (Bayliss 1985), with subsequent surveys conducted irregularly since then, but not yet published.

Biodiversity knowledge held by the Tiwi people has recently been compiled (Puruntatameri 2001), with special attention to plants used for foods, medicines and cultural reasons.

Conservation values

While below we recognise that there are clearly some localities which have special conservation assets and some species which merit special attention, the fundamental conservation value of this bioregion is more pervasive, that the bioregion as a whole comprises extensive relatively unmodified landscapes which support an intact biota. This value is shared by few other Australian bioregions, although it may be matched in the North Kimberley bioregion.

A second pervasive value is the isolation of most of this bioregion, which has allowed many species to remain unaffected by threatening processes which have eliminated or diminished populations across their former mainland range. This refugial value may well increase as the number and impact of threatening processes continue to magnify on the mainland (Fensham and Cowie 1998; Woinarski 2000). The brush-tailed rabbit-rat *Conilurus penicillatus* illustrates this process. Formerly it was widespread across monsoonal areas of the Northern Territory, to the extent that Dahl (1897) noted that “in Arnhem Land (it) is everywhere common in the vicinity of water”, a status corroborated by a very large collection of specimens obtained independently by Tunney in 1902-03 from the Alligator Rivers Region (Thomas 1904). Despite thorough surveys across most of the monsoonal areas of the Northern Territory over the last decade, the species is now known in the Northern Territory mainland only from Cobourg Peninsula and one small (<10km^2) site within Kakadu National Park; offshore, it still occurs on one island in the Pellew group (Gulf Coastal bioregion), from Groote Eylandt, one island in the English Company group (Arnhem Coastal bioregion) and Bathurst and Melville Islands (Woinarski *et al*. 2001).

threatened species

The most explicit and detailed catalogue of conservation values for any part of the bioregion was that given by Woinarski *et al*. (2000) for the Tiwi Islands. This listed 11 terrestrial vertebrate species and 14 plant species considered threatened at Territory or national levels, mapped and/or modelled their distribution on the Tiwi Islands, and assessed the major threats to these taxa. Additional to the threatened species listed there, the Tiwi islands also supports populations of four threatened species of marine turtle (Table 2).

There is far less information for threatened species on the Cobourg Peninsula or Croker components of the bioregion, but at least five additional threatened taxa are known from these areas (gouldian finch, north Australian subspecies of masked owl, leatherback turtle, an undescribed *Cryptoblepharus* skink, and the palm *Arenga australasica*).

A total of 14 taxa known from this bioregion are currently listed as threatened under the EPBCA. Appendix A provides more detailed accounts of all threatened taxa. A current revision of the conservation status of all NT plant species suggests that an additional 10 species should be listed as threatened, but five of the species currently listed should be de-listed.

threatened ecosystems

As for the Northern Territory as a whole, no ecosystems in this bioregion are listed as threatened under the EPBCA.

Notwithstanding this lack of formal listing, three environments of this bioregion may be considered to be under some threat.

monsoon rainforests. These occur as small patches widely distributed across much of the bioregion. Most patches are being degraded, mostly through the impacts of feral animals (pigs, buffalo, banteng, horses, goats and/or cattle), but also through invasion by weeds and increased incidence and severity of fire (Russell-Smith and Bowman 1992; Fensham and Woinarski 1992). For example, Fensham and Woinarski (1992) reported pig damage evident in all 17 of the wet monsoon rainforest patches, and in 65% of the dry monsoon rainforest patches, sampled on Bathurst Island. Monsoon rainforests dependent upon aquifers may also be vulnerable to broad-scale clearing and plantation forestry in their surrounds.

treeless plains. Wilson and Fensham (1994) noted that, over the period 1975-1993, more than 10% of this community had been cleared and developed for plantation of exotic tree species. However, more recent forestry developments have concentrated instead on the native eucalypt forests.

eucalyptus open forests. Tall open forests dominated by *Eucalyptus tetrodonta, E. miniata* and/or *E. nesophila* are the most extensive vegetation type across this bioregion. However, a recently approved proposal for the development of exotic timber plantations would result in the clearing of about 5% of this vegetation type on the Tiwi islands, with a further 10% under consideration.

Ramsar wetlands

Cobourg Peninsula was one of Australia's first declared Ramsar sites. All wetlands (including mangrove communities) on the Peninsula, and on the adjacent Sir George Hope island group, are included in the Ramsar site and in the Directory of Important Wetlands in Australia (Chatto and Whitehead 1996).

significant colonies

Colonial seabirds are known to nest in at least 19 sites in the bioregion (Table 3; Fig. 5), of which 13 sites are probably of national or international significance. For example, Seagull Island supports the largest breeding colony known for crested tern in the world, and the bioregion also contains Australia's largest colonies of black-naped tern (Chatto 2001).

Breeding sites for marine turtle in this bioregion have not yet been so thoroughly documented; however the islands to the east of Croker are considered to support Australia's largest breeding populations of olive ridley turtles; for flatback turtles, the south-west of Bathurst Island, parts of the northern coast of Melville Island, Greenhill Island, and most of the islands to the east of Croker island are among the best nesting areas in the Northern Territory, for green turtle, Smith Point on Cobourg Peninsula is among the best nesting sites in the Northern Territory, and several of the few Australian breeding records of the leatherback turtle have been from Cobourg Peninsula (Chatto 1998).

endemic taxa

By virtue of their relatively large size, isolation, proximity to Indonesian islands to the north, and environmental location (highest rainfall in the Northern Territory), the Tiwi Islands support many plants and animals which occur nowhere else in the Northern Territory, and some entirely endemic taxa.

Nine plant species are considered entirely restricted to these islands (Table 4). A further 12 plant species have no other Northern Territory records, but are known also from elsewhere in Australia (typically Cape York Peninsula) and/or from south-eastern Asia.

Note that for many other plant species, the Tiwi Islands are of major significance in that, although not endemic, a very high proportion (>50%) of their total population or known sites of occurrence occur there. Such plants include the rainforest species *Hypolytrum nemorum, Lindsaea walkerae* (known only from 6 records in perennially wet, rainforest habitats on Melville and Bathurst Islands, and one record from eastern Arnhem Land), *Nervilia peltata* (known from only four locations in the Northern Territory, of which two are on the Tiwi Islands), *Selenodesmium obscurum, Vittaria ensiformis, Melodinus australis, Mapania macrocephala, Elaeocarpus culminicola, Endospermum medullosum, Dysoxylum latifolium, Acmena hemilampra, Syzygium fibrosum, Luisia teretifolia* and *Psychotria coelosperma*, and a smaller number of open forest species including the dominant tree *Eucalyptus nesophila* and the herb *Zornia disticha*. Except for three of these species which are also classified as threatened, we do not deal specifically with these species

here, although we recognise that the conservation management of the Tiwi Islands is highly influential in their fate.

The invertebrate fauna is poorly known, but at least two ant and two dragonfly species are considered to be endemic (Brown 1998; Brown and Theischinger 1998) (Table 4). Eight subspecies of birds are considered endemic (Mason and Schodde 1997; Schodde and Mason 1999; I. Mason *pers. comm*.), as are two subspecies of mammals.

endemic environments

There has been no comprehensive vegetation mapping of this bioregion within a context of the broader monsoonal Top End of the Northern Territory, which renders the identification of endemic environments effectively impossible.

However, at the 1:1,000,000 scale of the NT vegetation mapping, the treeless plains of the Tiwi Islands are unique, although none of the component species is endemic to the Tiwi Islands and smaller patches of comparable vegetation occur in a few places elsewhere in the Top End (e.g. Labelle-Elizabeth Downs in the Darwin Coastal bioregion, and SE of Gove in the Arnhem Coast bioregion).

The most systematic framework for identifying endemicity in this bioregion's environments is the very extensive sampling of NT monsoon rainforest patches by Russell-Smith (1991). Based on analyses of species lists from 1219 rainforest patches (including 98 from the Tiwi Islands), he classified the variety of rainforests into 16 floristic assemblages, of which two (groups 3 and 5 - both associated with springs and drainage lines) were restricted to the Tiwi Islands. Five other rainforest types (4,6,7,8,9) also occurred in the Tiwi-Cobourg bioregion, but these all were also widespread elsewhere.

The most extensive environment in the bioregion, tall eucalypt forests dominated by *Eucalyptus miniata, E. tetrodonta* and *E. nesophila* is also largely restricted to this bioregion: at the 1:1,000,000 scale 7999 km^2 of its total NT extent of 8546 km^2 (93.6%) occurs in the Tiwi-Cobourg bioregion. The residue occurs adjacent to this bioregion, in the mainland area to the immediate south of the isthmus of Cobourg Peninsula. This vegetation type is distinctive because of its unusually tall stature, high basal area and the co-dominance of the relatively restricted Melville Island Bloodwood *E. nesophila*.

fossil sites

There is an important fossil site on coastal sandstone cliffs at Cape van Diemen, Melville Island. This contains the best known representations of Tertiary plant fossils (impressions only, without cuticle) from Australia (Pole and Bowman 1996). It is currently without any formal protection. It may be threatened by unregulated collecting or ongoing erosional events, exacerbated by tidal surge during cyclone or storm events.

exotic threatened species

A somewhat quirky conservation value for the bioregion is the large population (9,000 to 11,000 individuals: K. Saalfeld D. Lawson unpubl data from 2001 surveys) and of feral banteng on Cobourg Peninsula. This species is considered to be vulnerable within its native range in south-eastern Asia, and occurs in few national parks there (Bowman 1992*b*). The Cobourg Peninsula population may represent the largest free-living herd.

Table 2. Listed threatened species known from the Tiwi-Cobourg bioregion. *EPBCA*=listed under the *Environment Protection and Biodiversity Conservation Act* (as at November 2001). Status in brackets refer to those given nationally under the most recent action plans - Garnett and Crowley (2000) for birds and Duncan *et al*. (1999) for bats, and on current re-assessment of the conservation status for all NT plant species. TPWCA=listed under regulations of the *Territory Parks and Wildlife Conservation Act 2000*. CR=critically endangered, E=endangered, V=vulnerable, DD=data deficient, lr=lower risk. This table lists marine species only if they are known to breed on lands in this bioregion.

species	***Conservation status***		***occurrence***		
	EPBCA	***TPWCA***	**Tiwi**	**Cobourg**	**Croker**
flatback turtle *Natator depressus*	V	-	Y	Y	Y
green turtle *Chelonia mydas*	V	-	Y	Y	Y
hawksbill turtle *Eretmochelys imbricata*	V	-	Y	Y	Y
olive ridley turtle *Lepidochelys olivacea*	E	-	Y	Y	Y
leatherback turtle *Dermochelys coriacea*	V	V		Y	
unnamed skink *Cryptoblepharus* sp.nov.*	-	- (V)			Y
taipan *Oxyuranus scutellatus*	-	DD	Y		
chestnut-backed button-quail *Turnix castanota*	-	DD	Y	Y	
red goshawk *Erythrotriorchis radiatus*	V	V	Y	Y	
partridge pigeon *Geophaps smithii smithii*	V (lr)	-	Y	Y	
masked owl (Melville Island subsp.) *Tyto novaehollandiae melvillensis*	V (E)	E	Y		
masked owl (northern Australia subsp.) *Tyto novaehollandiae kimberli*	V (lr)	-		Y	
hooded robin (Tiwi Island subsp.) *Melanodryas cucullata melvillensis*	- (V)	-	Y		
gouldian finch *Erythrura gouldiae*	E	V		Y	
butler's dunnart *Sminthopsis butleri*	V	V	Y		
bare-rumped sheathtail-bat *Saccolaimus saccolaimus nudicluniatus*	- (CR)	DD	Y?		
little northwestern freetail bat *Mormopterus loriae coburgiana*	- (DD)	-	Y	Y	
brush-tailed rabbit-rat *Conilurus penicillatus*	-	V	Y	Y	
false water-rat *Xeromys myoides*	V	-	Y		
Arenga australasica	V	-		Y	
Burmannia sp. DNA61177 "Melville Island"	E	E	Y		
Calochilus caeruleus	-	V	Y		
Cephalomanes obscurum	-	- (E)	Y		
Cerbera manghas	-	V (lr)	Y		

Cryptocarya hypospodia	-	- (E)		Y	
Cycas armstrongii	-	V (Ir)	Y		
Cycas maconochie var *maconochie*	-	V (Ir)	Y		
Dendrobium trilamellatum	-	V (Ir)	Y		
Dendromyza reinwardtiana	-	- (V)	Y		
Elaeocarpus miegei	-	E	Y		
Endiandra limnophila	-	- (V)	Y		
Freycinetia percostata	-	V	Y		
Garcinia warrenii	-	- (E)	Y		
Hedyotis auricularia	-	V (Ir)	Y		
Hoya australis var *oramicola*	-	V	Y		
Luisia teretifolia	-	V	Y		
Mapania macrocephala	-	V	Y		
Mitrella D24710	-	- (V)	Y		
Tarennoidea wallichii	-	- (E)	Y		
Thrixspermum congestum	-	V	Y		
Tropidia curculigoides	-	V	Y		
Typhonium jonesii	-	- (E)	Y		
Typhonium mirabile	-	- (E)	Y		
Xylopia D30127 Melville Island	-	- (V)	Y		

* a distinctive species of this genus has been discovered recently from only one island in the McClure group, east of Croker Island. It would currently meet IUCN criteria for at least Vulnerable category.

Table 3. Confirmed seabird breeding colonies in the Tiwi-Cobourg bioregion (from Chatto 2001). Significance is as given by Chatto (2001), based on numbers relative to estimates of the total world population of the species recorded breeding.

subregion	*site*	*site no.*	*significance*	*notes*
2 (Cobourg)	Coral Bay	S001	National ?	28 Little Tern
	Black Point	S005	Low	pair of Little Tern
	Port Bremner	S004	National	90 Black-naped Tern; 10 Roseate Tern
	Sandy Island 1	S006	National	90 Black-naped Tern; 10 Roseate Tern
	Sandy Island 2	S007	National	400 Bridled Tern; 2,000 Crested Tern; 80 Silver Gull. (possibly also Black-naped, Roseate and Caspian Terns)
	unnamed island near Cape Don	S044	Regionally high	200 Crested Tern; 150 Roseate and/or Black-naped Tern
	Warla Island	S114	National (?)	90 Black-naped Tern; 10 Roseate Tern
	Templer Island	S109	Low	28 Black-naped Tern
	Cowlard Island	S011	National	300 Black-naped Tern; 500 Bridled Tern
	Lawson Island	S078	Low	pair of Little Tern
	Grant Island	S110	National (?)	1,300 Black-naped Tern; 600 Roseate Tern
	Little Lawson Island	S111	National (?)	100 Black-naped & Roseate Tern; 2 Little Tern
	New Year Island	S112	National (?)	500 Black-naped Tern; probably 500 Roseate Tern
	Oxley Island	S113	Low	20 Black-naped Tern
1 (Tiwi)	Seagull Island	S009	National	60,000 Crested Tern; 800 Silver Gull
	NW Melville Island	S018	National	12+ Little Tern
	Buchanan Island	S138	National (?)	80 Little Tern; 12 Silver Gull
	Radford Point	S145	Regionally high	30 Little Tern
	unnamed island near Brace Point	S146	National (?)	70 Little Tern

Figure 5. Seabird breeding colonies in the Tiwi-Cobourg bioregion, with indication of significance (from Chatto 2001).

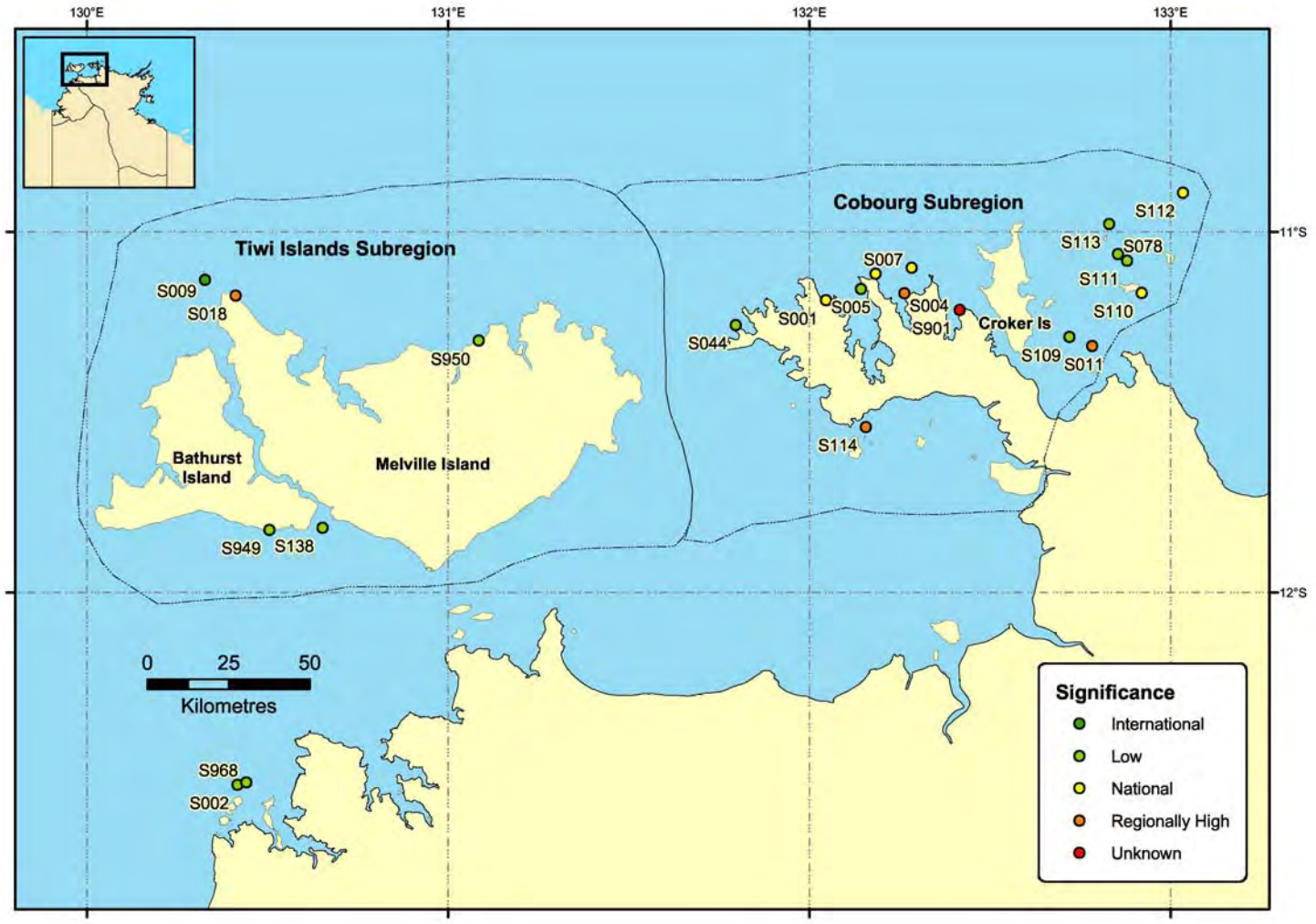


Table 4. Endemic or mostly endemic taxa known from the Tiwi Islands.

(a) Plant species occurring only on the Tiwi islands

species
Typhonium jonesii
Typhonium mirabile
Lindernia cowiei
Desmodium tiwiense
Burmannia sp. DNA61177 'Melville Island'
Mitrella D24710 'Melville Island'
Embelia sp. DNA 48980
Parsonsia sp.DNA 30178 'Melville Island'
Miliusa sp. D30127
Hoya australis var. *oramicola*

(b) Plant species occurring on the Tiwi Islands but not elsewhere in the Northern Territory, other than species in (a) above.

species	**other occurrences beyond Australia**	**other Australian occurrences**
Garcinia warreni	-	Qld
Tarennoidea wallichii	Malesia	N
Elaeocarpus miegei	Malesia; New Guinea	-
Acmenosperma claviflorum	Malesia	Qld
Dendromyza reinwardtiana	Malesia	Qld
Endiandra limnophila	-	Qld
Litsea breviumbellata	-	Qld
Scleria carphiformis	-	Qld
Calochilus caeruleus	New Guinea	WA, Qld.
Strychnos minor	Malesia	Qld
Hedyotis auricularia	Malesia, Melanesia	Qld

(c) Invertebrates

taxon	***taxonomic authority***
Nososticta taracumbi	Watson and Theischinger (1984)
Huonia melvillensis	Brown and Theischinger (1998)
Rhytidoponera reflexa	Andersen (in press)
Rhytidoponera sp. (araneoides group)	

(d) Vertebrates

taxon	***taxonomic authority***
brush-tailed rabbit-rat *Conilurus penicillatus melibius*	*Walton (1988)*
black-footed tree-rat *Mesembriomys gouldii melvillensis*	
masked owl *Tyto novaehollandiae melvillensis*	*Mason and Schodde (1997); Schodde and Mason (1999); Mason (pers. comm*).
hooded robin *Melanodryas cucullata melvillensis*	
rufous whistler *Pachycephala rufiventris minor*	
yellow-tinted honeyeater *Lichenostomus flavescens melvillensis*	
striated pardalote *Pardalotus striatus melvillensis*	
brown honeyeater *Lichmera indistincta melvillensis*	
orange-footed scrub-fowl *Megapodius reinwardt melvillensis*	
blue-winged kookaburra *Dacelo leachii nana*	

Loss of biodiversity

Reasonably comprehensive species lists for mammals and birds on the Tiwi Islands from about 1890 to 1920 (Thomas 1913, 1921; Mathews 1914; Zietz 1914a,b), and extensive collections of animals from the early settlement of Port Essington (Cobourg Peninsula), mostly by John Gilbert in 1840-41 (Calaby 1974), provide an unusually good baseline from which to gauge change in vertebrate assemblages across the bioregion since European settlement.

Except for two cases of probable misidentification, no bird or mammal species appears to have been lost from the Tiwi Islands over the last century. The single possible exception is the Tiwi Islands subspecies of hooded robin *Melanodryas cucullata*, which is known from a few specimens collected by Zietz (1914) and a few observations in 1991-92 (Fensham and Woinarski 1992). It has not been recorded subsequently, despite extensive sampling across both islands (Mason and Schodde 1997; Woinarski *et al*. 2000).

Frith and Hitchcock (1974) described differences in the bird species of Cobourg Peninsula recorded by them in the 1960s and 1970s and those recorded by Gilbert there in the 1840s. Of a combined species list of 164 species, 36 species were recorded in the 1960-1970s but not in the 1840s, and 18 species were reported in the 1840s but not 1960-1970s. Most of these variations were trite, referring mainly to uncommon vagrants or migrants, or to purported oversights in the earlier documentation. Indeed, they noted "*We … are surprised at how few birds we found that Gilbert did not and how few of those that he recorded have eluded us*". However, at least one species, the gouldian finch *Erythrura gouldiae*, is an almost certain loss from the bioregion. Of the other bird species listed by Frith and Hitchcock (1974) as reported in the 1840s but not in their sampling during the 1960s and 1970s, there have been no subsequent records of a further four species - purple swamphen *Porphyrio porphyrio*, Latham's snipe *Gallinago hardwickii*, brown songlark *Cinclorhamphus cruralis* and little wood-swallow *Artamus minor*, suggesting that these species may also have declined or even disappeared from the bioregion.

Calaby and Keith (1974) noted that one mammal species reliably reported from Cobourg Peninsula in the 1840s, was not recorded also during their survey: the orange leaf-nosed bat *Rhinonicteris aurantius* (for which Port Essington was the type locality).

In reviewing the historical record for reptiles and frogs on Cobourg Peninsula, Cogger and Lindner (1974) noted the substantial problems with nomenclature and ascription of correct locality data, but concluded that no herpetofauna species had been lost from the Cobourg Peninsula since European settlement.

Across the bioregion, the historical baseline for plants is far less rich than that for vertebrates and provides no information on possible losses of species.

Protected area system

There is one conservation reserve in the bioregion, **Garig Gunak Barlu National Park** (formerly Gurig National Park and Cobourg Marine Park). This encompasses all of Cobourg Peninsula, the Sir George Hope Islands to the immediate south, and some small islands to the immediate north (Fig. 1), and the seas around them.

The terrestrial component of Garig Gunak Barlu National Park has an area of 2207 km^2, 22% of the bioregion. Hence, this bioregion has the second highest level of

reservation of any Northern Territory bioregion (after only Arnhem Plateau: Connors *et al*. 1996). However, the entire reserved area is in one subregion, with the Tiwi Islands subregion entirely unreserved.

Assessment of the comprehensiveness of bioregional reservation is handicapped by the very coarse scale (1:1,000,000) of the only consistent vegetation mapping available across the bioregion. However, even at this coarse level, only 4 of the bioregion's 11 vegetation types are included within the reserved area (Table 5).

The Garig Gunak Barlu National Park includes 14 of the 44 threatened species known from the bioregion (Table 2), 5 of the 13 nationally significant seabird nesting colony sites (Table 3) and, self-evidently, none of the 23 endemic Tiwi plants and animals (Table 4).

Table 5. The occurrence of vegetation types across the bioregion, and their reserved extent (for the Tiwi-Cobourg bioregion only), from the 1:1 000 000 vegetation mapping of Wilson *et al*. (1990). Note that plant names follow those used in Wilson *et al*. (1990).

vegetation type	***area (km^2)***		***% area reserved***
	Garig Gunak Barlu National Park	bioregion as a whole	
1. mixed-species closed forest (monsoon vine-thicket)	- *	56	0
3. *Eucalyptus miniata- E. tetrodonta – E. nesophila* open forest with *Sorghum* grassland understorey	1899	7999	23.7
4. *Eucalyptus miniata- E. tetrodonta* open forest with *Sorghum* grassland understorey	28	333	8.4
18. *Eucalyptus papuana – E. polycarpa* woodland with grassland understorey	0	229	0
32. *Eucalyptus dichromophloia - E. miniata* low open woodland with *Plectrachne pungens* pen hummock grassland understorey	0	3.5	0
47. *Acacia* open shrubland with *Sorghum* grassland understorey ("treeless plains")	0	191	0
53. *Melaleuca* open forest (paperbark swamp)	0	50	0
54. mixed closed grassland-sedgeland (seasonal floodplain)	0	32	0
102. coastal dune complex	0	4.2	0
105. Mangal low closed-forest (mangroves)	98	697	14.1
106. saline tidal flats with scattered chenopod low open shrubland (samphire)	39	185	21.1

* rainforest patches occur on Cobourg Peninsula, but not of sufficient size to be defined at this scale of mapping.

There are five rangers associated with the Garig Gunak Barlu National Park. Of these, one is devoted exclusively to marine science. Two of the other ranger staff are generally local Aboriginal land-owners, although currently these are on rotation at other reserves. Excluding the marine science, the annual budget of this Park is about

$60,000 (operating) and $200,000 (personnel). Infrastructure includes six ranger houses, a small office and visitor centre, signs, two boats, walking tracks and a road/track network.

There are no permanent positions on the Tiwi Islands devoted to land management. However, a marine ranger position was established in 2001, one Landcare officer has been seconded to the Tiwi Land Council from the Government's Department of Lands, Planning and Environment since 2000, and another short-term environmental planning position has been established in 2001, with funding from a 2-year NHT project.

At Minjilang, an Aboriginal ranger program is currently developing, using CDEP and NHT funding. Traditional owners of Croker Island community are currently considering the option for a land and marine reserve, a proposal which would include funding for additional ranger staff.

Management issues and threats

Broad-based consideration of conservation management issues has been discussed for the Tiwi Islands (Woinarski *et al*. 2000; Tiwi Land Council 2000) and Cobourg Peninsula (within the Plans of Management for Cobourg National Park, and a draft plan for Garig Gunak Barlu National Park). More narrowly focussed considerations include an assessment of the management of rainforests on the Tiwi Islands (Fensham and Woinarski 1992), of the status and potential impacts of weeds on the Tiwi Islands (Fensham and Cowie 1998), of the impacts of plantation forestry development on the Tiwi Islands (ForSci 1999, Department of Lands, Planning and Environment 1999, Brock *et al*. 2000), of the impacts of feral animals on vegetation on Cobourg Peninsula (Bowman and Panton 1991; Bowman 1993; Panton 1993), of the impacts of fire on vegetation on Cobourg Peninsula (Bowman *et al*. 1990; Bowman 1993), and of the occurrence of exotic plants across the bioregion (Leach 1992).

fire

As with almost all lands in northern Australia, fire regimes in this bioregion have probably changed from a pattern of frequent fine-scale mosaic burns, especially in the early dry season to a less regular pattern marked by a generally reduced frequency and intricacy of fires but an increased proportion of fires in the late dry season (Williams *et al*. 2002). In this bioregion, this change has been due largely to

a relatively more sedentary Aboriginal population, with most people congregated in a few settlements rather than relatively thinly but evenly dispersed;
a reduced dependence upon bush tucker and hence active management of the land to optimise food resources;
channeling of human activity because of the vehicle track network;
some loss of traditional land management knowledge;
some explicit regulations discouraging or preventing burning in forestry areas of Melville Island;
changes in people's priorities and time allocation.

Figure 6 presents a fire history which is probably typical of most of the bioregion. Areas which are relatively accessible and/or close to major human settlements are burnt with a frequency of greater than one fire every two years, and annually in some places.

More remote areas (such as the eastern half of Melville Island) are burnt less frequently.

Parts of Garig Gunak Barlu National Park have been managed recently to attempt to return to an intricate fire regime with minimisation of late dry season fires (J. Williams *pers. comm*.).

The otherwise generally pervasive changes in the application or incidence of fire have undoubtedly had some impacts upon biodiversity. For the broad matrix of eucalypt forests, these changes would include declines or loss of fire-sensitive species, such as *Callitris intratropica* (Bowman and Panton 1993; Price and Bowman 1994), reduced incidence of large old trees (Williams *et al*. 1999*b*), a change in the structure of forest understorey (increased cover of grasses but reduced cover of tall broad-leaved shrubs) (Bowman *et al*. 1988; Russell-Smith *et al*. ms), and some changes in the abundance and phenological patterning of fruits, seeds and flowers (Williams *et al*. 1999*a*). In turn, these vegetation changes would have reduced habitat suitability for many mammal and some bird species (Woinarski *et al*. 2001).

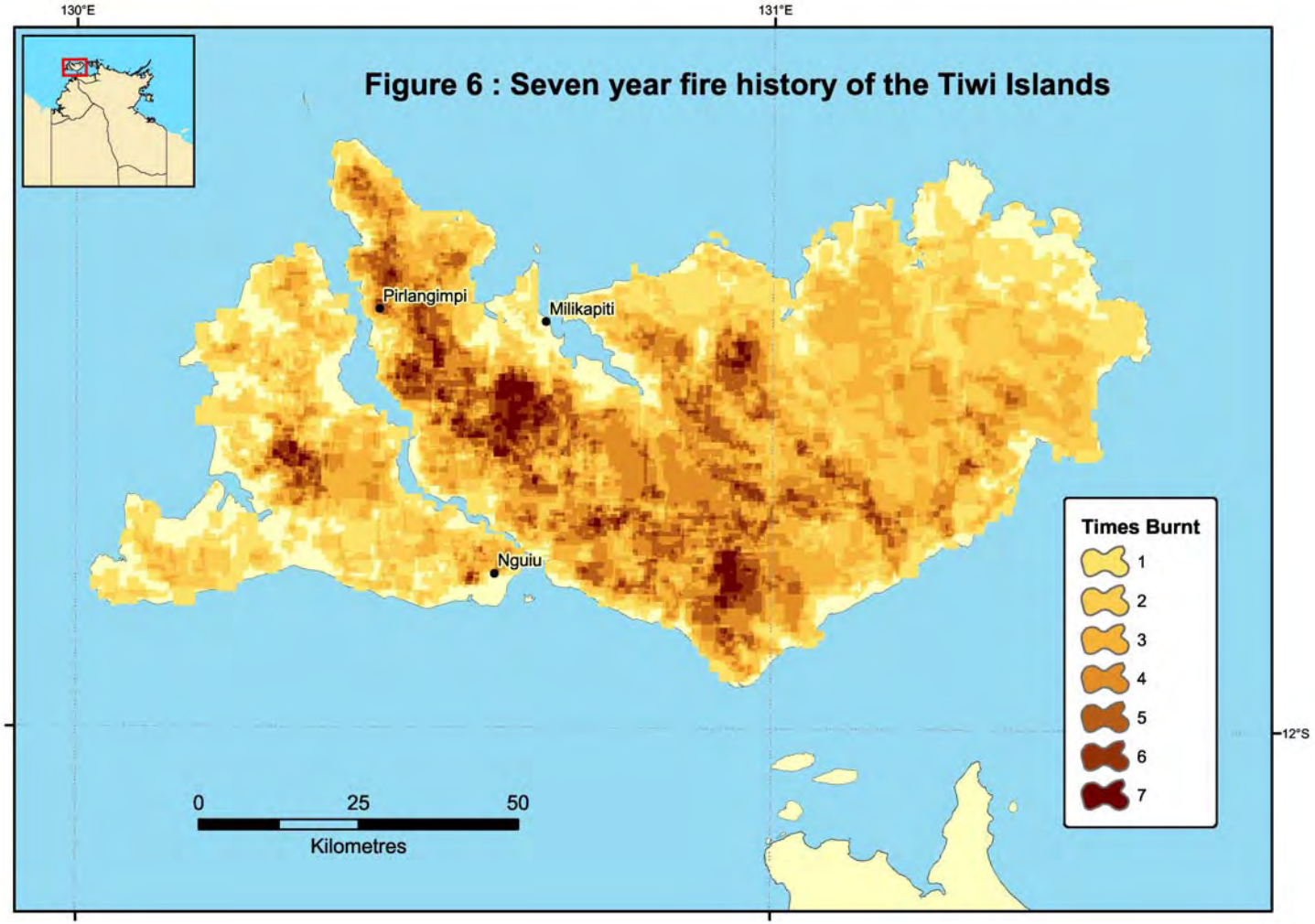
Increased incidence of extensive late dry season fires in the eucalypt forests would also affect the condition of smaller landscape elements embedded within the matrix, most notably the patches of monsoon rainforests. As an example of this impact, 38% of the wet rainforest patches sampled by Russell-Smith and Bowman (1992) on the Tiwi Islands were "severely disturbed" by fire.

The vegetation dynamics of coastal dune and chenier mosaics also appears to be related to the incidence of fire, and of grazing by feral animals. Bowman *et al*. (1990) noted that, over a 20-year period in which fire incidence in coastal grassland mosaics was probably reduced, dry rainforest clumps expanded at the expense of grasslands at Cobourg Peninsula. Such expansion and contraction of monsoon rainforest patches has probably also occurred over a longer time frame. Using information from this bioregion, Stocker (1971) concluded that the occurrence of now abandoned nesting mounds of orange-footed scrub-fowl in eucalypt forests was evidence that monsoon rainforests had declined substantially over the course of the late Holocene, presumably because of the institution and perpetuation of a frequent fire regime following colonisation by Aboriginal people. In contrast, Bowman *et al*. (1999) interpreted similar data as showing incidence of cyclone and occasional subsequent severe fire events.

feral animals

Feral animals are a conservation management issue across almost all of this bioregion (Letts *et al*. 1979). In some respects, Cobourg Peninsula is managed as a large open air menagerie, with large feral mammals being one of the most conspicuous (and, for some, attractive) wildlife features of the park. The area currently supports abundant populations of feral horse *Equus cabalus*, pig *Sus scrofa*, sambar deer *Cervus unicolor*, banteng *Bos javanicus* and water buffalo *Bubalus bubalis*, mostly introduced during the nineteenth century settlements. The population density of bantengs on Cobourg Peninsula (about 10,000 individuals in 2200 km^2) is about the same order of magnitude as that of livestock on most pastoral properties, arguably substantially deflating the significance of this conservation reserve. A fence across the Peninsula's narrow isthmus is designed to keep these feral animals within Garig Gunak Barlu National Park. Unusually, Cobourg Peninsula appears to have no feral cats (Calaby and Keith 1974).

Figure 6. A seven year (1993-1999) fire history for the Tiwi Islands.



Feral pigs are also common on Bathurst Island, but absent on Melville Island. Feral water buffalo and horses are absent on Bathurst Island, but reach very high densities (buffalo densities exceeding 10 individuals/km^2: Bayliss 1985) on Melville Island, particularly in the south-east. In 1992, when subject to moderately intense harvesting, the total population of feral buffalo on Melville Island was estimated at around 7000 (Forrest 1998). There has been no intensive hunting since then, and populations are thought to have escalated substantially. There are also small populations of feral cattle on both islands, and feral cats occur on both, especially near settlements.

Croker Island has very high densities of feral pigs and cattle, and an estimated 2000 feral horses (B. Panton *pers. comm*.).

Of these feral species, high densities of pigs on Bathurst Island, Croker island and Cobourg Peninsula are probably having the most significant impact. Bowman and Panton (1991) reported that pigs on Cobourg Peninsula "damage severely" swamp communities, and they are causing extensive damage to the floodplains and seasonal swamps on Croker Island. Pigs are also known to degrade monsoon rainforests and Fensham (1993*a*) considered that pig rooting was endangering the highly restricted rainforest herb *Burmannia* sp. "Melville Island" on Bathurst Island.

Bowman and Panton (1991) also considered that feral banteng may have some deleterious impacts, especially on monsoon rainforest patches (where their density was estimated at 70 km^{-2}). After three years of protection from Banteng, matched plots on Cobourg Peninsula had far greater herb biomass in exclosures than in unfenced areas, for both eucalypt savanna woodland (133 g/m^2 in fenced cf. 77 g/m^2 in unfenced) and rainforest ecotone (46 g/m^2 cf. 3 g/m^2) environments (Bowman 1993). After five years, fenced plots on coastal grassland sites had far greater herb cover than unfenced matched plots (9.2% cf. 0.7% respectively: Panton 1993).

High densities of water buffalo, such as on Melville Island, are associated with changed soil salinity, consequent tree death and inhibition of seedling recruitment in *Melaleuca* forests, changed hydrology in sedgelands, and changed vegetation structure in rainforest patches (through rubbing and trampling) (Stocker 1971; Braithwaite *et al.* 1984; Bowman and Panton 1991).

Feral cats may also have major biodiversity impacts on the Tiwi Islands. Feral cats have probably been a major contributory factor to recent decline of many medium-sized mammals on the Top End mainland (Woinarski *et al*. 2001).

weeds

Compared to most other bioregions in the Northern Territory, there are relatively few species of exotic plants in the Tiwi-Cobourg bioregion, a legacy of its isolation, relative lack of major infrastructure development and lack of intensive pastoralism.

Major existing weed problems in the bioregion include relatively small infestations of para grass *Urochloa mutica* and mimosa *Mimosa pigra* on the floodplains of Croker Island, lion's tail *Leonotis nepetifolia* and mission grass *Pennisetum polystachion* near settlements on

Croker Island (Smith 2001), and mission grass on Melville Island (Fensham and Cowie 1997). Fensham and Cowie (1997) also noted very small populations of the highly invasive prickly mimosa *Mimosa pigra* and para grass at Nguiu on Bathurst Island, and generally small populations of the other invasive species coffeebush *Leuceana leucocephala*, lantana *Lantana camara* and sicklepod *Senna obtusifolia*. Other exotic species, notably hyptis *Hyptis suaveolens* and flannel weed *Sida cordifolia*, are widespread on the Tiwi islands and Cobourg Peninsula, but probably have relatively minor impacts.

commercial forestry

Through the environmental impact assessment process, approvals have been granted recently for broad-scale clearing of native forests on Melville Island for the development of commercial plantations of exotic timber species. This project proposes plantation areas of 30,000 to 100,000 ha, a scale unprecedented on Aboriginal-owned land. Such a development will have some substantial consequences for biodiversity, although the plantation development has been sited to minimise impacts upon threatened and endemic species (Woinarski *et al*. 2000). A strategic plan for the forestry development has been prepared (Tiwi Land Council 2000), which incorporates planning for management of weeds, fire, soil, water and biodiversity.

Assessment of current conservation management contributions

There is remarkably little formal conservation management activity in this bioregion. The only continuous management input is by ranger staff at Garig Gunak Barlu National Park, who undertake some fire management, management of tourism, weed control and other activities within the park area, and provide some resources and management input into neighbouring areas.

Less consistently, there are occasional research and monitoring activities in the bioregion, notably including major wildlife surveys of the Tiwi Islands in 2000 and 2001, and irregular aerial surveys of feral animals.

Additional to these activities, NHT projects and proposals for plantation forestry on Melville Island have spurred short-term appointments of two staff to the Tiwi Land Council in 2000 and 2001.

AQIS undertakes occasional assessments of exotic plants across the bioregion.

Aboriginal rangers employed with CDEP fundings include some conservation management activities on Croker Island.

A summary of these management inputs is provided in Table 6. This suggests an annual input to conservation management across the bioregion of about $134,000, or $13/km^2. This figure obviously excludes the unpaid efforts of Aboriginal landowners practising traditional management activities, such as burning country. Conservation management input may also increase substantially in association with development of plantation forestry on Melville Island, to which a permanent environmental officer would be attached.

Table 6. Average annual input to conservation management in the bioregion.

activity	*conservation management input ($ '000)*	*average input per year (averaged over past 5 years) ($ '000)*
fire & biodiversity management at Garig Gunak Barlu NP	50	50
wildlife surveys, Tiwi Islands, 2000-01	120	24
occasional aerial survey		10
Tiwi Land Council environmental officers, 2000-01	100	20
occasional AQIS exotic plant surveys		5
CDEP rangers, Croker Island	117	25
total		**134**

OPTIONS FOR CONSERVATION MANAGEMENT

A superficial consideration of this bioregion would leave the impression that it is travelling unusually well, and that there are no pressing reservation or management problems. Such an impression would be based on features including:

- a relatively high proportion (>20%) of the bioregion is reserved;
- an extremely high proportion of the bioregion is in an apparently natural condition (less than 5% cleared or otherwise grossly disturbed);
- the human population, both resident and visiting, is low;
- much of the bioregion is isolated and/or remote;
- the bioregion holds good populations of many species which have declined elsewhere;
- while there may have been losses from the bioregion of gouldian finch and perhaps a few other bird species, there is little evidence otherwise of decline within the bioregion;
- much of the land is managed in a manner comparable to the way it has been managed for tens of thousands of years;
- the major wetland in the bioregion is reserved, and its value recognised through Ramsar listing;
- with the exception of possible expansion of plantation forestry on Melville Island, there is no great push for increased resource development or land-use changes.

However, this impression is beguiling, and masks a gradual deterioration in conservation values, a steadily increasing incidence of threat, and a substantial inadequacy in the formal reservation system. The conservation management problems here are not acute, obvious and localised: rather, they are subtle, chronic and insidious. In this feature, the Tiwi-Cobourg bioregion is typical of many other bioregions in northern and central Australia, and especially so of those where the population base is sparse and predominantly Aboriginal. Conservation management in such bioregions has been severely handicapped by the misplaced assumption of environmental well-being, and/or by a prioritisation system that places greater weight (and resources) on propping up the environmental shards of more densely populated regions of temperate Australia than on fighting to maintain the integrity of large intact environments.

Conservation management in these remote bioregions is both harder and easier than that in densely populated, highly disturbed areas. Here, there are only three land titles across the whole bioregion, so the delivery of management is theoretically simple, without the problem for integrating management across a multitude of small landholdings. However, all lands are cooperatively owned, so there may be substantial problems in obtaining clear direction for conservation management. The economic base in the Tiwi-Cobourg bioregion is extremely small and tenuous. This allows landholders little luxury for devoting resources to land management problems, but it also means that external resources devoted to conservation management and/or job opportunities associated with this, may be more eagerly embraced.

In the following sections we discuss the applicability, priority, cost and likely effectiveness of a range of options for increasing the conservation management delivery in this bioregion.

Expansion of the reserve system

This bioregion falls well short of the national aim of comprehensiveness. Seven of the 11 described vegetation types are not represented, nor are the many taxa endemic to the Tiwi Islands. It is a relatively straightforward desktop exercise to design additions to the reserve system to remedy this deficiency. However, the lack of any equivalent of Vacant Crown Land renders such an exercise close to futile. Rather, additions to the formal reserve system can come only through negotiation and collaboration of the Aboriginal landowners and the Land Councils representing them. A broad range of options is available, including Indigenous Protected Areas, agreements under Section 73 of the *Territory Parks and Wildlife Conservation Act*, leasebacks such as Kakadu National Park, and joint management agreements such as at Garig Gunak Barlu National Park (PWCNT 1998; Woenne-Greene *et al*. n.d.).

The major priorities for reservation for biodiversity are on the Tiwi Islands, with some consideration now underway for a large reserved area in the east of Melville Island, and a smaller area in the south-west of Bathurst Island. These would greatly enhance the comprehensiveness of the bioregion's reserve system, notably by including representation of the major deficiency in the current Tiwi-Cobourg reserve system - the zero reservation in one subregion, and the zero reservation of one endemic environment, the treeless plains. A large reserve on the Tiwi Islands can also readily be designed to include representation of three of the six other unreserved vegetation types: vegetation types 1 (monsoon rainforest), 18 (woodland dominated by *Eucalyptus papuana* - *E. polycarpa*), and 53 (*Melaleuca* open forest).

The Garig Gunak Barlu National Park provides a reasonable model for establishment and ongoing costs for a comparably large conservation reserve on Melville Island. Obviously there are no land acquisition costs associated with reserve establishment. Development costs (ranger station, housing, some other infrastructure) would be about $500,000, a permanent staff of four would cost around $180,000 per year, and a management operations budget would be around $100,000 per year. These costs could also extend to cover a smaller reserved area on Bathurst Island.

Reserve expansion on the Tiwi Islands may be constrained by competition for land with plantation forestry, a perception by some Tiwi people that options for alternative land-uses would have been eliminated for little benefit, some unease that an external agency may now unduly influence Tiwi activity, and the possibility of inequitable distribution of benefits (e.g. jobs) among the different clan groups.

Three of the bioregion's vegetation types occur (in this bioregion) only on Croker Island - vegetation types 32 (low open woodland of *Eucalyptus dichromophloia* - *E. miniata*), 54 (seasonal floodplain) and 102 (coastal dune complex). On the scale at which these vegetation types have been defined, type 32 is widely represented (15%) in the NT reserve system beyond this bioregion, and the Tiwi-Cobourg extent (3.5km^2) is small, and a very low percentage (0.04%) of its total range; type 54 is very widely represented (24%) in the NT reserve system beyond this bioregion, and the Tiwi-Cobourg extent (32km^2) is a

relatively minor occurrence (0.37%); however, type 102 is unrepresented in the entire NT reserve system, but the Tiwi-Cobourg extent (4.2km^2) represents only a very small proportion (0.9%) of its NT distribution. Given this context, extension of the formal reserve system to include these environments on Croker is not a particularly high priority.

At least three of the small islands to the east and north-east of Croker Island may merit greater conservation security, especially due to their importance for seabird colonies and as nesting sites for marine turtles. Given the small size and isolation of these islands, and lack of immediate threat, this protection probably does not need to be in the form of National Park, but rather through a management agreement.

Management of threatened species and ecosystems

Of the 17 nationally listed threatened species reported from this bioregion, none have approved Recovery Plans under the EPBCA. Of the 24 species listed as threatened under NT legislation, there are species management plans for only the two cycads (PWCNT 1997).

Factors affecting the status of biodiversity, particularly threatened species, in this bioregion, which have been formally listed as *Key Threatening Processes* under the EPBCA comprise:

- *Incidental catch (by-catch) of sea turtle during coastal trawling operations within Australian waters north of 28^{o}S;*
- *Land clearance;*
- *Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases;*
- *Predation by feral cats;* and
- *Predation, habitat degradation, competition and disease transmission by feral pigs*.

Of these, a Threat Abatement Plan has been approved only for predation by feral cats.

No vegetation types or habitat have been listed as threatened nationally under the EPBCA, nor as “essential habitat” under the *Territory Parks and Wildlife Conservation Amendment Act*.

Given the above, there is almost no existing formal guidance for conservation management for threatened species within this bioregion. This is evidence of a major gap in conservation management for this bioregion (and, by analogy, comparable bioregions elsewhere in Australia): there is almost no specific action towards management for threatened species, almost no resourcing commitment, no framework for prioritising action, no substantial monitoring program, a generally inadequate baseline of information, and no management targets. Lacking such specifics, the only (quasi-) formal guidelines for management of these threatened species are the short information sketches offered in the Action Plans published for some major animal groups, such as that for bats (Duncan *et al*. 1999), birds (Garnett and Crowley 2000), rodents (Lee 1995) and marsupials and monotremes (Maxwell *et al*. 1996).

Less official guidance is offered for some species in some situations. For example, Chatto (2000) provides management advice for seabird colonies (including those in this bioregion) and Woinarski *et al*. (2000) provides some assessment of the threatening processes and management requirements for threatened species on the Tiwi Islands.

The 34 listed taxa known from this bioregion (Table 2) include some clear groupings which can be related to management priorities:

- 5 species of marine turtle, for which the main priority is protection of the breeding sites;
- 11 plant species (*Arenga australasica, Burmannia* sp. DNA61177 "Melville Island", *Cerbera manghas, Elaeocarpus miegei, Freycinetia percostata, Hedyotis auricularia, Hoya australis* var. *oramicola*, *Luisia teretifolia, Mapania macrocephala, Thrixspermum congestum* and *Tropidia curculigoides*), each restricted to a small number of rainforest patches, mostly on the Tiwi Islands; and
- 10 animal (taipan, chestnut-backed button-quail, red goshawk, partridge pigeon, both masked owl subspecies, hooded robin, butler's dunnart, bare-rumped sheathtail bat, and brush-tailed rabbit-rat) and 2 plant species (*Cycas armstrongii* and *C. maconochie* var *maconochie*) whose survival is largely dependent upon the maintenance of habitat quality across extensive areas of eucalypt tall open forest.

The remaining species have more idiosyncratic distributions or threats within the bioregion.

The conservation of marine turtles in this bioregion involves mainly the minimisation of the by-catch associated with commercial fisheries and safeguarding of their breeding sites. The more accessible breeding sites are affected by human harvest and predation by feral dogs (and in some instances by goannas). These threats can be moderated, where appropriate, by landowner agreements to manage this resource sustainably and by dog-culling operations. The more remote nesting colonies (such as on the small islands to the north and east of Croker) are relatively secure from harvest or predation (and indeed may have the greatest long-term security of any of the world's marine turtle nesting sites). However, even these may be affected by extrinsic factors, including sea-level rise resulting from global climate change and the gradual whittling down of turtle populations because of deliberate or inadvertent capture away from breeding sites.

The threatened rainforest plants, and the rainforest estate in this bioregion generally, present a formidable conservation management problem. For individual species, the total population is low, this is generally highly fragmented, and the patches which support them are small and susceptible to disturbance. For the rainforest patches as a whole, the highly idiosyncratic species assemblages of individual patches means that it is almost impossible to fully represent the rainforest biota within a conventional reserve network (Russell-Smith *et al*. 1992; Price *et al*. 1995). Further, the rainforest patches are viewed as components of a disjunct habitat by many rainforest-dependent mobile species, such that the loss of any patch may affect the maintenance of individuals or species within the remaining patches (Price *et al*. 1999). There is also an obligate permeability for many rainforest vertebrates, requiring daily or seasonal movements between rainforest and surrounding habitat to track shifting resource availability, rendering the retention of the rainforest biota dependent not only upon the maintenance of the rainforest patch itself, but also upon the maintenance of habitat quality in the surrounding eucalypt savanna (Price *et al*. 1999). On

top of these awkward ecological traits, the rainforest patches are particularly vulnerable to disturbance because of their typically very small size, the attraction their environments offer to destructive feral animals and/or to weed species, and the susceptibility of their constituent plants to fire. As a consequence, most of the rainforest patches sampled in this bioregion have been shown to be degraded by at least one of these processes (Russell-Smith and Bowman 1992). Woinarski *et al*. (2000) provided guidelines for the maintenance of rainforest on the Tiwi Islands within a context of possible greatly expanded development of plantation forestry. These were: (1) do not clear any rainforest patch; and (2) retain native vegetation in a buffer around every rainforest patch (with this buffer extending 500 m from wet rainforests and 250 m from all other patches). These guidelines were subsequently accepted as obligate conditions within the Territory and Federal environmental approval for the development proposal. While they provide some succour against threatening processes which are clearly circumscribed, they provide less help against more pervasive threatening processes, such as detrimental fire regimes operating across the landscape generally, weed expansion, altered hydrological conditions (such as aquifer drawdown associated with irrigation), uncontrolled feral animals, or climate change. Amelioration of these processes needs integrated landscape-wide management.

Management of the set of threatened species occurring mostly in eucalypt forests is generally more consistent with the the way conservation management is conventionally practised in developed Australia. To a large extent, the total population of these threatened species is directly proportional to the area of the habitat retained. Currently, most of these species are travelling reasonably well in this bioregion, but as increasingly large areas of their habitat is cleared and fragmented, the total population will decline. Conservation management for these species is then largely about the interaction of territory size, retained area, use of and retention of corridors, and minimum viable populations. Woinarski *et al*. (2000) used distributional modelling of three species (Tiwi Islands subspecies of masked owl, black-footed tree-rat and brush-tailed rabbit-rat) to plan conservation reserves, and to assess impacts of tree clearing on Melville Island. However, as with the rainforests considered above, the retention of these species is also very dependent upon the maintenance of habitat quality, and this can be severely compromised by pervasive threatening processes including changed fire regimes, exotic predators (cats), feral stock, and weeds.

Of the six remaining threatened species recorded from this bioregion, two plants (*Calochilus caeruleus* and *Dendrobium trilamellatum*) are restricted to paperbark (*Melaleuca* spp.) forests and woodlands, and both may be affected by changed fire regimes, feral animals or altered hydrological conditions; two animal species (false water-rat and little northwestern freetail bat) are associated mostly with mangrove forests and/or adjacent coastal saline grasslands and are unlikely to be affected by any current or imminent threatening factors; one skink (*Cryptoblepharus* sp.) is known from only one small island, but is not facing any current threat there; and one species (gouldian finch) has probably disappeared from the bioregion.

Other Natural Resource Management approaches

The conservation management challenge for this bioregion is largely about retaining as best possible the high quality environments which currently exist across almost all of the bioregion. This challenge must be faced within a management environment in which there are few resources available; the existing capacity is both high (in terms of Aboriginal

landholders still knowing their country well and being well-versed in routine management action) and low (in terms of competency with many of the tools of modern conservation management, such as chemical control of weeds, GIS, and numeracy and literacy generally); and where alternative land-uses may promise far greater economic returns to a generally economically impoverished community than does conservation.

The following sections describe the applicability of some approaches which have been listed nationally as possible ingredients of bioregional NRM.

incentives

There is no existing program in place in this bioregion to provide incentives to landowners for the retention of biodiversity values on their lands, with the exception of the annual fee paid to landowners on Cobourg Peninsula for use of their lands as park, and the quota paid to them for safari trophy animals killed.

The lack of such incentives has worked to increase the appeal to landowners of plantation forestry, and to give some landowners motivation for keeping or introducing feral game animals, as both of these may lead to increases in income from their land from the current zero return.

legislation

Across the Territory, there remain major unresolved issues of natural resource management on lands granted as Aboriginal freehold title under the *Aboriginal Land Rights (Northern Territory) Act 1976*. In this case, these issues complicate the control of feral animals and weeds, the protection of threatened species (most notably the invocation of "essential habitat"), the assessment of environmental impacts associated with development proposals, and the control of vegetation clearance generally. There is also no clear resolution to potential problems of non-sustainable harvest by Aboriginal landowners for resources such as the eggs of colonially-nesting seabirds and marine turtles.

structural/institutional reform

In this bioregion, there is no requirement for structural reform to change existing land-use or industrial practices which have been shown to be unsustainable.

valuing ecosystem services

With the relatively minor exception of some tourism and some art-related products (principally pandanus leaves, ironwood for sculptures and *Eucalyptus tetrodonta* bark for paintings) the landowners derive very little commercial value from the maintenance of natural values in this bioregion. Such lack of value serves to make any land-use change more appealing, and hence acts as a major disincentive for conservation.

There has been no formal assessment of the service value that natural environments provide in this bioregion. However, it is possible to provide some estimates of carbon credits associated with native vegetation. The Australian Greenhouse Office (1999) noted that Australia's forest and woodland area of 156 million ha offset 6% of Australia's total carbon dioxide equivalent emissions of 431 million t, and that carbon credits were of the order of $30/t of CO_2 emitted. These figures suggest that the carbon credit value of forests are about $5/ha. At this rate, the total existing eucalypt forests of the bioregion represent a carbon credit resource of $4 million. Currently, none of this value materialises to the Aboriginal landowners.

threat abatement planning

Notwithstanding some protection offered by the isolation of most of this bioregion, the major management issue is the gradual degradation of conservation values, because of the almost continuously increasing incidence or abundance of feral animals, weeds and/or extent of changed fire regimes. These issues affect almost every part of this bioregion, with the exception of some of the most remote islands. They all require landscape-wide integrated remedial action.

The most immediate management priorities are the eradication of isolated outbreaks of particularly detrimental weeds, such as para grass on the Croker Island floodplains and mission grass at a few sites on Melville Island. In these cases, a small resource investment now will prevent an unmanageable problem developing in the near future. Other existing weed problems in the bioregion are generally relatively minor (e.g. the widespread occurrence of *Hyptis suaveolens*, which is generally regarded as relatively benign). A higher priority than attempts at control of these is the need for vigilance and quarantine, to either prevent the introduction of new weeds, or to discover the occurrence of new weeds early enough to allow rapid control. Flanagan (2000) described quarantine and control procedures designed to minimise the impacts of a developing plantation forestry industry on Melville Island. As an aid in the early detection of exotic plants, Puruntatameri (2001) provided, especially for Tiwi landowners, photographs of, descriptions of, and comment on problems produced by, a range of weed species which had colonised or may colonise the Tiwi Islands.

Feral animals are a major environmental problem in all the larger land masses of this bioregion. The most critical current issues are the control of feral pigs on Bathurst and Croker Islands; the control of feral buffalo (especially), cattle and horses on Melville Island; the control of feral horses and cattle on Croker island; the control of feral cats on Bathurst, Melville and Croker Island; the control of feral dogs on Melville Island; and the establishment of environmentally sustainable levels of feral animals within Garig Gunak Barlu National Park. Aerial shooting of feral cattle and horses is technically relatively straightforward, and would cost around $30-50,000 per year and require repeating at 3-5 year intervals. However, such a control program would require the consent and collaboration of Aboriginal landowners. This is a major conservation issue, as many landholders are deeply disturbed by "shoot to waste" control practices. Feral animals are an important food resource across much of this bioregion, particularly on Croker Island, where there are no large native mammals, and throughout the region generally because purchase of meat is often not a realistic proposition.

Feral dog control (using 1080 baits) around significant breeding colonies of marine turtles is also relatively straightforward and inexpensive, but again requires the consent and collaboration of landowners.

The control of feral cats, and of feral pigs on Bathurst and Croker Island, is technically harder. Pigs may be controllable with a combination of aerial shooting and trapping, and their impacts upon particularly important sites (such as the two rainforest sites known to contain the endangered herb *Burmannia* sp. “Melville Island”) may be reduced by exclosure fencing. As with weeds, a high priority with feral animal management is the prevention of further introductions and outbreaks. The most likely of these is the assisted or unassisted (a swim across the few hundred metres of Apsley Strait) spread of feral pigs from Bathurst to Melville Island. Landholders more informed about the conservation costs may reduce the likelihood of deliberate introductions and increase the likelihood of early reporting of new incidences.

Across almost the entire bioregion, fire regimes have changed over the last 20-200 years, mostly to have reduced intricacy of burning and increased incidence of extensive hot late dry season fires. This change is generally detrimental to conservation values, and will be stabilised without management response. There are two options for returning to a more traditional burning regime - a relatively sophisticated route (aerial incendiary burning) or a lower tech route (through encouraging Aboriginal landowners to manage their estates more intensively). The former approach is widely used across much of northern Australia, including Aboriginal-owned lands such as Kakadu National Park. But it is probably the less preferred option in this bioregion, because it disenfranchises Aboriginal land owners, further removing them from management responsibility, because it is a relatively coarse process, and because it is probably more expensive. Rather, a preferable approach would be to more explicitly recognise the obligation of Aboriginal landowners to undertake appropriate fire management across their lands. This may involve: some payment (such as through ranger programs topping up CDEP funding); some more access to vehicles (e.g. provision of a 4WD associated with Aboriginal ranger schemes on Bathurst Island, Melville Island and Croker Island); and some consultation concerning impacts of fires on biodiversity and conservation values (aimed especially at increasing the incidence of fires lit in the early dry season and reducing the incidence of fires lit in the late dry season).

Monitoring of fire regimes is now practicable through satellite imagery, and such information is readily available, however this needs some resourcing to provide histories, interpretation, ground-truthing and reporting. Many ranger staff on existing PWCNT reserves in other bioregions now routinely use regular (weekly or monthly) updates of fire imagery to guide burning programs, or to help manage wildfire. Such practice is not yet established at Garig Gunak Barlu National Park, but the mechanism is available. Some additional computer resources and support would be needed to provide this service in any additional reserves or for any Aboriginal ranger scheme.

codes of practice

There are two major industries affecting land conservation values in the bioregion: plantation forestry and safari hunting.

A strategic plan for the forestry industry on Melville Island was completed in 2000 (Tiwi Land Council 2000), and this includes explicit plans and practices for management of fire,

weeds, water resources, prevention of soil erosion, soil biodiversity, monitoring and forestry generally. This plan has been endorsed by Territory Government regulatory agencies.

There is no formal code of practice for safari hunting on Cobourg Peninsula, but there is regular consideration by the Management Board of bounty levels, the number of animals available for take, and acceptable population density of feral animals.

environmental management systems

The only approach to EMS in this bioregion, and the only area where relevant, is for plantation forestry on Melville Island. The Strategic Plan offers an attempt to integrate forestry development with a consideration of environmental management across a gamut of issues.

capacity building with landholders

This is a crucial issue affecting conservation management in this bioregion. Many of the conservation problems in this bioregion can be addressed, even solved, with relatively little economic cost, so long as personnel are available, adequately trained and adequately motivated.

Aboriginal ranger programs, largely supported by CDEP funding, have provided this capacity building and direction in many Aboriginal communities. The Djelk rangers at Maningrida provide a good example of an Aboriginal ranger program working well to address conservation management issues. Elsewhere, some Aboriginal ranger programs have foundered through lack of direction or motivation and/or inadequate funding.

Such ranger schemes could be established on the Tiwi Islands, either as part of a collaborative management of reserved areas with PWCNT, with direct responsibility for an IPA, or without direct link to any conservation reserve but rather with a charter to increase conservation management effort across all Tiwi lands. A ranger scheme has recently been established on Croker Island, charged largely with responsibility for some NRM across the whole of Croker and adjacent islands. Such programs need vehicles, equipment (e.g. weedicides and spraying equipment; rifles and traps), training, uniforms, and office support. In the case of Croker (and other Aboriginal community ranger programs elsewhere), some training is provided by government agency staff (e.g. in weed identification and control methodology) and some support is available through the Northern Land Council, through specifically tailored courses run by tertiary institutes, and through collaborative studies or exercises (e.g. wildlife survey camps) with Government agencies or university staff. Ethnobiologists have worked successfully with Aboriginal landowners across this bioregion to exchange knowledge about the biota and environments.

In some cases, NHT funding has provided access to some resources to support such ranger programs or to address more specific management problems. For Croker Island, the NT Bushcare Officer and the Northern Land Council have provided the support necessary to draft project applications and to establish programs. Until recently, on the Tiwi Islands, there has been only limited attempt to seek funding for environmental issues,

however, the four recent cases have provided collaborative studies between Government agencies and the Tiwi Land Council:

- to investigate water resources and their protection;
- to provide an inventory of biodiversity and to derive a conservation plan;
- to provide an environmental officer charged particularly with management of erosion and soil resources; and
- to derive a land-use plan.

other planning mechanisms

There are no planning schemes based on catchment, property or local government areas in this bioregion, and no real need for these.

There is no integrated conservation planning explicitly addressing the whole of this bioregion. Such a whole bioregion approach is constrained here by the marked divide between Tiwi people in one part of the bioregion and people of different language groups in the other part. Further, the Tiwi people are represented by the Tiwi Land Council, which broke away from the Northern Land Council (which represents Aboriginal people in the eastern part of this bioregion) specifically because they felt themselves distinct from other Aboriginal peoples.

Thresholds and targets

A satisfactory conservation outcome for this bioregion would meet the thresholds and targets described in Table 7 below.

Table 7. Indicative targets and thresholds for biodiversity conservation in this bioregion.

target	*achieved by …*
CAR reserve system: provide formal protection for >20% of all environments and species (other than the three environments restricted to Croker island)	1) large conservation reserve or IPA on Melville Island (and possibly Bathurst Island), including extensive areas of treeless plains, many rainforest patches, and *Eucalyptus papuana* - *E. polycarpa* woodlands), designed to also adequately represent endemic Tiwi Island taxa. 2) conservation agreements established on islands with important seabird and/or turtle colonies.
off-reserve conservation: maintain or improve broad conservation values across the entire bioregion	1) through increased management effort, retain conservation values in the three environments restricted to Croker Island (especially the floodplains); 2) retain all rainforest patches and riparian areas, with adequate buffers around every one; 3) reduce to low levels the numbers of feral animals, especially pigs on Bathurst Islands, cats generally, and buffalo on Melville Island;

	4) eliminate the existing small populations of particularly detrimental weeds; 5) establish effective quarantine and surveillance programs; 6) reduce incidence of late dry season fires, and increase intricacy and number of early dry season fires.
improve landowner capacity	1) employ and train at least two Aboriginal rangers as part of Tiwi conservation reserve(s); 2) maintain, develop and/or extend Aboriginal community ranger scheme on Croker Island, and establish mechanism for its adequate resourcing.
maintain viable populations of all endemic and/or threatened taxa	1) develop and implement conservation plans which ensure the retention of viable populations of those species whose principal habitat is the Tiwi eucalypt forest favoured for plantation forestry; 2) safeguard nesting turtle populations through development of agreements on sustainable use, and predator removal (where necessary).
ensure adequate inventory and monitoring information exists	1) undertake a biodiversity inventory program on Croker and adjacent islands, in collaboration with Aboriginal landowners; 2) update biodiversity information on Cobourg Peninsula; 3) produce a vegetation map for the entire bioregion at scale of at least 1:250,000; 4) develop monitoring programs for all threatened taxa, weeds, and feral animals.
retain >50% of the bioregion's native vegetation	1) ensure compliance of all development proposals with NT legislation; 2) consult with Aboriginal landowners about the value of retaining extensive areas of native vegetation, and attempt to provide some economic return for this asset through provision of employment opportunities or resources associated with community ranger program or conservation reserves.

Summary of conservation management priorities

The conservation management activities and outcomes described in this report can be summarised in the following table (Table 8), and compressed into pie-charts in Fig. 7.

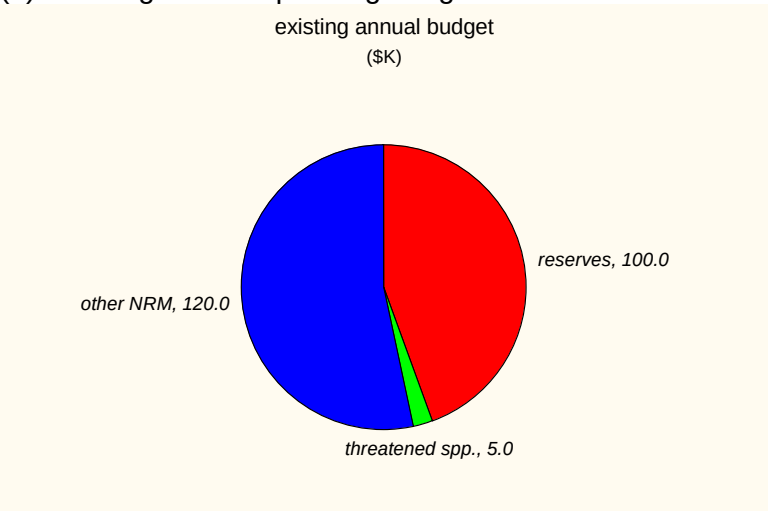
Table 8. Summary table of enhancements required for conservation management actions and priorities.

broad management measure	***current level of effort, achievement***	***activity, target***	***priority***	***timeframe***	***outcome***	***indicative cost***	***constraints***
reserve consolidation	moderate	establish reserve(s) or IPA on Tiwi Islands	high	1-5 years	adequate representation of all main envts, endemic taxa		current lack of enthusiastic support among many Tiwi; finances
		establish conservation agreements for important colony sites	moderate	1-20 years	adequate protection of all significant colonies	low (<$10,000)	may impose some constraints on harvest
management of threatened species, ecosystems	low	as for row above (marine turtle breeding sites)	"	"	"	"	"
		ensure retention of all rainforest patches	moderate	1-20 years	retention of many threatened rainforest plants	low ($<10,000)	may impose some constraints on development options
		ensure retention of viable populations of all threatened taxa whose preferred habitat is eucalypt forest	high	1-5 years	retention of viable populations of threatened taxa in eucalypt forests	low ($<10,000)	will impose some constraints on development options
		establish monitoring programs for threatened species	moderate	1-20 years	provision of measures of success of management	moderate ($10,000 per year)	resourcing
other NRM	low	enhance Aboriginal ranger program on Croker	moderate	1-5 years	mechanism for delivery of management on Croker	moderate-high ($30,000 establishment, $50,000 per year)	resourcing
		weed control	high	1-5 years	eradication of the worst exotics	low (<$5,000)	resourcing; capability
		establish quarantine and surveillance program	moderate	1-20 years	prevention of new infestations	moderate (<$5,000 per year)	resourcing

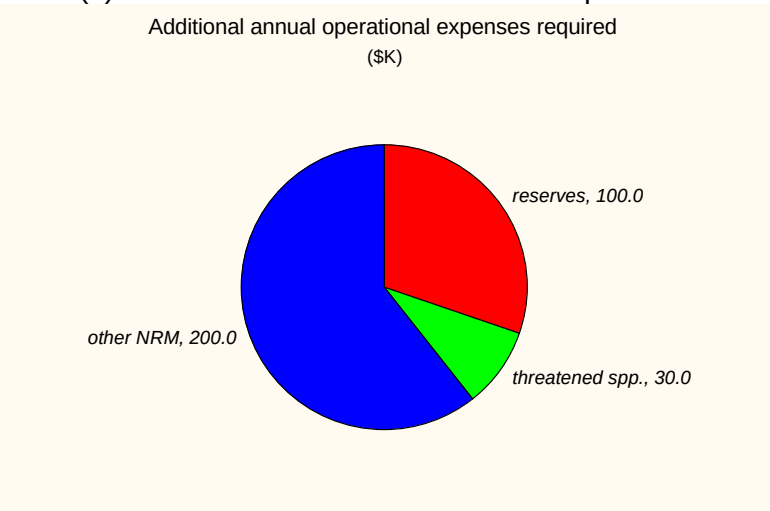
		control of feral animals (1) pigs on Bathurst	high	1-20 years	reduction to low levels; halt to additional translocations; ?exclosure fencing of significant sites	moderate ($10,000 per year, plus $20,000 one-off fencing)	resourcing; some possible lack of consent by landowners
		control of feral animals (2) buffalo on Melville	moderate	1-20 years	reduction to low levels	low ($5,000 per year)	as above
		control of feral animals (3) cats	moderate	1-20 years	reduction to low levels; halt to additional translocations	low ($5,000 per year)	limited effectiveness of available control mechanisms
		improve fire regimes	high	1-20 years	reduction in incidence of hot late dry season fires; monitoring of performance	moderate ($20,000 per year)	may be unwillingness to change current practice; limited access to some areas
		minimise impacts of exploitative land use	high	1-20 years	implement and monitor EMP associated with plantation forestry	high ($100,000 per year)	localised high impacts may be expected
information adequacy	moderate	biodiversity inventory of Croker and update of Cobourg	moderate	1-20 years	provide more comprehensive and recent biodiversity information	moderate ($50,000)	resourcing
		develop a vegetation map for bioregion at appropriate scale	moderate	1-5 years	provision of necessary conservation planning and management information	moderate ($50,000)	resourcing

Figure 7. Summary of existing and additional resourcing required for conservation management.

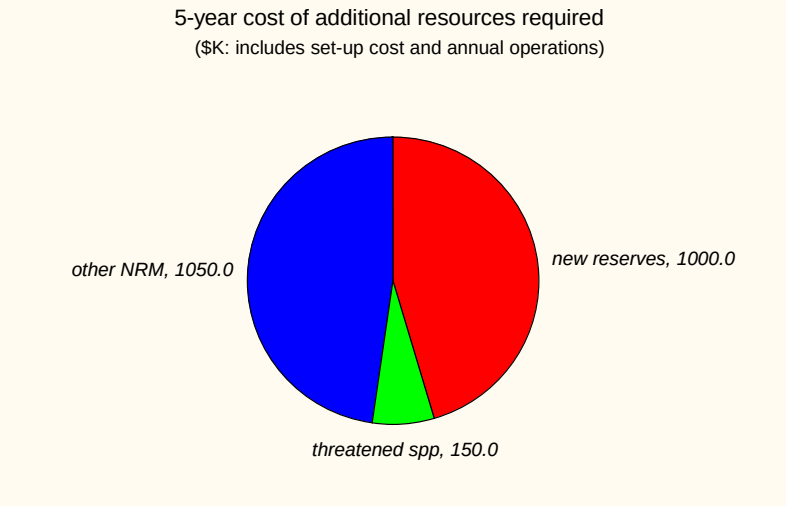
(a) Existing annual operating budget



(b) ADDITIONAL annual resources required



(c) ADDITIONAL resources required over 5 years (including establishment costs, and 5 years of annual operations costs)



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APPENDIX: Dossiers on individual threatened species

PLANTS

Australian arenga palm ***Arenga australasica*** (Arecacea)

EPBCA status: VULNERABLE
TPWCA status: -

In the Northern Territory, this small palm is restricted to coastal and subcoastal rainforests from Cobourg Peninsula through north-eastern Arnhem Land to Groote Eylandt. It occurs also in north-eastern Queensland. Its persistence may be affected by disturbance by feral animals, especially pigs.

***Burmannia* sp. DNA61177 'Melville Island'** (Burmanniaceae)
[=*Burmannia sp. Melville Island (R.Fensham 1021)*]

EPBCA status: ENDANGERED
TPWCA status: ENDANGERED

This species is a small saprophytic herb, whose entire known range is restricted to two adjacent wet rainforest patches, both on Bathurst Island (in contradistinction to its misleading informal name). Both populations are threatened by the impacts of feral pigs. The last count, in 1991, suggested the total population was 500 to 2000 individuals (Fensham 1993). Surveys in 2001 confirmed its persistence in these two sites.

This plant has not been recorded on Melville Island, despite considerable sampling effort in wet rainforest patches.

Conservation management for this species should involve repeat searches, monitoring and control (either through removal or fencing out) of feral pigs in the two rainforest patches from which it is known.

Calochilus caeruleus (Orchidaceae)

EPBCA status: -
TPWCA status: VULNERABLE

This terrestrial orchid is known in the Northern Territory from only two collections, both on Melville Island. Beyond the Territory, it is also known from Queensland, Western Australia and New Guinea.

Its preferred habitat appears to be seasonal paperbark swamps.

Its persistence on the Tiwi Islands is dependent upon the maintenance of hydrological integrity in the paperbark swamp systems, and control of the impact of feral animals and weeds.

Cerbera manghas (Apocynaceae)

EPBCA status: -
TPWCA status: VULNERABLE

This small "native frangipani" tree is usually associated with coastal rainforest thickets. It is known from a few scattered records from the Northern Territory (mainly in the north-west and north-east coast of the Top End and offshore islands: Woinarski *et al*. 2000*b*). Beyond the Territory, it is widely distributed across the tropics, and including Queensland.

There are no immediate threats to the single population known on the Tiwi islands (west coast of Bathurst).

Cycas armstrongii (Cycadaceae)

EPBCA status: -
TPWCA status: VULNERABLE

This species is restricted to the Top End of the Northern Territory, with a range comprising the Darwin area south to Hayes Creek, and the Tiwi Islands. Hill (1996) noted that it is

> "*locally extremely abundant, not to be considered at risk … the extreme abundance of this species would buffer it from any threat in the medium term. However frequent fire effectively blocks reproduction, and uncontrolled development progressively alienates significant proportions of the habitat. Several of the Northern Territory species, including this one, are probably the most abundant of all cycads, with populations numbering into tens of millions*"

A Management Plan for Cycads in the Northern Territory has been established by PWCNT (PWCNT 1997) which stipulates that:

> "*The potential local and regional effects on the status of cycad populations will be taken into account in considering land clearing and other development applications. The cumulative effects of land use decisions on cycad populations will be taken into account in preparing nature*

On the Tiwi Islands, *Cycas armstrongii* is common and widespread, reaching highest abundance in eucalypt tall open forest. As this vegetation type is likely to be most affected by the development of plantations of *Acacia mangium*, some substantial reduction in population may be expected.

Cycas maconochiei* var. *maconochiei (Cycadaceae)

EPBCA status: -
TPWCA status: VULNERABLE

This cycad subspecies is restricted to a small area between Fog Bay and Port Darwin, where it is locally extremely abundant, "not considered to be at risk", and (its) "extreme abundance .. would buffer it from any threat in the medium term" (Hill 1996).

It occurs on flat sites with sandy soil over Tertiary laterites in open forests typically dominated by *Eucalyptus miniata* and *E. tetrodonta* (Hill 1996).

There are few isolated records from the Tiwi Islands, and these include reports from the barge landing and gardens around Pularumpi.

Dendrobium trilamellatum (Orchidaceae)

EPBCA status: -
TPWCA status: VULNERABLE

This epiphytic orchid is known in the Northern Territory from only two locations on Melville Island. Beyond the Territory, it is known from northern Queensland (where it is described as "very common": Jones 1988) and New Guinea.

It typically grows on the trunks of *Melaleuca* trees in swampy areas, but also occurs in rainforest patches and more open forests.

Elaeocarpus miegei (Elaeocarpaceae)

EPBCA status: -
TPWCA status: ENDANGERED

The only Australian occurrences of this tall rainforest tree are on the Tiwi Islands. Beyond Australia, it is also known from New Guinea, Malesia and the Solomon Islands.

On the Tiwi Islands it has been recorded from seven wet rainforest patches, where it grows in permanently moist soils.

The maintenance of this species on the Tiwi Islands depends upon the retention of the rainforest network, maintenance of hydrological conditions and control of the impact of feral animals (especially pigs) in this rainforest environment.

Eleocharis geniculata (Cyperaceae)

EPBCA status: -
TPWCA status: VULNERABLE

This short annual sedge occurs widely in tropical and subtropical regions of the world, and in the Top End of the Northern Territory, extending more sparsely to central Australia.

This species occurs in the margins of semi-permanent wetlands, including streambeds, lakes, swamps and springs on moist sandy, gravelly or organic soil (Cowie *et al*. 2000). There does not appear to be any major threat to its few known Tiwi populations, although it may be affected by the impacts of feral animals and any changes in water regimes.

Freycinetia percostata (Pandanaceae)

EPBCA status: -

TPWCA status: VULNERABLE

This climbing shrub is known in the Northern Territory from only three locations on Bathurst Island and two from the Arafura Swamp area of north central Arnhem Land.

It occurs in spring-fed wet rainforests. The maintenance of this species depends upon the retention of the Tiwi rainforest network, the maintenance of hydrological conditions in this catchment, and control of the impact of feral horses and buffalo in this environment.

Hedyotis auricularia (Rubiaceae)

EPBCA status: -
TPWCA status: VULNERABLE

This rainforest herb is known in the Northern Territory only from the Tiwi Islands, but it also occurs in Queensland. Its known distribution on Melville Island is restricted to the Mindelu Creek system, where it grows on the sandy creek bank among a relatively wide band of gallery forest (Fensham and Woinarski 1992). It is also known from two sites on Bathurst Island.

The maintenance of this species depends upon the retention of the Tiwi rainforest network, the maintenance of hydrological conditions in this catchment, and control of the impact of feral animals in this environment.

Hoya australis* var *oramicola (Asclepiadaceae)

EPBCA status: -
TPWCA status: VULNERABLE

This vine is associated with coastal rainforest thickets. It has been recorded in the Northern Territory only from two sites on Bathurst Island and one site on Melville Island.

There are no immediate threats to the few scattered populations on the Tiwi Islands.

Luisia teretifolia (Orchidaceae)

EPBCA status: -
TPWCA status: VULNERABLE

This epiphytic orchid is known in the Northern Territory from around 12 sites on Melville Island and three locations on the mainland (in the Darwin-Litchfield area). It also occurs in Queensland, New Guinea, Indonesia and Malaysia.

It occurs mainly on the dry margins of wet rainforests. Recorded hosts include the trees *Canarium australianum, Vitex glabrata, Sterculia quadrifida* and *Barringtonia acutangula*.

The maintenance of this species depends upon the retention of the Tiwi rainforest network, the maintenance of hydrological conditions in this catchment, and control of the impact of feral horses and buffalo in this environment.

Mapania macrocephala (Cyperaceae)

EPBCA status: -
TPWCA status: VULNERABLE

This sedge is known in the Northern Territory from only three collections, one each on Bathurst and Melville Islands and one from north-eastern Arnhem Land.

It occurs in spring-fed wet rainforests. The maintenance of this species depends upon the retention of the Tiwi rainforest network, the maintenance of hydrological conditions in this catchment, and control of the impact of feral animals in this environment.

Thrixspermum congestum (Orchidaceae)

EPBCA status: -
TPWCA status: VULNERABLE

This epiphytic orchid is known in the Northern Territory only from a small set of wet rainforest patches in high rainfall areas of northwestern Melville Island and northern Bathurst Island. Beyond the Northern Territory, it occurs in northern Queensland and Malesia.

The maintenance of this species depends upon the retention of the Tiwi rainforest network, the maintenance of hydrological conditions in this catchment, and control of the impact of feral animals in this environment.

Tropidia curculigoides (Orchidaceae)

EPBCA status: -
TPWCA status: VULNERABLE

This terrestrial orchid is known in the Northern Territory from only six collections: one on Melville Island, four from around Darwin and one from Groote Eylandt. Beyond the Territory, it is also known from Indonesia and Malaysia.

It typically occurs in semi-deciduous rainforest thickets and the drier margins of spring rainforests.

The maintenance of this species depends upon the retention of the Tiwi rainforest network and control of the impact of feral horses and buffalo in this environment.

REPTILES

Flatback turtle *Natator depressus*

EPBCA status: VULNERABLE
TPWCA status: -

Flatback turtles nest widely across the bioregion, including the south-east and north of Bathurst Island, north of Melville Island, Greenhill Island, northern beaches of Cobourg Peninsula, Croker Island, and most of the smaller islands to the northeast of Croker (New Year, Oxley, Lawson, McCluer and Grant) (Chatto 1998; Hope and Smit 1998). There are no good estimates of abundance or trends in population, but Hope and Smit (1998) present data on beach counts of turtle tracks (species undifferentiated, but probably with flatback turtles as the main species). On Greenhill Island, flatbacks comprised 91% of 187 turtles captured over brief visits in three years for mark-recapture studies. The small islands to the north-east of Croker are probably especially important due to the high numbers of breeding turtle (these islands had 61% of the turtle tracks reported in a study encompassing these islands, Croker, Cobourg Peninsula and adjacent mainland areas of Arnhem Land) and the relatively low predation rates compared to Croker island and the mainland (where goannas, dogs and people consume a high proportion of eggs).

Green turtle *Chelonia mydas*

EPBCA status: VULNERABLE
TPWCA status: -

As with flatback turtles, green turtles use much of the bioregion's coast for breeding, but generally prefer bigger, wider, dune-backed sandy beaches, and to concentrate in fewer but higher density breeding sites (Chatto 1998). Smith Point on Cobourg Peninsula is one of the most significant breeding sites for this species in the Northern Territory (Chatto 1998).

Hawksbill turtle *Eretmochelys imbricata*

EPBCA status: VULNERABLE
TPWCA status: -

In the Northern Territory, hawksbills tend to nest on islands, with only occasional records on mainland beaches. Most breeding sites are in north-eastern Arnhem Land, but there are some records from the small islands to the north-east of Croker, and scattered records across most of the rest of the bioregion's coast (Chatto 1998).

Olive ridley turtle *Lepidochelys olivacea*

EPBCA status: ENDANGERED
TPWCA status: -

The small islands to the north-east of Croker are probably the most significant breeding site for this species in the Northern Territory, but other sites used frequently include Seagull Island (off the northwest of Melville Island) and Black Point (Cobourg

Peninsula) (Chatto 1998). Limpus (1993) regarded the McCluer group as the most important nesting site in Australia.

Leatherback turtle *Dermochelys coriacea*

EPBCA status: VULNERABLE
TPWCA status: VULNERABLE

This large turtle is very uncommon in Australia, but there are a few records from Cobourg Peninsula, including isolated nesting attempts (Limpus 1993; Chatto 1998).

unnamed skink *Cryptoblepharus* sp.

EPBCA status: -
TPWCA status: -

This species is known from only a few specimens collected on one island of the McCluer group (northeast of Croker), within the last decade. Its description is currently in preparation (P. Horner, Museums & Art Galleries of the Northern Territory, *pers. comm*.). Given its putative restricted range, it is likely to be listed as Vulnerable in the next revision of the threatened species list attached to the TPWCA.

Taipan *Oxyuranus scutellatus*

EPBCA status: -
TPWCA status: DATA DEFICIENT

In contrast to its abundance in parts of northeastern Australia, there are extremely few records of the taipan from the Northern Territory. Based on very meagre data, the species appears to be more abundant on the Tiwi Islands than elsewhere in the Territory, however the few documented records are insufficient to estimate population size or to model distribution or habitat requirements.

BIRDS

Chestnut-backed button-quail *Turnix castanota*

EPBCA status: -
TPWCA status: DATA DEFICIENT

Across its national range, there is some evidence for decline in the abundance and range of the chestnut-backed button-quail, with Garnett and Crowley (2000) concluding that "population density has probably been reduced over half of the species' range". This decline appears to be related to vegetation change caused by altered fire regimes and/or pastoralism. There are relatively few records of the species on the Territory mainland, where it is largely restricted to grasslands and grassy understoreys of savanna woodlands on gravelly hills. The species appears to be unusually common on the Tiwi Islands, and relatively widespread.

On the Tiwi Islands, chestnut-backed button-quail are restricted to eucalypt woodlands and tall open forests, and have not been recorded in any of areas of exotic plantations. Hence, it is likely to be disadvantaged by broad-scale conversion of eucalypt forests to plantations of exotic species.

Red goshawk *Erythrotriorchis radiatus*

EPBCA status: VULNERABLE
TPWCA status: VULNERABLE

The red goshawk has an extensive range across much of northern Australia, but throughout this range is typically very patchily distributed and at low densities, such that the total population is estimated at fewer than 1,000 mature individuals (Garnett and Crowley 2000). Its decline in northeastern Australia has been blamed on widespread clearing for agriculture (Czechura and Hobson 2000; Garnett and Crowley 2000).

It is widely regarded as being relatively more common (albeit still rare) on the Tiwi Islands (Mason and Schodde 1997) than elsewhere; there are a few scattered records from Cobourg Peninsula. Estimates (from elsewhere in northern Australia) of home range size (around 100 to 200 km^2 for breeding pairs: Aumann and Baker-Gabb 1991) can be used to provide a rough indication of total population size on the Tiwi Islands. Across both islands and assuming that all land is used, and that home ranges are non-overlapping (as is likely), this suggests a total Tiwi population of about 80-160 adult birds (that is, something like a tenth of the entire Australian population of this species).

Elsewhere in its range, it is associated mainly with eucalypt tall open forests and *Melaleuca* riparian forests, and all of the Tiwi records with adequate data are from eucalypt tall open forests.

The retention of a viable red goshawk population on the Tiwi Islands is dependent upon the maintenance of extensive tracts of tall open forest, especially where these also include some riparian areas.

Partridge pigeon *Geophaps smithii*

EPBCA status: VULNERABLE (but nb may be downgraded to "Lower Risk" following review by Garnett and Crowley 2000).
TPWCA status: -

The partridge pigeon occurs across the Top End of the Northern Territory (subspecies *G.s. smithii*) and Kimberley (subspecies *G.s. blaauwi*). It has declined substantially over the last 100 years, especially from the drier southern fringe of its range (Garnett and Crowley 2000), probably due to vegetation change associated with altered fire regimes and/or pastoralism. Recent radio-tracking studies of the species in Kakadu indicate that it is prefers burning regimes which include fine-scale early dry season fires, and that it is disadvantaged by either fire exclusion or frequent extensive late dry season fires.

Although there are no good comparative data, partridge pigeons appear to be more common on the Tiwi Islands than the mainland. They appear to be reasonably widespread across both Bathurst and Melville Islands, and on Cobourg Peninsula.

In this bioregion, partridge pigeons occur mainly in eucalypt tall open forest (dominated by *Eucalyptus miniata, E. tetrodonta* and *E. nesophila*), generally consistent with what is known of their habitat preference on the mainland. It has also been recorded in some eucalypt woodlands and plantations of *Acacia mangium* and other exotic trees, although these observations were infrequent relative to those in eucalypt tall open forests. Extensive conversion of eucalypt tall open forests to *Acacia* plantation will disadvantage this species.

Masked owl (Melville Island subspecies) *Tyto novaehollandiae melvillensis*

EPBCA status: VULNERABLE (but nb may be upgraded to "Endangered" following review by Garnett and Crowley 2000).
TPWCA status: ENDANGERED

There are four Australian subspecies of masked owl, which combined occupy a very extensive range across much of Australia other than arid and semi-arid areas. The subspecies with the smallest range is restricted to the Tiwi Islands, and is regarded as either vulnerable or endangered in current Territory and national lists. Based on population densities recorded elsewhere in Australia (from estimated home ranges of 5-10km^2), Garnett and Crowley (2000) estimated the total population of this Tiwi subspecies at about 1,000 mature birds.

Based on systematic searches on the Tiwi Islands, the main habitat used is eucalypt open forests, although it also uses rainforest patches and treeless plains, for roosting and foraging. This is consistent with the ecology of masked owls in south-eastern Australia (Kavanagh and Murray 1996), where they have been shown to occur mainly in eucalypt tall open forest but to forage or roost in a range of other habitats.

Extensive conversion of eucalypt tall open forests to *Acacia* plantation will disadvantage this species, most likely by reducing an already relatively small population by the proportion of open forest to be lost relative to the current extent.

Masked owl (northern Australia subsp.) *Tyto novaehollandiae kimberli*

EPBCA status: VULNERABLE (but nb may be downgraded to "Lower Risk" following review by Garnett and Crowley 2000).
TPWCA status: -

The mainland subspecies of masked owl occurs widely across northern Australia, but typically at low densities. It is known from several records in eucalypt tall open forest on Cobourg Peninsula.

Hooded robin (Tiwi subspecies) *Melanodryas cucullata melvillensis*

EPBCA status: - (but nb may be upgraded to "Vulnerable" following review by Garnett and Crowley 2000).
TPWCA status: - (but likely to be upgraded to "Endangered" in forthcoming revision of the regulations)

The hooded robin has an extensive range across continental Australia. It is undergoing a substantial decline in south-eastern Australia (Reid 1999) and is relatively uncommon in the Top End of the Northern Territory. The Tiwi subspecies was described from a few collected individuals in 1914. It was tentatively accepted as a valid taxon by Schodde and Mason (1999), although they cautioned that "further material is needed to confirm it; the only material seen is badly worn".

The Tiwi hooded robin has been very rarely documented since its description. Fensham and Woinarski (1992) recorded it from one site on each of Bathurst and Melville Islands. It has not subsequently been reported, despite specific searching by Mason and Schodde (1997) and Woinarski *et al*. (2000) on Melville Island, PWCNT surveys on Bathurst Island during 2001.

Based on projections of densities from elsewhere in Australia, and assuming continuous distribution over the Tiwi Islands, Garnett and Crowley (2000) estimated the total population size of this taxon at 8,000 mature individuals. This estimate now appears to be far too large, as the Tiwi hooded robins are clearly extremely discontinuously distributed on the Islands and extremely uncommon.

The habitats at the two sites in which Fensham and Woinarski (1992) recorded hooded robins were treeless plains and tall eucalypt open forest. This meagre data is inadequate to model or generalise habitat relationships or population numbers. Based on information from elsewhere in Australia (e.g. Woinarski and Fisher 1995; Fitri and Ford 1997), it is most likely to be associated with the treeless plains and with eucalypt open forests in which frequent fine-scale fires result in patches with little grass cover. Changes in fire regimes over the last century may have altered the understorey structure on the Tiwi Islands (as they appear to have done on the Top End mainland), disadvantaging this species and leading to a substantial and ongoing decline.

The most appropriate conservation action for this rare endemic subspecies is to retain treeless plains, and to retain fine-scale burning regimes. More targetted research is needed to better define its population size, habitat requirements and threats.

Gouldian finch *Erythrura gouldiae*

EPBCA status: ENDANGERED
TPWCA status: VULNERABLE

The gouldian finch has declined across most of its range in northern Australia, probably because of habitat alteration caused by pastoralism and/or changed fire regimes. Gouldian finches are known in the bioregion only through the collections by John Gilbert in 1840-41. The lack of recent records suggests that they have become regionally extinct.

MAMMALS

Butler's dunnart *Sminthopsis butleri*

EPBCA status: VULNERABLE
TPWCA status: VULNERABLE

There is remarkably little known about this species (Woinarski *et al*. 1996). There are only two records from any location other than the Tiwi Islands, both from Kalumburu in the north Kimberley, about 35 years ago.

The Tiwi records comprise two locations on Bathurst Island (from December 1994), an indefinite location on Melville Island in 1913, near Andranangoo Creek in 1996 (Horner and Griffiths 1998, mistakenly as *S. virginiae*), two locations on Melville Island in 2000 (Woinarski *et al*. 2000) and one on Bathurst Island during PWCNT surveys in 2001.

This set of observations is insufficient for predictive distributional modelling or for estimation of population size. About all that can be said is that the species appears to be sparse, but probably widespread on Bathurst and Melville Islands.

Three of the five recent records are from tall eucalypt forest. While this may indicate a preference for such habitat, this conclusion should be tempered by acknowledgement that this vegetation type has been subjected to the greatest sampling effort.

The lack of information substantially hinders conservation management planning for this species. In the lack of any more useful information, our advice is to retain native vegetation in a 1 km radius around each of the five known sites.

Bare-rumped sheathtail-bat *Saccolaimus saccolaimus nudicluniatus*

EPBCA status: - (but this status may be upgraded to "Critically Endangered" based on the recent revision of Duncan *et al*. 1999)
TPWCA status: DATA DEFICIENT

This subspecies of bat is known mainly from Cape York Peninsula, where the sparsity of recent records prompted its national classification as critically endangered (Duncan *et al*. 1999). There are only two confirmed records of this species from the Northern Territory, both from Kapalga (Kakadu NP), collected more than 20 years ago (McKean *et al*. 1981; Thomson 1991). There is some uncertainty about whether this taxon is the same subspecies as the Queensland population (Duncan *et al*. 1999).

This species occurs predominantly in eucalypt woodlands, but may also use coastal rainforests. It mainly uses tree hollows as roosts, and may be critically dependent upon suitable tree roosts in open eucalypt woodlands (Compton and Johnson 1983).

The taxon is listed from the bioregion only on the basis of an unconfirmed record from an unspecified location on Melville Island in ForSci (1999), based on "a single call sequence", accompanied by the comment that this record "needs to be verified with a collection of a voucher specimen".

This species was not recorded during subsequent PWCNT surveys (Woinarski *et al*. 2000), despite the collection of bat call recordings from more than 200 widely scattered

sites across all habitats on Melville Island. The most parsimonious response is to ignore the doubtful ForSci record.

Little north-western freetail bat *Mormopterus loriae cobourgiana*

EPBCA status: - (regarded as "Data Deficient" in the recent review by Duncan *et al*. 19990)
TPWCA status: VULNERABLE

This small bat is included as threatened here on the basis of its categorisation in Duncan *et al*. (1999) as "Data Deficient". This status recognises the relatively few previous documented records (12 localities in northern Western Australia and four in the Top End of the Northern Territory: Duncan *et al*. 1999).

Prior to the recent PWCNT surveys of the Tiwi Islands (Woinarski *et al*. 2000), the only record from the Tiwi Islands was that of ForSci (1999), from an unspecified location on Melville Island. The species is generally found in mangroves and rainforests, and roosts in small spouts in trees (Thomson 1991; Duncan *et al*. 1999).

Our surveys found that this species appears to be reasonably widespread and abundant on Melville Island, with records from five locations. Most of these sites are in or adjacent to mangroves, riparian areas or rainforests, but we detected it also from more open habitats including treeless plains and eucalypt forests.

Our records suggest no substantial conservation concern for this species, and that the limited documentation of its occurrence in the Top End is probably largely due to relative lack of survey effort. Maintenance of its preferred habitat of mangroves and rainforests should ensure its persistence.

The type location of this taxon is Cobourg Peninsula, and the limited survey effort suggests that it is probably common in mangrove and adjacent vegetation types there.

Brush-tailed rabbit-rat *Conilurus penicillatus melibius*

EPBCA status: -
TPWCA status: VULNERABLE

This moderately large rodent is known from the Kimberley, the Top End of the Northern Territory, a few records in New Guinea and from one Queensland island in the Gulf of Carpentaria (Kemper and Schmitt 1992). Since the 1890s, it has disappeared from lower rainfall parts of its range (e.g. Dampier Peninsula in Western Australia, the Roper-Gulf area of the NT), and has declined substantially in much of the remaining mainland portions of its distribution (McKenzie 1981; Woinarski 2000), with changed fire regimes and/or feral cats being the most likely cause.

The Tiwi Island population is one of three recognised subspecies, and occurs only on the Tiwi Islands (Kemper and Schmitt 1992). Rabbit-rats occur widely across the Tiwi Islands, other than the central plateau and far east of Melville Island. Woinarski *et al*. (2000) recorded that the mean home range size was about 0.6 ha, that home ranges showed substantial overlap, that the highest recorded density was 8 individuals/ha at one site in tall eucalypt open forest with a shrubby understorey, and that it roosts in fallen hollow logs, hollows in large trees, and/or in the crown of *Pandanus* or *Livistona*.

Its diet includes mainly grass seeds and fleshy fruits (typically from shrubs such as *Terminalia, Persoonia* and *Buchanania*).

Although it has been recorded from a range of vegetation types, most records are from eucalypt woodlands and tall open forests. This preferred habitat includes areas which are recognised as those most suitable for conversion to *Acacia mangium* plantation. Conversion of large areas of native forest to plantation may be expected to have a significant impact upon this taxon.

Another subspecies of brush-tailed rabbit-rat remains abundant on the Cobourg Peninsula (PWCNT 2000).

False water-rat *Xeromys myoides*

EPBCA status: VULNERABLE
TPWCA status: -

The false water-rat is known from a small number of sites in coastal areas of the Northern Territory, New Guinea and eastern Queensland (Woinarski *et al*. 2000*a*).

It occurs in mangroves and the (typically adjacent) coastal saline grasslands (Woinarski *et al*. 2000). There is only one report from this bioregion, of three animals collected from a mound in mangrove forest (dominated by *Bruguiera parviflora* and *Ceriops tagal*) 7 km upstream from the mouth of Andranangoo Creek, Melville Island, in 1975 (Magnusson *et al*. 1976).

Its conservation status should be secure on the Tiwi Islands provided that mangroves and saline grasslands and sedgelands are retained.