BIODIVERSITY CONSERVATION ON THE TIWI ISLANDS:

plants, vegetation types and terrestrial vertebrates on Melville Island.

A report to the Tiwi Land Council

Report prepared by John Woinarski, Kym Brennan, Craig Hempel, Ron Firth and Felicity Watt.

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SUMMARY

This report describes the environments, terrestrial flora (1180 native species) and vertebrate fauna (334 native species) of the Tiwi Islands (based on collation of previous records and three months of field work), and issues related to their conservation. This biota includes a large component of taxa which are considered threatened (on lists attached to national or Territory legislation), and taxa which are restricted to these Islands. The number of these conservation values clearly renders the Tiwi Islands of at least national conservation significance. A digest of information on each of these threatened or endemic taxa is presented.

This study was prompted by proposals for a substantial expansion of plantation forestry on these islands. Its objective was to describe the conservation values of these islands, to assess the management requirements of those values, and to propose mechanisms (including the delineation of areas which should be retained) for their maintenance. A proposed retained area network is outlined, which is devised in a stepwise manner (first identifying highly localised features, especially rainforests and riparian areas; then non-rainforest species which are known from very few localities; then more wide-ranging threatened taxa; then adding sufficient representation of the full range of environments present on the islands). The total retained area network proposed is extensive (=73% of the Islands area), but should ensure maintenance of all biodiversity conservation values.

This outcome ("Scenario 1") is unlikely to be acceptable to the Tiwi landowners, as it overly constrains options for other land uses. More acceptable outcomes, requiring less land area, can be developed only through weakening the conservation targets we set for the principal conservation values of the Islands.

We assess the conservation costs and benefits of a more realistic outcome ("Scenario 2") which includes a large area of eastern Melville Island largely for conservation, but weakens the conservation criteria applied to western Melville Island. Recognising that the boundaries of any such conservation area remain unresolved, and that the Tiwi Land Council has not committed to such an outcome, our analysis suggests that this sort of outcome is likely to achieve much of the conservation targets that are appropriate for the Tiwi environments and biota.

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1. INTRODUCTION

1.1. Purpose of this report

This report presents an assessment of the natural conservation values of Melville Island, based on an intensive field survey and collation of previous documentation. It aims to define and describe these values, and to provide recommendations concerning management for their retention. This assessment is limited to vascular plants and terrestrial vertebrate animals, and excludes consideration of invertebrates, and aquatic and marine species.

This work was prompted by a proposal (ForSci 1999; First Management Corporation 1999) for the re-establishment of extensive commercial forestry on the Tiwi Islands (=Melville and Bathurst Islands, and some far smaller islands off these). That proposal sought to convert about 30,000 ha of native forest to short-rotation plantations of the exotic *Acacia mangium*. In response to the initial stages of this proposal, it was recognised - by the relevant government agencies, by the proponents and by the Tiwi Land Council - that assessment of environmental impacts was hampered by inadequate contextual information, specifically concerning the distribution, status and habitat requirements of a number of threatened and/or endemic plant and animal taxa on the Tiwi Islands as a whole (Department of Lands, Planning and Environment 1999). This report attempts to provide such contextual information. It is not an Environmental Impact Statement for the proposed forestry development. However, it does provide the potential to contribute towards a more precise assessment of this and other developments on the Tiwi Islands.

This report provides the documentation of our results. But much of the utility of this project lies with the compiled GIS coverages and data bases (mostly collated now as Foxpro and Excel files). Custodianship of these currently lies with Parks and Wildlife Commission, but these should be available to all parties interested in conservation, management and development issues on the Tiwi islands, subject to the joint approval of PWCNT and the Tiwi Land Council.

This project was overseen by a joint Interdepartmental Committee on Tiwi Island Forestry Development. The terms of reference for the project are listed in Appendix A.

This work is a precursor to a more comprehensive conservation plan for the Tiwi Islands, proposed jointly by the Tiwi Land Council, Parks and Wildlife Commission and Sylvatech, and currently being evaluated for Natural Heritage Trust funding. That proposed work will cover many aspects not (adequately) considered here, most notably by inclusion of Bathurst Island and of sampling during the wet season.

1.2. Brief description of the Tiwi Islands

The Tiwi Islands comprise the closely abutting Melville Island (with a land area of 5788km^2 – Australia's largest island other than Tasmania) and Bathurst Island (1693km^2), plus a few scattered much smaller islands just off the coast of these two large islands (including Buchanan, Seagull and Irrititu). The islands lie just to the north of Darwin (Fig. 1),

separated from the Northern Territory mainland by 20 km of the narrow Clarence Strait (between Beagle Gulf to the west and van Diemen Gulf to the east), in which lie the small Vernon Islands group. Clarence Strait and the Beagle Gulf are relatively shallow, such that a sea level fall of 30m would result in connection of the Tiwi Islands to the mainland. The current isolation of the Tiwi Islands results from rapid sea level rise between about 12,000 and 8,000 years ago (Woodroffe *et al*. 1992), which split Melville from Bathurst along the very narrow (typically <500m) Apsley Strait and sundered both from the mainland.

The Tiwi Islands are relatively low (highest point 102m) and topographically simple. Both islands comprise a central plateau, mostly composed of Tertiary laterite and van Diemen sandstone, and Cretaceous sandstones, surrounded by more recent depositional material. A series of moderately large creeks drain northward on Melville Island, and there is a small floodplain on Andranangoo Creek. More detailed information on Tiwi Islands geology, geomorphology and soils is given in Anon (1998) and ForSci (1999).

The Tiwi Islands have the Territory's highest rainfall (to about 2000mm annual average rainfall in the north of Bathurst Island and north-west of Melville Island), with about 90% of this falling in a 5 month wet season (November to April).

The islands support a population of around 1700 to 2000 (overwhelmingly comprising the traditional Aboriginal owners, the Tiwi people), mostly in the towns of Nguiu (Bathurst Island) and Milikapiti and Pirlangimpi (Melville Island), with smaller scattered outstations. The entire area is Aboriginal freehold lands (held under the Tiwi Aboriginal Land Trust). The track network is best developed on Bathurst Island and the west of Melville Island: much of the eastern half of Melville Island is inaccessible by road. More detailed information on the history and people of the Tiwi Islands is given in Forrest (1998).

1.3. Biogeographic and conservation context

By virtue of their isolation, in having the Territory's highest rainfall, and in being at the northern extreme of the Territory, the Tiwi Islands support a distinctive biota, including a number of endemic species and subspecies of plants and animals. This places a conservation focus and onus on the Tiwi Islands, as axiomatically these taxa cannot be maintained in the wild anywhere but on the Tiwi Islands.

The distinctiveness of the Tiwi Islands is relative, and many of the Tiwi species and environments are shared with the Territory mainland, most notably with Cobourg Peninsula to the immediate east (Brocklehurst and Edmeades 1998). At the Territory scale, this is reflected in the recognition of a "Tiwi-Cobourg" bioregion comprising the Tiwi Islands, Cobourg Peninsula and Croker Island, and which forms one of three Territory divisions of the nationally recognised "Top End coastal" bioregion (Thackway and Cresswell 1995). Because Cobourg Peninsula includes the large Gurig National Park, several of the environments which occur on the Tiwi Islands can be broadly considered to be represented within conservation reserves (Table 1), and the Tiwi-Cobourg bioregion is among the most substantially reserved (20.5% of the area is reserved) of all Territory bioregions. This extent of reservation provides some assurance that the broad environments present on the Tiwi Islands (Fig. 2) are generally relatively well protected (elsewhere), however the coarse scale of this vegetation mapping (1:1,000,000) obscures much of the variability within

vegetation types, and is far less detailed than that accepted (1:250,000 or 1:100,000) as appropriate for bioregional conservation planning (ANZECC 1999).

Table 1. The occurrence of coarsely-defined Tiwi vegetation types, and their representation within Northern Territory reserves (based on the 1:1 000 000 vegetation mapping of Wilson *et al*. 1990).

vegetation type	area (km^2)			% area reserved
	on the Tiwi Islands (% of total NT distribution)	in Gurig National Park	in the Northern Territory	
1. mixed-species closed forest (monsoon vine-thicket)	36 (14.0%)	-	258	6.2
3. *Eucalyptus miniata- E. tetrodonta – E. nesophila* open forest with *Sorghum* grassland understorey	6100 (71.4%)	1894	8546	22.1
18. *Eucalyptus papuana – E. polycarpa* woodland with grassland understorey	229 (9.4%)	-	2435	1.3
47. *Acacia* open shrubland with *Sorghum* grassland understorey ("treeless plains")	191 (100%)	-	192	0
53. *Melaleuca* open forest (paperbark swamp)	50 (3.1%)	-	1590	27.3
105. Mangal low closed-forest (mangroves)	598 (41.5%)	97	1440	8.1
106. saline tidal flats with scattered chenopod low open shrubland (samphire)	146 (1.9%)	39	7815	15.2

However, even this coarse analysis indicates that one Tiwi vegetation type (unit 47: the "treeless plains") is endemic, and cannot be protected other than on the Tiwi Islands. It also suggests that, on a Territory-wide scale, the current reservation level of unit 18 (*Eucalyptus papuana-E. polycarpa* woodland) is inadequate.

There are no formal conservation reserves on the Tiwi Islands themselves. In part, this recognises an implicit assumption that the Tiwi conservation values are being appropriately managed and retained through the Islands-wide imposition of long-standing traditional ways of looking after country, such that the formal declaration of parts of the Islands as reserve may appear unnecessary, superfluous and artificial. This assumption may not remain valid if extensive developments proceed. Section 7 of this report discusses options for mechanisms for the retention of conservation areas on the Tiwi Islands.

1.4. Previous biodiversity documentation

As noted above, the existing documentation of the biodiversity and environments of the Tiwi Islands is meagre, and especially so given their size and ecological significance.

Some of the intimate knowledge of their environment held by Tiwi people has been documented in Anon (1998) and in Wightman *et al*. (in press).

European knowledge of Tiwi environments is generally thin and fragmentary. A phase of wildlife collection around the turn of the nineteenth century (e.g. Holtze 1891, J.P. Rogers in 1911-1912 and W.D. Dodd in 1914) fuelled the description of many bird and mammal species, forms considered then to be restricted to the Tiwi Islands (Thomas 1913, 1921; Mathews 1914; Zietz 1914*a,*b). With more circumspect consideration of taxonomic boundaries, and more knowledge of variation and distribution of species across northern Australia generally, most of these supposed Tiwi-endemic species have been dismissed (Walton 1988; Mason and Schodde 1997; Schodde and Mason 1999).

Other than limited opportunistic collection of "unusual" specimens by Europeans associated with the Nguiu mission, and occasional brief notes (Dodd 1935; Goodfellow 1935; Hayman 1936; Harney and Elkin 1943), the Tiwi Islands were then largely ignored biologically until proposals for plantation forestry in the 1960s.

The development of forestry fuelled 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.

Coincident with the detailed ecological studies on the Tiwi eucalypt forests by Fensham and Wilson, Russell-Smith (1991) undertook floristic inventories of 98 rainforest patches on the Tiwi Islands, as part of a survey of Territory rainforest communities generally, and demonstrated that Tiwi rainforests included some assemblages that were generally distinct from those of the mainland. 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.

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).

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).

Modern studies of the Tiwi fauna have been less comprehensive. Invertebrates in particular have been poorly sampled. The only systematic surveys 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. 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". Invertebrate species which are known only from the Tiwi Islands include the dragonflies *Nososticta taracumbi* and *Huonia melvillensis* (Brown 1998; Brown and Theischinger 1998).

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. No fish species is endemic to the Tiwi Islands.

The frog fauna of Melville Island was 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). No frog taxon is endemic to the Tiwi Islands.

The reptile fauna known from the Tiwi Islands is listed in Fensham and Woinarski (1992) and Woinarski (1998), although this listing is 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 (R. Chatto *unpubl*.). No reptile species is known to be endemic to the Tiwi Islands.

The bird fauna of the Tiwi Islands has been 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 have been sampled, mainly in a series of aerial surveys by R. Chatto (unpubl.)

Five subspecies of birds were accepted as restricted to the Tiwi Islands by Mason and Schodde (1997) – of masked owl *Tyto novaehollandiae melvillensis*, striated pardalote *Pardalotus striatus melvillensis*, weebill *Smicrornis brevirostris melvillensis*, yellow-tinted honeyeater *Lichenostomus flavescens melvillensis* and brown honeyeater *Lichmera indistincta melvillensis*. Subsequently, Schodde and Mason (1999) recognised all these as valid except for the weebill, and also accepted the validity of a Tiwi-endemic subspecies of hooded robin *Melanodryas cucullata melvillensis*.

The mammal fauna of the Tiwi Islands is reported in Fensham and Woinarski (1992) and Woinarski (1998), although this listing is 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). As with birds, many mammal species and subspecies have been described as restricted to the Tiwi Islands, although most are no longer recognised as such. Only two valid mammal taxa are now considered to be endemic – subspecies of brush-tailed rabbit-rat *Conilurus penicillatus melibius* and black-footed tree-rat *Mesembriomys gouldii melvillensis*.

The feral mammals of the Tiwi Islands (pig, water buffalo, horse and cattle) have been surveyed as part of a Territory-wide aerial survey in 1985 (Bayliss 1985). The water buffalo is not present on Bathurst Island, but reaches very high densities (exceeding 10 individuals/km^2) on Melville Island, particularly in the south-east. Feral pigs are common on Bathurst island, but absent on Melville Island.

Biodiversity conservation issues on the Tiwi islands have been considered by Fensham and Woinarski (1992) and Anon (1998). Fensham and Cowie (1998) considered the threats posed by potentially or recently colonising weeds (principally mission grass *Pennisetum polystachion* and hyptis *Hyptis suaveolens*). Biodiversity issues associated with the development of *Acacia* plantations were considered generally in ForSci (1999), in responses to that assessment (Department of Lands, Planning and Environment 1999), and in specific assessments of a plantation development proposal of 2700 ha (Brock *et al*. 2000).

1.5. Guidelines and obligations in conservation planning

A range of international, national and Territory initiatives, strategies and legislation relates to, and gives direction to, planning for biodiversity conservation.

These include the:

- Japan-Australia Migratory Bird Agreement (JAMBA, 1974);

- Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention, 1979);
- China- Australia Migratory Bird Agreement (CAMBA, 1986);
- National Strategy for Ecologically Sustainable Development (December 1992);
- Australian National Strategy for the Conservation of Australian Species and Communities Threatened with Extinction (Endangered Species Advisory Committee 1992);
- National Forests Policy Statement 1992;
- Nationally Agreed Criteria for the establishment of a comprehensive, adequate and representative reserve system for forests in Australia (JANIS 1996);
- National Strategy for the Conservation of Australia's Biological Diversity 1996;
- Northern Territory Parks Masterplan 1997;
- National Greenhouse Strategy 1998;
- National Principles and Guidelines for Rangeland Management (Australian & New Zealand Environment and Conservation Council [ANZECC], and Agriculture & Resource Management Council of Australia & New Zealand [ARMCANZ] 1999);
- Australian guidelines for establishing the National Reserve System (ANZECC 1999);
- Natural Heritage Trust – Agreed special circumstances affecting land and resource administration in the Northern Territory (1999);
- National Framework for the management and monitoring of Australia's native vegetation (ANZECC 1999); and the
- Strategy for Conservation of the Biological Diversity of Wetlands in the Northern Territory of Australia (2000)

Of most relevance for conservation planning on the Tiwi Islands, these strategies and initiatives include commitments to

- **the establishment of a comprehensive, adequate and representative conservation reserve system**. For forest environments, this system should include at least 15% of the area of all forest types (recognised at the 1:100,000 or 1:250,000 scale), and far higher proportions of forest types recognised as vulnerable or endangered. For other ecosystems generally, reservation should be sufficient to "provide ecological viability and integrity" (NRS guidelines).
- **particular attention to, and obligation for, the conservation needs of threatened species and environments**;
- **particular attention to, and obligation for, the conservation needs of migratory species (and especially birds)**;
- **consideration of the landscape setting of the reserve system**, most notably in the provision of corridors between reserves;
- **bioregional planning, which seeks *inter alia* to co-ordinate and encourage cooperation in conservation management across all tenures**;
- **maintenance of the native forest cover** ("the Governments will adopt the policy that further clearing of public native forests for non-forest use or plantation establishment will be avoided or limited, consistent with ecologically sustainable management, to those instances in which regional conservation and catchment management objectives are not compromised", – NFPS);

- **implementation and encouragement of conservation mechanisms and actions off-reserve**, including the incorporation of biodiversity conservation objectives into property management planning, recognition that landholders have a "duty of care" obligation for the sustainable management of native vegetation on lands for which they are responsible, and that incentives should be provided for public conservation services additional to this fundamental duty of care.
- **continual review of the impact of agricultural and pastoral management activities on biological diversity** and seeking changes where appropriate (Biodiversity Strategy);
- **control of the introduction and spread of introduced species** with emphasis given to "(a) assessing the types and levels of impacts and the likely extent of harm to native biological diversity; (b) increasing risk assessment studies of potential impacts on biological diversity of species introduced for commercial, scientific and other purposes" (Biodiversity Strategy), and prevention of the development of new weed and pest problems.
- **reduction in the adverse impacts of altered fire regimes on biological diversity**;
- **maintenance and enhancement of the ecological integrity and physical stability of ground and surface water systems**, including associated riparian zones and wetlands; protection and rehabilitation of lowland wetlands and saltmarshes.

and recognition that:

- the absence of scientific certainty should not be used to forestall prudent conservation actions;
- "investment in actions that seek to avoid emergence of unsustainable practices and so prevent severe damage of landscapes and their ecological function will generate greater economic and environmental returns to the Territory community than will belated, expensive and often ineffectual attempts at rehabilitation" (NHT – NT special circumstances).

Extracts from three of the most relevant national forest strategies and initiatives are attached in Appendix B.

Much of this body of commitments was given legislative power in the recent federal *Environment Protection and Biodiversity Conservation Act 1999*, which *inter alia* defines the Commonwealth's role in the assessment of actions likely to have environmental impact. That Act commits a Commonwealth assessment and approval process for matters of identified national significance, defined to include World Heritage properties, Ramsar wetlands, nationally threatened species and ecological communities, migratory species, Commonwealth marine areas and nuclear actions. Appendix B includes a summary of operational guidelines for the assessment of the significance of any impact upon these matters.

At a Territory level, the most relevant conservation planning legislation is included within current amendments to the *Territory Parks and Wildlife Conservation Act*. These amendments include an obligation to classify the conservation status of all NT species, and define the power to declare any area as *essential habitat*, necessary for the

maintenance of one or more species. The relevant sections of this Bill are included in Appendix C.

Some target criteria for conservation planning on the Tiwi Islands can be drawn from this body of strategies, agreements and legislation. Our interpretation is that these should include the set listed in Box 1.

These are very conservative criteria, and reflect the focus of most national strategies on forested areas of southern and eastern Australia, where priority is forced by the generally highly fragmented and substantially reduced forest estate, and where the bulk of native forests is held in public lands. The national forest goals and guidelines do not apply so well for the Tiwi Islands (and many other parts of the northern half of the Northern Territory), where all forests are in private lands, and where retention of 15% of forest cover would represent a major loss of biodiversity from that held within the current extent of 90 to 100% of the original forest extent.

Box 1. Conservation planning criteria derived from international, national and Territory strategies, initiatives and legislation

- A minimum of 15% of every forest type (recognised at at least 1:250,000 scale) should be maintained.
- Preferably this retained forest should be incorporated in some formal conservation reserve system.
- There should be no ecologically significant reduction in the population (or viability) of any nationally recognised threatened plant or animal taxon, nor of the condition of the main habitats of these.
- There should be no ecologically significant reduction in the population (or viability) of any listed migratory animal taxon, nor of the condition of the main habitats of these.
- There should be no ecologically significant reduction in the value or viability of aquatic systems, especially those of riparian areas and wetlands.
- Development which leads to the regional loss of any species or community is by definition not ecologically sustainable and hence should not be approved.

2.COLLATION & COLLECTION OF BIODIVERSITY INFORMATION

2.1. Collation of existing information: species records

As noted in Section 1.4 above, there is only very limited published information on biodiversity of the Tiwi Islands. For conservation planning, the utility of data is related largely to locational precision and the extent of systematic sampling. Unfortunately, much of the early documentation of Tiwi biodiversity is geographically imprecise (with records typically noting only "Melville Island" as location) and lacks information on habitat or abundance. While these early records now have diminished value, they do provide some context and contribution to the basic inventory of the Islands' biodiversity.

The more useful data sets for conservation planning are listed in Table 2 below, and their coverage is mapped in Figs. 3 and 4 (following).

There are some notable caveats in the interpretation of most of these data sets.

- The locational information for all data sets originating before about 1995 is generally lacking tight precision.
- The nomenclature used, especially for plants, has been variable, and there have been some major taxonomic changes since some of the data sets were collected. Wherever possible, we have updated and standardised this nomenclature - to that of Dunlop *et al*. (1995) for plants, Christidis and Boles (1994) and Schodde and Mason (1999) for birds, Cogger (2000) for reptiles and frogs, and Strahan (1995) for mammals.
- Some quadrat-based data sets, especially for plants, are far from comprehensive (e.g. recording only woody plants), and hence the non-recording of a particular species at a particular sampled site can't be interpreted unambiguously as an absence.
- There is generally a major geographic bias in data collection, with most records from the western half of Melville Island.
- The environmental information accompanying species records has been especially variable and inconsistent. Some data bases have no associated environmental data. In general, the inconsistencies in sample variables (and the ways in which these were measured) preclude the amalgamation of these across data sets.

These data sets were generally in idiosyncratic filing systems. All have now been collated to a consistent format (accessible either in Foxpro or Excel).

Table 2: The main data sets available for records of plants and animals on the Tiwi islands.

(i) Plants

data set	no. of sites	no. of records	taxa recorded	quadrat-based?	period	locational precision	reference
rainforest patches	118	7213	all plant species	N	1989-92	+/- 100m	Russell-Smith (1991); Fensham & Woinarski (1992)
NT 1:1,000,000 vegetation map	62	1156	all plant species (but generally incomplete)	Y	1987-91	+/- 500m	Wilson *et al*. (1990)
"treeless plain" – forest boundary	123	2930	all plant species	Y	1988-90	data lost	Wilson (1991)
eucalypt forest composition	193	5271	all plant species	Y	1988-90	+/- 100m	Fensham (1990)
this survey	204	1131	mostly woody species	Y	2000	+/- 10m	
herbarium and AMRAD quadrats	270	4410	all plant species	Y	1995+	+/- 10m	NT Herbarium
weeds	50	741	all plant species	Y	1988-92	+/- 100m	Fensham & Woinarski (1992); Fensham & Cowie (1998)
flora atlas/herbarium records	-	4249*	individual records of individual species	N	19th century on	variable	NT Herbarium

* note that this includes some duplication with the other data bases listed (e.g. where herbarium specimens were collected from sample sites).

(ii) Vertebrates

data set	no. of sites	no. of records	taxa recorded	quadrat-based?	period	locational precision	reference
rainforest patches (and adjacent habitats)	97	1708	frogs, reptiles, birds, mammals	Y	1990-92	+/- 100 m	Fensham & Woinarski (1992)
aquatic habitats (and adjacent areas)	38	183	reptiles, mammals	Y	October 1996	+/- 10m	Horner & Griffiths (1998)
CSIRO birds	-	268	birds	N	October 1996	+/- 1 km	Mason & Schodde (1997)
this survey	204	4519	frogs, reptiles, birds, mammals	Y	31/1/00 –7/2/00; 1/7/00 - 27/9/00	+/- 10 m	
Birds Australia bird atlas	6	149	birds	Y?	1998-2000	+/- 100 m	-
fauna atlas	-	806*	individual records of individual spp.	N	19th century on	variable, from +/- 10 m to +/- 20 km	-

* note that this includes some duplication with the other data bases listed (e.g. where museum specimens were collected from sample sites).

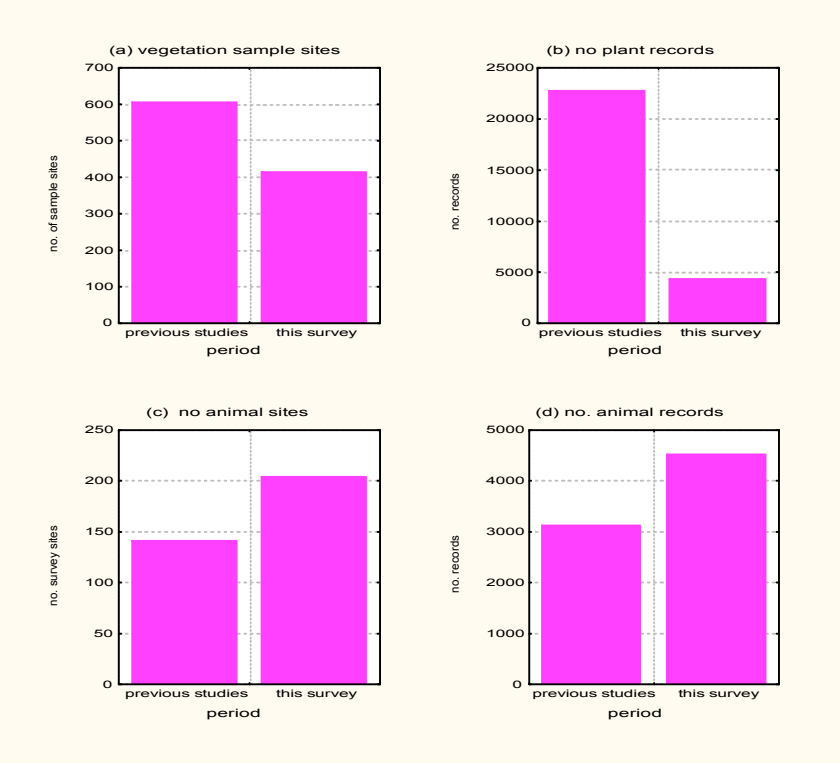
2.2. Collection of additional plant and animal records: this study.

Recognising the deficiencies in existing biodiversity information from the Tiwi Islands, a main objective of this study was to sample biota as comprehensively and intensively as possible, within the tight confines of a commencement date of 1 July 2000 and a final reporting date of 31 October 2000.

Fieldwork was undertaken continuously over the period 1 July to 29 September (for a total of 355 person-days), and included sampling of plants and vertebrate animals in 185 quadrats (each sampled over a 3 night period). Sampling was stratified to attempt to cover as much of Melville Island as was accessible (Fig. 5), and to sample the environmental range present (albeit with a bias towards eucalypt forests, the likely target habitat of plantation development). Sampling methodology generally followed now standard practice used for wildlife survey by Parks and Wildlife Commission of the Northern Territory (see Appendix C), and hence was consistent with 19 quadrats sampled by us on Melville Island in February 2000 (Brock *et al*. 2000).

This sampling produced 4519 records of vertebrates from quadrats, with a further 524 geo-coded incidental vertebrate records, 1131 records of plants from those quadrats, and a further 3244 records of plants from 209 quadrats sampled this year by PWCNT Herbarium staff (included within "herbarium and AMRAD quadrats" in Table 2). This survey effort substantially increased the amount of information documented for Tiwi biota, and especially so for vertebrate animals (Fig. 6).

Figure 6. Number of samples and records from this survey and collations of previous studies. (nb tallies for this study exclude incidental records).



Species added during this study to those previously known from the Tiwi Islands included the brush-tailed phascogale *Phascogale tapoatafa* and the whip snake *Demansia simplex*.

Species lists derived from the current survey and collation of previous records are included in Appendices G and H. These list a total of 339 vertebrate species (39 native mammals, 5 feral mammals, 210 birds, 69 reptiles and 16 amphibians) and 1192 plant species from the Tiwi Islands.

More detailed information on individual species of conservation significance is given in Section 5 of this report.

2.3. Collation of existing information: environmental layers

There are few accessible and useful environmental coverages of the Tiwi Islands. Characteristics of coverages are listed below.

- *Northern Territory vegetation map*. A GIS coverage of the 1:1,000,000 Northern Territory vegetation map (Wilson *et al*. 1990) is available (Fig. 2), but of very limited use for this study because of the coarse scale.
- *Northern Territory rainforest map*. Rainforests occurring in the Top End of the Northern Territory were mapped from aerial photography (at scales between 1: 15,000 and 1: 80,000), then scanned and digitised by Russell-Smith and Lucas (in Russell-Smith *et al*. 1992). Mapped rainforests were broadly categorised into "wet" (generally spring-based or riparian) and "dry" (mostly on sheltered drop-off areas). The coverage is illustrated in Fig. 7.
- *Surficial geology*. A 1:250,000 coverage of surficial geology has been produced by the Department of National Resources Bureau of Mineral Resources , Geology and Geophysics (sheet SC 52-15 and SC 52-16) (Fig. 8). This is a coarse coverage, and is known to contain some inaccuracies (Trevor Haig, DLPE *pers. comm*.). In part, such inaccuracies are now being corrected by the Water Resources Division of Department of Lands Planning & Environment.
- *Climate*. A national coverage of 16 climatic variables was considered (ANUCLIM). Generally, these show little variation across the islands, and the extrapolative accuracy of any such variation is hampered by the concentration of the few meteorological stations on the west of Melville Island and the facing east coast of Bathurst Island. The most usable coverage is that of annual rainfall, which is illustrated in Fig. 9.
- *Forest types*. A 1:250,000 "forest type" map was compiled for the Tiwi Islands in 1978 by the Forestry Section of the Forestry, Fisheries & Land Conservation Branch of the Department of the Northern Territory, but only a hard copy was available for this study (it is currently being scanned and digitised by the Department of Lands Planning and Environment). The coverage is of limited use, as it classifies and maps only five native vegetation types anyway, and there is now little information on its derivation.
- *Land unit and land system mapping*. Hard-copy land unit maps of relatively small parts of western Melville Island were developed by van Cuylenburg and Dunlop (1973) and Wells and van Cuylenburg (1978) at scales ranging from 1:16,000 to 1:50,000, and a coarser-scale (1:100,000) map of land systems for the western half of Melville Island was produced by Wells *et al*. (1978). These coverages are currently being scanned and digitised by the Department of Lands Planning and Environment.

- *Melaleuca*. A 1:100,000 scale GIS-based coverage of *Melaleuca*–dominated vegetation was developed by Brocklehurst and Lynch, derived mainly from interpretation of aerial photography. This coverage is illustrated in Fig. 7.
- *Generalised vegetation types*. Brocklehurst (1998) collated many of the above coverages into a composite 1:250,000 map of "generalised vegetation types" for the Tiwi Islands. This coverage was not made available to us by the Department of Lands Planning and Environment in time for inclusion in this report.
- *Topography*. The only publicly available topographic layer for the Tiwi Islands is a 9 second Digital Elevation Model, which is illustrated in Fig. 10. This scale is generally too coarse for biodiversity planning and distributional modelling. The Department of Defence holds a 3 second Digital Elevation Terrain Model, which is at appropriate scale, but this was not made available to us in time for this report.

2.4. Vegetation mapping

Three Landsat satellite scenes (Path/Row 105/68) were examined for this exercise. These datasets were acquired in the early dry season for the years 1990, 1995 and 1999. Due to the presence of large amounts of cloud cover and extensive fire scarring on the 1990 and 1999 datasets, the 1995 image was used as a basis for a landcover map of both Melville and Bathurst Islands.

Initially a topographic base map was constructed for the Tiwi Islands from 19 1:50,000 scanned raster mapsheets. The 1995 Landsat Image was rectified and co-registered to this base map to ensure a high degree of spatial accuracy. Areas containing pine forest plantation, and areas covered by cloud on the eastern side of Melville Island were masked from this rectified dataset. An unsupervised classification was run on all 7 image bands using ER Mapper's isoclass algorithm, yielding 155 unique spectral classes. The mean class value in each of the 7 bands was used to construct a dendrogram using classification modules in PATN. These 155 spectral classes could then be grouped into broader vegetation/landcover types using this dendrogram in conjuction with field data points displayed on the classified dataset in a GIS. An identical process was used to classify those areas masked out as cloud on the 1995 dataset using the 1999 image.

This methodology enabled the stratification of the classified image into seven broad categories: mangal forest (mangroves); dense forest; open forest; open country; samphire; rainforest; and swamp/drainage floors.

Previous mapping of rainforests by Russell-Smith and Lucas (*unpubl.*) and Melaleuca dominated communities by Brocklehurst and Lynch (*unpubl*.) was incorporated into to highlight such communities not well defined in the classification process.

This image classification was then vectorised to reduce the number of small polygons and enable manual separation of treeless plains and *Eucalyptus oligantha* woodlands from spectrally similar woodland / open woodland communities generally. Built up areas and pine plantations were also appended to the vectorised map to provide a complete coverage of all land use types.

2.5. Distributional modelling of particular species of conservation significance

While the distribution of particular vegetation types can be relatively easily circumscribed through interpretation of imagery, such is generally not the case for

particular species of plants or animals. Estimation of the range of wildlife species is derived by extrapolation from samples, based on comparison of environmental factors at sites where the species is known to occur and those where it is presumed not to occur. This modelling becomes increasingly reliable with increase in:

- the number of samples,
- the extent of environmental stratification of those samples,
- the number of samples from which the species is recorded,
- the probability of detection if present at a sampled site,
- the sedentariness of the species;
- the extent of specificity in habitat choice,
- the extent to which environmental variables that were measured relate to aspects that are critical in the species' assessment of habitat suitability, and
- the extent to which these environmental variables can be mapped with appropriate resolution.

Where these factors are favourable, distributional modelling provides a powerful estimation of the actual distribution (and spatial variation in relative abundance). Where unfavourable, the models may be misleading, and the only information that can be used with confidence is the recording or not recording of the species at sampled sites, which are typically small pinpricks in a broad landscape.

We seek to provide distributional models for all species deemed to be of conservation significance (as defined in Section 3). The models are all based on our quadrat sampling, supplemented by data from the few previous studies which used analogous sampling (e.g. Horner and Griffiths (1998) samples, for frogs, reptiles and mammals). To limit the problem of slight variation in sampling procedure between these studies, we reduce abundance data to presence/absence. We then use generalised linear modelling (Crawley 1993) to relate the probability of occurrence of a species to a small set of readily mappable environmental factors (vegetation type, topographic variation, geology, annual rainfall, values for each of Landsat bands 4 to 7, the first principal component of Landsat bands 1-3, distance to the nearest rainforest patch, distance to the nearest *Melaleuca* forest, and image-derived measure of water availability (NDVI)).

3. TIWI ISLANDS VEGETATION CLASSIFICATION AND MAPPING

A summary vegetation map for the Tiwi Islands is given in Figure 11 (following page 18). Twelve vegetation (landcover) types were recognised (Table 3), which are described in greater detail in Appendix E.

This classification is not yet as floristically crisp nor fine as we sought. The two main images that we worked off were flawed in that the 1999 image showed substantial areas (>20% of the Islands area) which had been recently burnt, and the 1995 image had about 10% of the Islands area covered by cloud. Some floristically and structurally distinct communities (most notably treeless plains and *Eucalyptus bleeseri* open forests with low open understorey) were effectively indistinguishable from the interpretation of the image alone. We were unable to access in time the fine detail topographic coverage, which would have provided a tool for the resolution of such ambiguity.

Hence our vegetation coverage should be treated as a working draft, which is supported by a considerable data base of site-specific vegetation information. With the imminent availability of finer resolution topographic information, and with a little additional field verification, this draft could be refined relatively easily.

These interpretational and classificationary problems are founded largely in the characteristics of the Tiwi landforms generally. With a few obvious exceptions there are no major contrasts and abrupt discontinuities in the Tiwi landscapes - variation is typically subdued, gradual and intricate (Fensham 1993*b*). Certainly, mangroves and monsoon rainforest patches are markedly distinct: but most of the rest of the Islands area comprises subtle variations on a dominant theme of eucalypt open forests, among which spatial changes in structural characteristics may be determined more by recent patterns of fire than by underlying edaphic differences. Differences in dominant tree species composition may not match well differences in understorey composition or amount (Fensham and Kirkpatrick 1992; Fensham and Bowman 1992; Wilson and Fensham 1994), and floristic variation may correspond very poorly with demaractaion of land units (Wilson and Fensham 1994).

Table 3. **Vegetation types on the Tiwi Islands, and their relative extent.**

class	description	area (km^2)		
		Bathurst	**Melville**	**total**
wet rainforest	floristically diverse tall closed forests around springs and some sheltered watercourses.	4.4	21.7	26.1
dry rainforest	coastal thickets and dry slopes of broken plateau edge	29.7	102.8	132.5
mangroves	tall dense forests to low open woodlands in tidally inundated coastal areas, with a range of dominant species including *Sonneratia alba, Rhizophora stylosa, Bruguiera parviflora, Xylocarpus mekongensis* and *Ceriops tagal*.	275.6	515.8	791.4
sand & salt	typically saline coastal areas intermixed	14.8	115.5	130.3

flats	with mangals, and supporting no vegetation, coastal dunefields, or grasslands dominated by *Sporobolus virginicus*.			
sedgelands & grasslands	mostly seasonally indundated areas, typically dominated by *Eleocharis dulcis* and *Scirpus litoralis*.	13.2	159.7	172.9
Melaleuca open forests	forests dominated by a range of *Melaleuca* spp. (typically including *M. leucadendra* and *M. viridiflora*) in riparian areas and swamplands	13.7	47.1	60.8
Melaleuca low woodlands	low woodlands or shrublands typically on poorly drained sites, dominated by *M. nervosa* and/or *M. viridiflora*	3.8	12.5	16.3
treeless plains	low open woodlands typically dominated by *Acacia* spp., *Grevillea pteridifolia* and *Banksia dentata*	22.1	160.7	182.8
eucalypt forest (dense)	tall forest dominated by *Eucalyptus miniata, E. tetrodonta* and/or *E. nesophila* (often with ironwood *Erythrophleum chlorostachys* subdominant), typically with dense tall understorey (variably including *Acacia* spp., *Gronophyllum*, *Livistona*); also including smaller areas of *Lophostemon lactifluus* and *Eucalyptus ptychocarpa* in drainage lines	610.0	1384.5	1994.5
eucalypt forest (mid-open)	tall forest dominated by *Eucalyptus miniata, E. tetrodonta* and/or *E. nesophila*, typically with grassy understorey	477.7	2130.9	2608.6
eucalypt forest (open)	forest typically dominated by *Eucalyptus bleeseri* with open grassy understorey	152.6	873.5	1026.1
eucalypt woodland	woodland dominated by *Eucalyptus oligantha* or *E. latifolia* or *E. alba* with grass understorey	0	94.8	94.8
plantations		{0?}	78.9	78.9
built-up area		19.5	6.2	25.7

This analysis illustrates the dominant extent of eucalypt forests and woodlands, with such formations comprising a total of 5725km^2 (76% of the total area of the Tiwi Islands). Our estimates of the extent of different vegetation types vary somewhat from those given in ForSci (1998) (Appendix E).

4. IDENTIFICATION OF CONSERVATION VALUES

4.1. Listed threatened animals

There have been many reviews of the conservation status of Australian wildlife. Such categorisation provides a measure of priorities for management and for the assessment of impacts of proposed land uses. Where these lists are annexed to legislation (such as in the federal *Environment Protection and Biodiversity Conservation Act 1999* and the *Territory Parks and Wildlife Conservation Amendment Act 2000*), they provide an explicit linkage for triggering particular actions or assessment. Lists are updated regularly to reflect increased knowledge, changes in conservation security, and trends in abundance. Here we collate current listings for Tiwi terrestrial vertebrate species. The lists we use are (i) the annexes to the *Environment Protection and Biodiversity Conservation Act 1999*; (ii) the current national list accepted by ANZECC; and (iii) the proposed list of conservation status of Northern Territory wildlife, appended to the *Territory Parks and Wildlife Conservation Amendment Act 2000*. In addition we include the classifications given in the recent national revision of *The Action Plan for Australian Birds* (Garnett 2000) and *The Action Plan for Australian Bats* (Duncan *et al*. 1999), which may be expected to be used for ongoing revisions to the above listings. Note that all five of these lists use the assessment protocol recommended as the international standard by IUCN (1994), which involves a series of at least semi-quantitative criteria. This protocol includes the classes:

- **Critically Endangered**, when the taxon "is facing an extremely high risk of extinction in the wild in the immediate future";
- **Endangered**, when the taxon "is facing a very high risk of extinction in the wild in the near future";
- **Vulnerable**, when the taxon "is facing a high risk of extinction in the wild in the medium-term future";
- **Lower Risk**, and
- **Data Deficient**, when there is "inadequate information to make a direct, or indirect, assessment of its risk to extinction based on its distribution and/or population status … listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate".

Of these categories, only Endangered and Vulnerable are included in the ANZECC and EPBCA lists.

Terrestrial vertebrates which have been recorded from the Tiwi Islands and which are listed as threatened are given in Table 4.

Table 4. List of Tiwi terrestrial vertebrate taxa which have been classified as threatened.
Listings: EPBCA=annexes to the *Environment Protection and Biodiversity Conservation Act 1999*; ANZECC=xxxx; TPWCA=listings proposed as Appendices to the *Territory Parks and Wildlife Conservation Amendment Act 2000*; Bird plan=Garnett (2000); Bat plan=Duncan *et al*. (1999).
Threatened category: CR=critically endangered; E=endangered; V=vulnerable; DD=data deficient; lr=lower risk.

taxon	EPBCA	ANZECC	TPWCA	Bird plan	Bat plan
butler's dunnart *Sminthopsis butleri*	V	V	V	-	-
bare-rumped sheathtail-bat *Saccolaimus saccolaimus nudicluniatus*	lr	lr	DD	-	CR
little north-western freetail bat *Mormopterus loriae cobourgiana*	lr	lr	lr	-	DD
brush-tailed rabbit-rat *Conilurus penicillatus*	lr	lr	V	-	-
false water-rat *Xeromys myoides*	V	V	lr	-	-
chestnut-backed button-quail *Turnix castanota*	lr	lr	DD	lr	-
red goshawk *Erythrotriorchis radiatus*	V	V	V	V	-
partridge pigeon (eastern subspecies) *Geophaps smithiii smithii*	V	V	lr	lr	-
masked owl (Melville Island subspecies) *Tyto novaehollandiae melvillensis*	V	V	E	E	-
hooded robin (Tiwi Islands subspecies) *Melanodryas cucullata melvillensis*	lr	lr	lr	V	-
taipan *Oxyuranus scutellatus*	lr	lr	DD	-	-

Categorisation of these taxa is identical for the ANZECC and EPBCA lists, but there is substantial divergence between these and the other listings.

- all relevant lists classify butler's dunnart and red goshawk as Vulnerable;
- there are insufficient records of the bare-rumped sheathtail-bat in the Northern Territory to assign it any categorisation here other than DD, but the most significant categorisation given in Duncan *et al*. (1999) contrasts with a lack of listing federally;
- the relatively few records of the little north-western freetail bat prompted a DD classification in Duncan *et al*. (1999), but no other listing regarded this species as threatened;
- the brush-tailed rabbit-rat has declined substantially in the Northern Territory (Woinarski 2000), which justifies a threatened listing at this level, but it is still abundant in the Kimberley;
- the false water-rat is listed nationally as Vulnerable, but is judged to be relatively widespread and under no immediate threat in the Territory (Woinarski 2000; Woinarski *et al*. 2000);
- the chestnut-backed button-quail is poorly known, and with a suggestion of decline in the Territory;
- the threatened status of partridge pigeon is equivocal, depending upon interpretation of extent and recency of decline and size of the remaining population;
- the Tiwi Island subspecies of masked owl is consistently recognised as at least Vulnerable, but the most recent analyses of status (the TPWCA and *Action Plan for Birds* lists) upgrade this status to Endangered, to reflect possible loss of prime habitat due to forestry operations;
- the Tiwi Island subspecies of hooded robin has only recently been re-recognised (Schodde and Mason 199). Its patchy occurrence, apparent rarity, small total range, and consistent pattern of decline for the species generally justify Vulnerable status;
- there are too few records of the taipan in the Northern Territory to assign it to any category other than DD; however it remains reasonably common elsewhere so is not listed as threatened nationally.

4.2. Listed threatened and protected plants

There are three lists of threatened plants relevant to the Tiwi Islands – that of the annexes to the national *Environment Protection and Biodiversity Conservation Act 1999*; that of protected or specially protected plants under the current *Territory Parks and Wildlife Conservation Act*; and that proposed as an annexe to the forthcoming *Territory Parks and Wildlife Conservation Amendment Act 2000*. Table 5 summarises Tiwi plants in these lists.

Additional to these species attached to legislation, Leach *et* al. (1992) provides a comprehensive listing of the conservation status of all Northern Territory plants. This listing is now dated, and revised categorisations of conservation status are given in the Tiwi plant species list attached here as Appendix G. Note that in most cases, species classed as threatened here are also included as threatened on the annexes to the *Territory Parks and Wildlife Conservation Amendment Act 2000*.

For many Tiwi plant species there is very little information available from which to assess status. With more knowledge, some Tiwi species now listed as threatened may be shown to be widespread and common; alternatively, some species now known from a few locations may actually be restricted to those locations, and an upgrading of their conservation status may be warranted. In many cases, the conservation status of Tiwi plant species may have been assumed to be secure, largely on the basis of lack of apparent threats. For species occurring in habitats or areas proposed for conversion to *Acacia mangium* plantations, this land-use change may be sufficient to justify upgrading of conservation status.

Table 5. Threatened and/or explicitly protected plants recorded from the Tiwi Islands, based on annexes in the *Environment Protection and Biodiversity Conservation Act 1999* (EPBCA), current regulations in the *Territory Parks and Wildlife Conservation Act* (TPWCA) and proposed listings under the *Territory Parks and Wildlife Conservation Amendment Act 2000* (TPWCA Amendments).

species	EPBCA	TPWCA	TPWCA Amendments
Burmannia sp. DNA61177 'Melville Island'	endangered		endangered
Calochilus caeruleus		protected	vulnerable
Calochilus holtzei		protected	
Cerbera manghas			vulnerable
Cycas armstrongii		protected	vulnerable
Cycas maconochiei var *maconochiei*		protected	vulnerable
Cymbidium canaliculatum		protected	
Dendrobium affine		protected	
Dendrobium canaliculatum		protected	
Dendrobium trilamellatum		protected	vulnerable
Didymoplexis pallens		protected	
Dipodium stenocheilum		protected	
Elaeocarpus miegei			endangered
Eleocharis geniculata		specially protected	
Freycinetia percostata			vulnerable
Geodorum neocaledonicum		protected	
Habenaria ferdinandi		protected	
Habenaria hymenophylla		protected	
Habenaria ochroleuca		protected	
Habenaria triplonema		protected	
Hedyotis auricularia			vulnerable
Hoya australis var *oramicola*			vulnerable
Liparis habenarina		protected	
Luisia teretifolia		protected	vulnerable
Malaxis acuminata		protected	
Mapania macrocephala			vulnerable
Nervilia D2882		protected	
Nervilia peltata		protected	
Thrixspermum congestum		protected	vulnerable
Tropidia curculigoides		protected	vulnerable

4.3. Tiwi-endemic animals

For any land mass (such as the Tiwi Islands), isolation over a period of around 10,000 years (with many periods of isolation preceding that), will have contributed to genetic divergence from mainland populations among resident plants and animals. The extent of this divergence is related to the island size, population size, generation time, environmental factors, and random processes. Divergence between populations on the Tiwi Islands and mainland is likely to have been promoted further by the location of the Tiwi Islands in area with appreciably higher rainfall than the mainland.

For some Tiwi plants and animals, the extent of this divergence is sufficient to recognise the Tiwi populations as taxonomically distinct. However, as noted in Section 1.4. above, taxonomic inconstancy has led to very variable assessments of the number of vertebrate taxa that are considered endemic to the Tiwi Islands. For invertebrate taxa, lack of collecting has led to very uncertain distributional bounds, and hence difficulties in judging the extent of endemism.

Endemism is an important component of conservation planning, because endemic taxa have no options for protection elsewhere. The animal taxa now regarded as restricted to the Tiwi Islands are listed in Table 6.

Table 6. Animal taxa which are considered endemic to the Tiwi Islands.
(a) 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*	Schodde and Mason (1999)
hooded robin *Melanodryas cucullata melvillensis*	
striated pardalote *Pardalotus striatus melvillensis*	
yellow-tinted honeyeater *Lichenostomus flavescens melvillensis*	
brown honeyeater *Lichmera indistincta melvillensis*	

(b) 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)	

4.4. Tiwi-endemic plants

Plant species which have been recorded nowhere else in the world other than on the Tiwi Islands are listed in Table 7 (a). Those known in the Northern Territory only from the Tiwi Islands (i.e. with some occurrence beyond the NT) are listed in Table 7 (b).

Table 7. Plants which are endemic to the Tiwi Islands.
(a) Plant species occurring only on the Tiwi islands

species	**Taxonomic authority**	**previous names**
Typhonium jonesii		
Typhonium mirabile	Hay (1992)	*Lazarum mirabile*
Lindernia cowiei	Barker (1998)	
Desmodium tiwiense		
Burmannia sp. DNA61177 'Melville Island'		
Mitrella D24710 'Melville Island'		*Desmos* sp. DNA30151; *Desmos* sp. D24710
Embelia sp. DNA 48980		
Parsonsia sp.DNA 30178 'Melville Island'		
Miliusa sp. D30127		
Spermacoce D132770 Piper Head		

(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**	**notes**
Garcinia warreni	-	Qld	
Tarennoidea wallichii	Malesia	Y	
Elaeocarpus miegei	Malesia; New Guinea	-	
Acmenosperma claviflorum	Malesia	Qld	
Dendromyza reinwardtiana	Malesia	Qld	
Endiandra limnophila	-	Qld	
Hoya australis var. *oramicola*	?	?	
Litsea breviumbellata	-	Qld	
Scleria carphiformis	-	Qld	
Calochilus caeruleus	New Guinea	WA, Qld.	
Strychnos minor	Malesia	Qld	
Hedyotis auricularia	?	Qld	*H. lapeyrousii* in Fensham & Woinarski)

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.

4.5. Animals listed under other treaties

Australia has formal obligations for the protection of migratory species listed under a number of international conventions and bilateral treaties, the most significant of which are the Japan-Australia Migratory Bird Agreement (JAMBA, 1974); the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention, 1979); and the China- Australia Migratory Bird Agreement (CAMBA, 1986). The protection of these listed species is regarded as a matter of national significance under the *Environment Protection and Biodiversity Conservation Act 1999*. Tiwi bird species included in annexes to these treaties are listed in Table 7. Note that several marine mammals and turtles recorded from Tiwi waters are also listed under these conventions and agreements, but are not discussed here.

Almost all of the species listed in Table 8 are seabirds, waterbirds or shorebirds (waders). The exceptions which are most notable for conservation planning on Tiwi lands are the oriental cuckoo and rainbow bee-eater.

Table 8. Migratory bird species which occur on the Tiwi Islands and are listed under international conventions or bilateral agreements.

	CAMBA	**JAMBA**	**Bonn**
Brown Booby *Sula leucogaster*	C	J	
Lesser Frigatebird *Fregata ariel*	C	J	
Great Egret *Egretta alba*	C	J	
Eastern Reef Egret *Egretta sacra*	C		
Glossy Ibis *Plegadis falcinellus*	C		B
Osprey *Pandion haliaetus*			B
White-bellied Sea-Eagle *Haliaeetus leucogaster*	C		
Grey Plover *Pluvialis squatarola*	C	J	
Pacific Golden Plover *Pluvialis fulva*	C	J	
Mongolian Plover *Charadrius mongolus*	C	J	
Large Sand-Plover *Charadrius leschenaultii*	C	J	
Little Curlew *Numenius minutus*	C	J	
Whimbrel *Numenius phaeopus*	C	J	
Eastern Curlew *Numenius madagascariensis*	C	J	
Black-tailed Godwit *Limosa limosa*	C	J	
Bar-tailed Godwit *Limosa lapponica*	C	J	
Marsh Sandpiper *Tringa stagnatilis*	C		

Greenshank *Tringa nebularia*	C	J	
Common Sandpiper *Tringa hypoleucos*	C	J	
Grey-tailed Tattler *Heteroscelus brevipes*	C	J	
Terek Sandpiper *Xenus cinereus*	C	J	
Ruddy Turnstone *Arenaria interpres*	C	J	
Swinhoe's Snipe *Gallinago megala*	C	J	
Red Knot *Calidris canutus*	C	J	
Great Knot *Calidris tenuirostris*	C	J	
Red-necked Stint *Calidris ruficollis*	C	J	
Sharp-tailed Sandpiper *Calidris acuminata*	C	J	
Curlew Sandpiper *Calidris ferruginea*	C	J	
Sanderling *Calidris alba*	C	J	
Broad-billed Sandpiper *Limicola falcinellus*	C	J	
White-winged Tern *Chlidonias leucopterus*	C	J	
Caspian Tern *Sterna caspia*	C		
Common Tern *Sterna hirundo*	C	J	
Little Tern *Sterna albifrons*	C	J	B
Crested Tern *Sterna bergii*		J	B
Lesser Crested Tern *Sterna bengalensis*	C		B
Oriental Cuckoo *Cuculus saturatus*	C	J	
White-throated Needletail *Hirundapus caudacutus*	C	J	
Fork-tailed Swift *Apus pacificus*	C	J	
Rainbow Bee-eater *Merops ornatus*		J	

4.6. Endemic vegetation types

As noted in section 1.3 above, one vegetation type recognised at the 1,000,000 scale for the Northern Territory (Wilson *et al*. 1990) occurs nowhere other than on the Tiwi Islands (vegetation type 47 - *Acacia* open shrubland with *Sorghum* grassland understorey ("treeless plains")).

The only other explicit consideration of vegetation types endemic to the Tiwi Islands is for monsoon rainforests, where two of 16 groups recognised for the Top End of the Northern Territory were reported to be (almost entirely) restricted to the Tiwi Islands (Russell-Smith 1991).

More than 70% of the Northern Territory extent of eucalypt tall open forests co-dominated by *Eucalyptus nesophila* occur on the Tiwi Islands. While this clearly doesn't make this vegetation type unique to the Tiwi Islands, we include it in this section, because this high proportion does suggest that the Tiwi Islands represent a major component of the conservation status of this environment.

4.7. Ecologically significant environments

Some environments have particular values which merit specific attention in conservation planning. Such environments include those that:

- provide important ecological services to other ecosystems;

- are relatively small in area but have such contrasting species composition to their more extensive surrounds that they contribute substantially to regional biodiversity;
- provide core habitat to a relatively large number of species;
- provide important linking elements in the landscape (such as for dispersal or migration); and/or
- are susceptible in the sense that destruction of a small proportion of them is likely to have a negative effect on a much larger proportion of the whole region.

In a comparable conservation plan for the Daly Basin bioregion (Price *et al*. 2000), three such environments were recognised – **riparian zones**, **rainforests** and **wetlands**. These three environments occur on the Tiwi Islands and should also be considered as of significance in planning for biodiversity conservation on the Tiwi Islands.

5. DISTRIBUTION AND PROTECTION OF CONSERVATION VALUES

The previous section defined biodiversity values which any conservation plan for the Tiwi Islands should aim to maintain or enhance. In this section, we discuss these values more explicitly, provide information on the distribution and/or abundance of those values, and propose some criteria for their protection.

In Section 5, we attempt to integrate the planning for all of these individual values, and along with criteria flowing from a range of national and Territory strategies (Box 1), develop a more cohesive set of proposals for the entire Melville Island area.

Information for each of the values listed in Section 4 is summarised in the following Boxes. Wherever possible we illustrate these values - in many cases we have shamelessly lifted these illustrations without permission from other publications.

Maps showing the location of all known records are given for each species. In these maps, we indicate presumed absences by open circles showing quadrats in which the species was not recorded. Note that we omit records which have not been geo-referenced with a precision of at least +/- 1 km, which deletes many of the historic records (where collecting location is generally no more precise than “Melville Island”).

For animal species recorded from more than 5 quadrats, we illustrate variation among broad habitat types in the proportion of quadrats in which the species was recorded. The broad habitats recognised here are: *mangroves* (including saltmarsh and strand vegetation: n=16 quadrats sampled), *wet rainforests* (types 3 and 5 of Russell-Smith (1991), that is those occurring around springs, riparian areas or other freshwater environments: n=25), *dry rainforests* (coastal thickets and rainforest patches on scree slopes: n=28), *melaleuca forest* (forests and woodlands dominated by *Melaleuca* spp.: n=9), *miniata/tetrodonta/n* (tall open forests dominated by *Eucalyptus miniata* and/or *E. tetrodonta* and/or *E. nesophila*: n=156), *euc. woodland* (woodlands dominated by *Eucalyptus oligantha, E. alba, E. papuana* s.l., and *Corymbia polysciada*: n=19), *euc. bleeseri* (woodlands typically on shallow or skeletal soils and dominated by *Eucalyptus bleeseri* and/or *E. dichromophloia*: n=6), *treeless plains* (n=30), *other plantation* (plantations of *Pinus* and/or *Callitris* spp.: n=5), *Acacia mangium* (plantations: n=7).

5.1. Summary of conservation priorities

The preceding boxes describe many conservation values, of varying degree of vulnerability and official "recognition", and for which the Tiwi Islands are variably significant in their protection. It becomes a confusing and inefficient exercise to treat each independently and with equal importance. In Table 10 below, we attempt to summarise these conservation attributes, draw priorities and group values into broad environments from which common conservation actions may be most efficiently derived.

Table 10: Summary table of conservation values, classified by broad environment and priority. Prioritisation is based here on our assessment of vulnerability, population size or extent of occurrence on the Tiwi Islands, and the relative significance of the Tiwi populations to those elsewhere. Note that some species occur across several environments, but are listed here only in one category, based on our knowledge of their main habitat preferences.

broad environment	conservation management priority	
	higher	**lower**
rainforests	*Burmannia* sp. DNA61177 'Melville Island' *Elaeocarpus miegei* *Freycinetia percostata* *Hedyotis auricularia* *Mapania macrocephala* *Thrixspermum congestum* *Miliusa* sp. D30127 *Garcinia warreni*	*Cerbera manghas* *Hoya australis* var *oramicola* *Luisia teretifolia* *Tropidia curculigoides* *Mitrella* D24710 'Melville Island' *Embelia* sp. DNA 48980 *Parsonsia* sp.DNA 30178 'Melville Island' *Tarennoidea wallichii* *Acmenosperma claviflorum* *Dendromyza reinwardtiana* *Endiandra limnophila* *Litsea breviumbellata* *Strychnos minor* Group 3 rainforest generally Group 5 rainforest generally
eucalypt open forests	butler's dunnart brush-tailed rabbit-rat red goshawk masked owl *Typhonium jonesii* *Typhonium mirabile* black-footed tree-rat	*Cycas armstrongii* *Cycas maconochiei* var *maconochiei* chestnut-backed button-quail partridge pigeon taipan *Desmodium tiwiense* striated pardalote yellow-tinted honeyeater brown honeyeater oriental cuckoo rainbow bee-eater *Eucalyptus nesophila* co-dominated forests generally
treeless plains	hooded robin	*Scleria carphiformis* treeless plains vegetation generally
swamps	*Calochilus caeruleus* *Dendrobium trilamellatum* *Lindernia cowiei*	*Eleocharis geniculata*

mangroves		little north-western freetail bat false water-rat
coastal dunes	*Spermacoce* D132770 Piper Head	

6. MAPPING AREAS FOR CONSERVATION

6.1. Rationale

This section describes options for identifying and prioritising a network of retained (that is, uncleared) areas which aim to protect and maintain the conservation attributes described in the previous section, along with other conservation obligations or standards arising from national and Territory initiatives or strategies (Box 1 above). Subsequent sections consider options for developing mechanisms for the formal management of such retained areas (Section 7), and consideration of actions for their management, and that of Tiwi environments more generally (Section 8).

We don't presume that this is a definitive prescription for a conservation area network on the Tiwi Islands. Decisions about land use are the responsibility primarily of the Tiwi people.

We also recognise that our view of biodiversity conservation may be very different to that of the Tiwi people, who may place a higher priority on maximising those plant or animal resources which are most useful or of most symbolic significance.

In contrast to the highly modified landscapes of southern Australia, the Tiwi environments and conservation values are generally intact and can be represented in retained areas in very many possible combinations. This flexibility allows for potential conservation networks to be varied in response to different arrays of other variables (such as potential for development, or to accommodate differences between clan groups in willingness to manage areas for conservation). Such balancing is an iterative process that has not yet been properly instigated among stakeholders for the Tiwi Islands. Hence our purpose here is largely to outline the process and types of rules that we consider should be used in establishing a network of areas retauined for conservation purposes, and to provide some indication of the area required to meet the necessary conservation requirements.

There are many alternative ways of representing some attributes (e.g. wide-ranging species such as yellow-tinted honeyeater, or a "reservation" target of 15% of an extensive vegetation type). In contrast, there may be no options for highly localised attributes (such as species known from only one or two sites). In general, the process of conservation planning is most efficient if it builds from the most localised attributes to the most generalised. The planning process is also most efficient if it can deal with many co-occurring attributes at once. We also recognise that the conservation attributes described in the previous section are not all of comparable value - for example, we consider that it is relatively unimportant to provide areas for oriental cuckoo, because that species is relatively widespread across the Tiwi Islands and elsewhere in northern Australia - whereas the plant *Burmannia* DNA61177 'Melville Island' is known in the world from only small populations in two rainforest patches on the Tiwi Islands.

Finally, the imperative for conservation planning on the Tiwi Islands is largely because of proposals to transform large areas of eucalypt open forests to plantations of exotic tree species. This suggests a substantial loss of biodiversity, which can be in some ways balanced by providing greater conservation security for biodiversity in the

retained vegetation. This argument rests on the assumption that at least some elements of biodiversity will be disadvantaged in the transformation from native forest to plantation. Our study incidentally provided a little evidence concerning this premise, and this is attached at Section 6.3 below.

6.2. Prioritised steps for conservation planning

In the section below we outline a framework for identifying areas which together represent the conservation values described in Section 5. This framework (labelled here as "Scenario 1") builds in a series of steps, with each subsequent step incorporating the outcomes of the preceding ones.

From Table 10 and Section 5 above generally, it is readily apparent that many of the most threatened, endemic or otherwise localised plant species found on the Tiwi Islands are confined to rainforest patches, and are dependent upon the retention of rainforest environments. The Tiwi Islands rainforest network is highly significant at a Territory scale: it constitites a relatively large proportion (5.8 to 14.8%, depending upon the scale of mapping) of the total rainforest area in the Territory, some of the largest individual patches, many species which occur nowehere else in the Territory, and two rainforest types which are endemic or virtually so.

There are a number of distinctive features of rainforests generally which afford them particular conservation priority (Russell-Smith and Bowman 1992; Russell-Smith *et al*. 1992; Price *et al*. 1995, 1999), including:

- patches typically vary substantially in their species composition, such that each patch has an idiosyncratic assemblage of plants;
- many rainforest plant species occur in only a very few patches;
- some species are typically represented in any given patch by very few individuals;
- patches are typically very small and together comprise only a very small proportion of the landscape;
- very many species which occur in rainforests do not also occur in the surrounding more extensive open forests and savanna;
- rainforests are readily degraded by weeds, feral animals and some fire regimes; and
- some rainforest animals require access to several or many rainforest patches at any one time or serially, and, complementarily, some rainforest plants exchange genetic material or otherwise "move" between rainforest patches in a manner that is dependent upon the persistence of animal dispersers.

Together, these features have justified a response now used in conservation planning in the Top End (e.g. Price *et al*. 2000) that all rainforest patches should be retained. This makes an appropriate start point for our conservation design.

STEP 1: Retain all rainforest patches.

Across Melville Island, this sums to 124 km^2 (or 2.14% of the Island area).
Across both Tiwi Islands, this sums to 158 km^2 (or 2.11%) of the Islands area.

But rainforests will not be maintained unless their perimeters are buffered from external threats, and their hydrological character is retained. Best practice guidelines for protection of rainforests were derived by Price *et al*. (2000), and applied for conservation planning in the Daly Basin bioregion. These stipulated that native vegetation should be retained in a 500m buffer around every rainforest patch. This is an appropriate benchmark for rainforests.

However, we recognise that the network of rainforest patches on the Tiwi Islands is composed of many more patches (a total of 302 on Bathurst Island and 959 on Melville Island) distributed across more of the landscape than for anywhere else in the Top End of the Northern Territory, such that the absolute application of the buffer guidelines would result in a substantial "cost" of land area. Accordingly, we here consider weakening this criterion, to apply only to those endemic rainforest groups 3 and 5 (which are most dependent upon maintenance of hydrological integrity), and reduce the buffer to 250m for all other rainforest groups on the Tiwi Islands.

STEP 2: Retain native vegetation in a buffer around all rainforest patches
(500m for Groups 3 & 5; 250m for other rainforest groups)

For Melville Island, this sums to 816 km^2 (or 14.1% of the Island area) (including the area of the rainforests themselves).

Across both Tiwi Islands, this sums to 1015km^2 (or 13.55% of the Islands area) (including the area of the rainforests themselves).

[Note that a buffer of 500m around all rainforest patches would increase this area to 1528km^2 (or 20.40%) of the Islands area (including the area of the rainforests themselves).]

Wetlands and river systems are the next group of localised features which self-evidently merit protection. Based on legislation now operating in Queensland (there is not as yet comparable legislation in the Northern Territory), Price *et al*. (2000) applied a set of simple rules for conservation of these attributes in the Daly Basin, and almost identical rules were also applied to land-use planning for the Ord Stage 2 development (Kinhill 2000). These are set out in Step 3 below, and are appropriate standards throughout the Territory.

STEP 3: Retain native vegatation in a buffer around all wetlands and river systems
(200m from each high bank of rivers; 100m from each bank of creeks; 50m to either side of other drainage lines; 200m around the wetland perimeter)

For Melville Island, this sums to an additional 694 km^2, hence a cumulative retained area of 1510 km^2 (26.1% of the Island area).

Across the Tiwi Islands, this sums to an additional 875 km^2, hence a cumulative retained area of 1890km^2 (25.23% of the Islands area).

The network of retained areas following Steps 1-3 is illustrated in Fig. 12.

The next priority is for inclusion of sites to represent the most localised of the listed threatened or endemic species not already included in this network. Other than the rainforest species (which should all have been "captured" in Steps 1 and 2 above), the highest priority of these are butler's dunnart, red goshawk, *Typhonium jonesii, Typhonium mirabile*, *Calochilus caeruleus*, *Dendrobium trilamellatum, Lindernia cowiei, Spermacoce* D132770 Piper Head. For all of these species, we have too few records to provide an adequate distribution model. While they may occur far more widely than we know, this is hypothetical and we consider it prudent to protect at least the few sites of proven occurrence. Protection of these sites may provide some assurance of long-term protection for the particularly localised plants, but it is a weak response for the two animal species here considered, which are far more wide-ranging, and for which the known sites represent but one individual each.

Based on what knowledge we have of locational precision of records, susceptibility to disturbance and population size, we set the following buffer rules for each occurrence of these threatened and localised species.

Table 11. Proposed buffer rules for the principal set of localised, threatened species, other than rainforest species. "Buffer" = the radius around known sites of occurrence, in which vegetation should be retained.

species	proposed buffer radius	no. of sites
butler's dunnart	1 km	5
red goshawk	2 km	7
hooded robin	1 km	2
Typhonium jonesii	500 m	2
Typhonium mirabile	500 m	5
Calochilus caeruleus	500 m	2
Dendrobium trilamellatum	500 m	2
Lindernia cowiei	500 m	1
Spermacoce D132770 Piper Head	500 m	1

The locations of these proposed buffered areas are illustrated in Fig. 13.

STEP 4: Retain native vegetation in a buffer around all occurrences of the most highly localised threatened species

For Melville Island, this sums to an additional 68 km^2, hence a cumulative retained area of 1578 km^2 (27.3% of the Island area).

Across the Tiwi Islands, this sums to an additional 85km^2, for a cumulative total of 1975km^2 (26.4% of the Islands area).

The retention of these areas provides some security for at last these localised plant species, but their long-term future will require protection of far more extensive areas of

suitable habitat, and this is the only way that the set of high priority threatened animal species (butler's dunnart, red goshawk, hooded robin, brush-tailed rabbit-rat, black-footed tree-rat and masked owl) will be maintained. For these species, we propose a goal of retaining either a minimum of 75% of their current Tiwi population (for the three of these species for which we have enough data to provide reasonable distributional models) or at least 75% of their known or presumed preferred habitat(s). We adopt these thresholds as a reasonably pragmatic compromise, which offers a realistic expectation of maintaining population viability while allowing for the development of some altrenative land uses. It is important to note that there is no fixed correct value, especially so in the absence of more detailed information on population sizes and factors influencing this size or survival. Our interpretation of the administrative guidelines for the federal *Environment Protection and Biodiversity Conservation Act 1999* (see Appendix B) is that *any* long-term decrease in the population, or extent of occupancy, of any listed threatened taxa would be regarded as a <u>significant impact</u>. The criterion we suggest here, of tolerating 25% loss of the entire population of Tiwi-endemic threatened taxa such as the Melville Island subspecies of masked owl, must then be seen unambiguously to be accepting a highly significant impact: that is, our design falls well short of an ideal result for biodiversity conservation.

The application of these criteria is obviously somewhat more difficult yet flexible than those of Steps 1 to 4 above. The first stage is to provide predictive models for the distributions of brush-tailed rabbit-rat, black-footed tree-rat and masked owl (Figs 14a-14c). The best models that we could derive for these three species are listed below. Note that all models were relatively weak in terms of the proportion of deviance explained, suggesting that these species were relatively equitably distributed across the Islands or that their distribution was associated with factors other than those we used as predictive variables.

<u>predictive distributional models</u>

for *masked owl*

$e^y / (1 + e^y) = -10.62 + 0.1077$ (band5) $- 0.000353$ (band5)^2.
[deviance explained =11%; $p<0.01$]

for *black-footed tree-rat*

$e^y / (1 + e^y) = -6.513 + 0.0656$ (band1) $- 0.000202$ (band1)$^2 + 0.000259$ (dist. to rainforest).
[deviance explained = 9.5%; $p<0.001$]

for *brush-tailed rabbit-rat*

$e^y / (1 + e^y) = -12.26 + 0.0135$ (band1) + [8.34 (if vegetation is eucalypt forest (open)) or 8.57 (if vegetation is eucalypt forest (dense or mid-open)) or 1.11 (if vegetation is *Melaleuca* open forests or low woodlands, or sedgelands and grasslands) or 8.10 (if vegetation is rainforests) or 0.23 (if vegetation is mangals) or -0.16 (if vegetation is treeless plains) or 8.95 (if vegetation is eucalypt woodlands) or 0.0135 (if vegetation is plantations)]
[deviance explained = 14%; $p<0.01$];

where **y** is the probability of occurrence (varying from 0 if certain to be absent to 1 if doubtless likely to be present) of the nominated species within a pixel, **band5** is values for Landsat bands 4 to 7, **band1** is the first principal component of Landsat bands 1,2,3 (i.e visual bands) and **dist. to rainforest** is the linear distance to the nearest mapped patch of rainforest.

By then overlaying predictive distributional maps for these species with maps of the preferred habitats for butler's dunnart, red goshawk and hooded robin, we can seek the geographic outcome which most efficiently simultaneously meets our conservation security guidelines for these species (noting as a starting point that some of the suitable habitat has already been earmarked from Steps 1-4 above). This exercise was undertaken for Melville Island alone.

One such solution (from an almost infinite number of solutions to these conservation criteria) is illustrated in Figure 15. This is clearly the most "land-hungry" of the steps considered. This is because the six animal species occur mainly in eucalypt forests, which occupy nearly 80% of Melville Island, and hence our target of retaining 75% of the population of these will unavoidably require a very high proportion of the Island area. Additionally, the distributional models for these species are not especially coincident, such that retaining areas of high concentration for one species will not necessarily contribute much to the retention of either of the other two modelled species.

STEP 5: Retain 75% of the Melville Island populations of masked owl, brush-tailed rabbit-rat and black-footed tree-rat; and 75% of the preferred habitat of butler's dunnart, hooded robin and red goshawk .

For Melville Island, this sums to an additional 2,630 km^2, hence a cumulative retained area of 4,208 km^2 (72.7% of the Island area).

We can now take stock and consider the extent to which the sum of responses to Steps 1 to 5 also provides for the conservation of those values which did not explicitly seed those Steps, and to the national guidelines for the establishment of a comprehensive, adequate and representative reserve system (=Step 6 below).

STEP 6: assess whether Steps 1-5 have picked up comprehensive representation of all mapped vegetation types, to at least 15% of their extent, and if not, add areas to bring up to these targets..

All vegetation types are represented by >15% of their extent by the retained area network shown in Figure 15.

No additional areas are needed to meet the explicit conservation targets set, and this network would provide adequate representation of all conservation attributes considered.

6.3. Consideration of biodiversity in Acacia plantations

This biodiversity conservation plan seeks to identify and maintain important conservation areas pre-emptive of major land-use change. One supposition of the need for this planning is that the land-use change will affect conservation values. Our survey data provide some assessment of such impact. We sampled six *Acacia mangium* sites (Fig. 17) with identical survey procedures to a much larger number (130 quadrats) of the eucalypt forest most suitable for conversion to *Acacia mangium* plantation (i.e. tall forests dominated by either *Eucalyptus miniata, E. tetrodonta* and/or *E. nesophila*: Fig. 16). The fauna of these different sets of quadrats was compared, using Mann-Whitney U tests, and the results are summarised in Figure 18 and Table 12.

Figure 16: tall open forest dominated by *Eucalyptus miniata, E. tetrodonta and/or E. nesophila*

There are two main caveats in interpreting these data. The first is that the number of quadrats sampled in *Acacia mangium* plantations was small, which reduces the authority with which the data can be interpreted (and which makes it difficult to achieve statistical significance in comparisons). The second caveat is that the existing plantations are relatively small and generally adjacent to more extensive areas of native eucalypt forests. Hence some of the species recorded in our samples of these

plantations may not persist in much larger plantation areas and where *Acacia mangium* plantations makes up a far higher proportion of the local environment.

Figure 17: *Acacia mangium* plantation

Notwithstanding these interpretative constraints, there is clearly a substantial change and loss in biodiversity from native eucalypt forests to *Acacia* plantation. A quadrat in *Acacia mangium* is likely to have far fewer birds and reptiles than one in native eucalypt forests. There is also a major change in species composition, with a relatively small number of species being favoured by plantation development (e.g. delicate mouse, western chestnut mouse, red-cheeked dunnart, the frog *Limnodynastes convexiusculus*, the dragon lizard *Diporiphora bilineata*, peaceful dove, brown honeyeater, rainbow bee-eater, and tawny frogmouth), and a much larger proportion of species being substantially reduced in abundance (with many species not recorded at all from our samples in *Acacia mangium* plantations).

Figure 18a. Variation in quadrat-level species richness between native eucalypt forest and plantations of *Acacia mangium*. Columns indicate means, with whiskers indicating standard error.

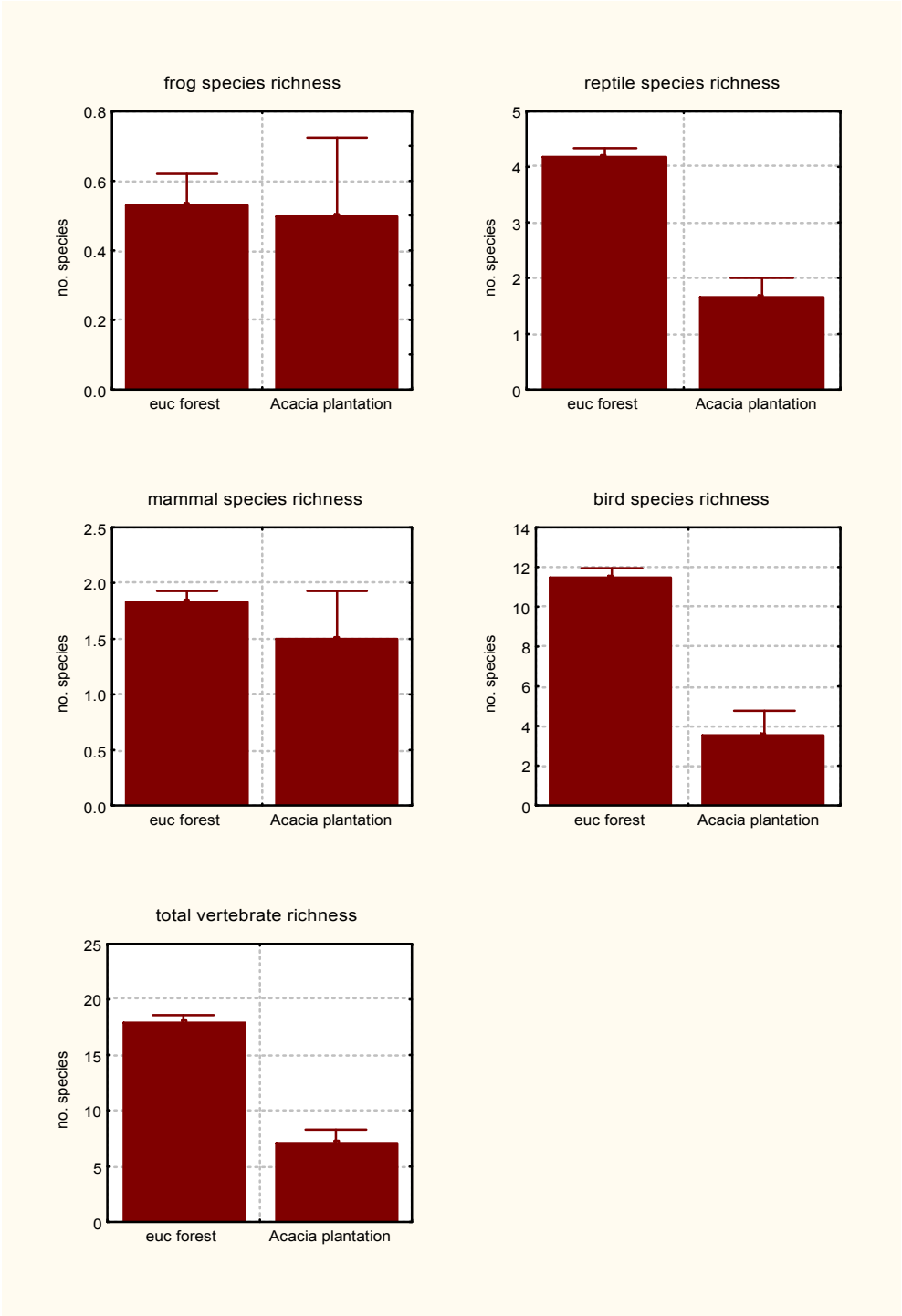


Figure 18b. Variation in quadrat-level abundance of vertebrates (no. recorded per uniform sampling effort – see Appendix D) between native eucalypt forest and plantations of *Acacia mangium*. Columns indicate means, with whiskers indicating standard error.

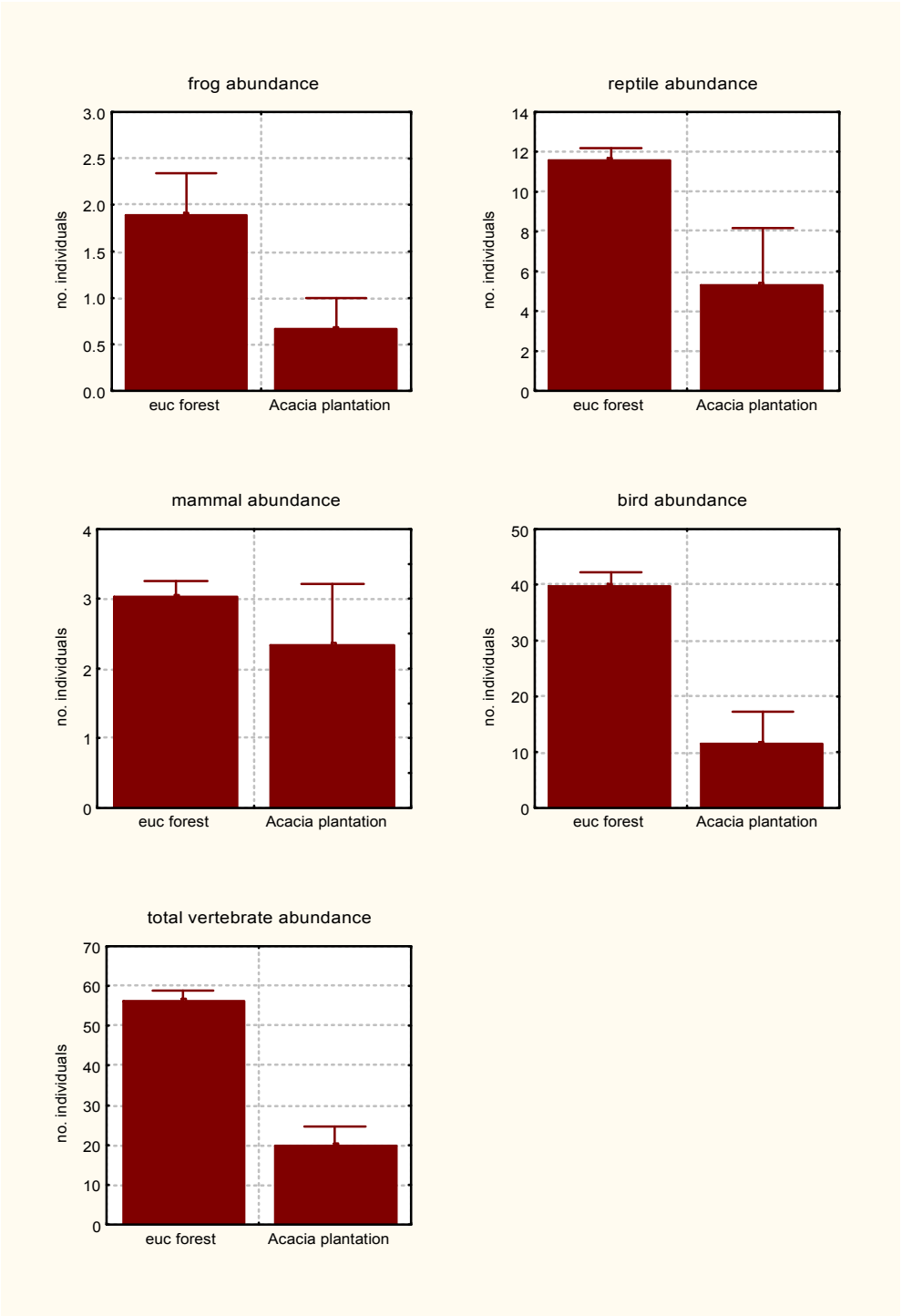


Table 12. Differences between eucalypt forest quadrats and *Acacia mangium* plantation quadrats in abundance of vertebrates. Values given are mean abundance per quadrat, with comparisons based on Mann-Whitney U tests, with probability levels: *** p<0.001; ** p<0.01; * p<0.05; (*) p<0.1; ns=not significant. Note that, given the small sample size of *Acacia* plantation quadrats, relatively few statistically significant differences would be expected to be detected. Within comparison classes, species are arranged in order of no. of quadrats from which recorded (minimum=5).

(a) birds.

	species	abundance		significance
		eucalypt forest	*Acacia* plantation	
more common in eucalypt forest	white-bellied cuckoo-shrike	1.59	0	*
	white-throated honeyeater	3.55	0.50	*
	weebill	3.11	0	*
	mistletoebird	0.97	0	*
	pied butcherbird	1.21	0	*
	rufous whistler	3.11	1.00	(*)
	striated pardalote	1.68	0.17	(*)
	red-winged parrot	0.79	0	(*)
	grey shrike-thrush	0.97	0	(*)
	yellow-tinted honeyeater	2.24	0	(*)
no significant difference (but mean euc > mean plantation)	northern fantail	1.22	0.67	ns
	leaden flycatcher	0.96	0.33	ns
	silver-crowned friarbird	1.04	0.17	ns
	spangled drongo	0.44	0	ns
	red-collared lorikeet	1.28	0	ns
	little friarbird	0.84	0.33	ns
	northern rosella	1.22	0	ns
	bar-shouldered dove	0.23	0	ns
	blue-winged kookaburra	0.26	0	ns
	pheasant coucal	0.19	0	ns
	grey-crowned babbler	0.58	0	ns
	red-backed fairy-wren	0.49	0	ns
	blue-faced honeyeater	0.52	0.17	ns
	varied lorikeet	2.22	0	ns
	sulphur-crested cockatoo	0.19	0	ns
	owlet nightjar	0.15	0	ns
	helmeted friarbird	0.43	0	ns
	white-gaped honeyeater	0.16	0	ns
	red-tailed black-cockatoo	0.33	0	ns
	varied sittella	0.43	0	ns
	common bronzewing	0.11	0	ns
	partridge pigeon	0.22	0	ns
	chestnut-backed button-quail	0.12	0	ns
	yellow-throated miner	2.75	0	ns
	black-faced cuckoo-shrike	0.22	0.17	ns
	dusky honeyeater	0.21	0.17	ns
no significant difference (but mean euc < mean plantation)	olive-backed oriole	0.16	0.17	ns
	peaceful dove	0.72	2.67	ns
	brown honeyeater	1.03	2.17	ns
	rainbow bee-eater	0.58	1.50	ns
	torresian crow	0.12	0.17	ns
	spotted nightjar	0.06	0.17	ns
	brown goshawk	0.05	0.33	ns
	bush stone-curlew	0.06	0.17	ns
more common in *Acacia* plantation	tawny frogmouth	0.12	0.33	(*)

(b) mammals

	species	abundance		significance
		eucalypt forest	*Acacia* plantation	
more common in eucalypt forest	northern brown bandicoot	0.74	0	(*)
	black-footed tree-rat	0.52	0	(*)
no significant difference (but mean euc > mean plantation)	brush-tailed rabbit-rat	0.54	0	ns
	common brushtail possum	0.49	0.17	ns
	grassland melomys	0.10	0	ns
	agile wallaby	0.12	0	ns
	pale field-rat	0.08	0	ns
no significant difference (but mean euc < mean plantation)	feral horse	0.05	0.50	ns
more common in *Acacia* plantation	delicate mouse	0.17	1.17	***
	red-cheeked dunnart	0.03	0.33	***
	western chestnut mouse	0.01	0.17	***

(c) reptiles

	species	abundance		significance
		eucalypt forest	*Acacia* plantation	
more common in eucalypt forest	*Carlia munda*	5.41	0.17	***
	Heteronotia binoei	1.19	0	*
no significant difference (but mean euc > mean plantation)	*Oedura rhombifer*	0.35	0	ns
	Morethia storri	0.32	0	ns
	Ctenotus borealis	0.40	0.17	ns
	Menetia greyii	0.26	0	ns
	Menetia alanae	0.60	0.17	ns
	Cryptoblepharus plagiocephalus	0.71	0.17	ns
	Glaphyromorphus douglasi	0.37	0	ns
	Gehyra australis	0.11	0	ns
	Ctenotus hilli	0.11	0	ns
no significant difference (but mean euc < mean plantation)	*Ctenotus essigntonii*	1.57	2.67	ns
	Diporiphora bilineata	0.56	2.00	ns
more common in *Acacia* plantation	-			

(d) frogs

	species	abundance		significance
		eucalypt forest	*Acacia* plantation	
more common in eucalypt forest	-			
no significant difference (but mean euc > mean plantation)	*Uperoleia inundata*	0.90	0.33	ns
	Litoria nasuta	0.21	0	ns
	Crinia remota	0.13	0	ns
	Sphenophryne adelphe	0.17	0	ns
	Litoria bicolor	0.21	0	ns
	Litoria tornieri	0.13	0	ns
no significant difference (but mean euc < mean plantation)	-			
more common in *Acacia* plantation	*Limnodynastes convexiusculus*	0.07	0.33	(*)

7. OPTIONS FOR PROTECTIVE MECHANISMS FOR RETAINED AREAS

The minimum requirement for the notional retained area network that we describe and map in the previous section is that these areas are not cleared or otherwise modified. But there are many options for their status beyond this simple exclusion from clearing.

These options should be evaluated, as a whole and for any given nominated location, in terms of:

- the amount of management input required to ensure the retention of the values for which the areas have been nominated;
- the significance of the values themselves;
- the size of the nominated tract of land;
- the landscape setting;
- the relationship between management status and likelihood of management support; and, ultimately and most importantly,
- the wishes of the Tiwi landowners.

Essentially, the five main options available for describing and managing retained areas, and for linking them to some regulatory status, are: National Park, Indigenous Protected Area, Section 73 Agreement, declaration as "essential habitat" and *status quo* (i.e. no new formal conservation designation). There is substantial overlap between the first three of these options, each of which can cover a broad spectrum of arrangements.

The Parks and Wildlife Commission of the Northern Territory has a range of cooperative arrangements with Aboriginal landowners for the joint management of National Parks and other conservation reserves, most notably including Nitmiluk National Park and Gurig National Park (PWCNT 1998), and Parks Australia has analogous but different cooperative arrangements with Aboriginal landowners for Kakadu and Uluru National Parks. The details of these agreements, and their successes and failures, are described in PWCNT (1998) and Woenne-Green *et al*. n.d.). The general principle is that there is a partnership for management of Aboriginal lands, and that conservation of biodiversity is an agreed aim. Within this broad ambit, there is considerable flexibility. For example, in both Gurig and Nitmiluk National Parks, executive power is vested in a Board of Management which has majority Aboriginal representation, and which is not subject to the direction of the Minister or Director of PWCNT. For Tiwi landowners, this option involves some ceding of management flexibilty and outright responsibility, as it requires the formal inclusion of a government conservation agency in management considerations, and the recognition of biodiversity conservation as an explicit land management objective. The National Park option also brings greater likelihood of training, jobs, availability of expertise, attraction for tourism, and management resources.

Environment Australia has recently developed a program for Indigenous Protected Areas, which can include similar arrangements to the joint management described above, but can also grade to unilateral management by Aboriginal landowners, but with

support for resourcing in exchange for the establishment of some conservation objectives and actions on those lands.

A similarly broad ambit is allowed for under Section 73 of the *Territory Parks and Wildlife Conservation Act*, which allows for Northern Territory government assistance for the protection and conservation of wildlife on Aboriginal lands, through bilateral agreements ranging from limited assistance to lease back. In general, this is a more flexible and less bureaucratic arrangement than cooperative management of National Parks, but it is less likely to attract management resources.

The *Territory Parks and Wildlife Conservation Amendment Act 2000* provides for the declaration of essential habitat for biodiversity conservation, which can be imposed upon an area of land judged to be necessary for the protection of a particular nominated species, or assemblage of species (see Appendix C below). This would generally be a last recourse, invoked only when other options for cooperative management for conservation were exhausted.

Finally, no formal conservation management program or conservation status may be attached to the retained lands. This would preserve absolute Tiwi authority over their lands, but it would be likely to reduce the probability of accessing management and employment resources, it may limit the possibility of improved land management (such as to control weeds or new pests), and the lack of establishment of formal conservation areas or conservation management programs may contribute to a negative assessment by government regulatory authorities of major land use proposals on the Tiwi Islands.

These options may readily be mixed. For example, there may be no special need for cooperative mechanisms simply to manage riverside buffers, whereas extensive retained areas with highly significant conservation values but substantial management problems may best be dealt with in some form of cooperative management, which can provide resources and employment for Tiwi people.

8. MANAGEMENT AND MONITORING

Regardless of whether much of Melville Island is cleared for plantation or designated as National Park, the conservation assets of retained areas will be gradually diminished unless they are appropriately managed. Obviously, over tens of thousands of years, traditional management by Tiwi people has ensured the maintenance of the values that we see today. But to some extent, traditional management practices have now changed. Large areas are now seldom visited, and hence no longer subjected to carefully modulated fire regimes. As bush tucker comprises an increasingly smaller proportion of people's diets, so the country will be increasingly less managed in ways that were formerly used to promote rich but sustainable harvests of yams and other foodstuffs. Inevitably this will produce some changes in vegetation patterning and hence the distribution and abundance of animal species, with some species benefitting from the less intricate and intimate environmental management and other species being disadvantaged. Superimposed on this relaxation of management, the ecology of the Islands has also been affected by the spread of a range of exotic plants and animals. Some of these introduced species exert a powerful influence on the environment. For example, mission grass *Pennisetum polystachion* grows so lushly that it can create a major increase in fuel loads and hence trigger increasingly more intense fires and thus major changes in plant communities. In rainforest patches, feral pigs may disturb the underlying natural water sources and consume such a high proportion of the fruits, seeds and seedlings of rainforest plants that recruitment is stopped, leading ultimately to the senescence and simplification of rainforest assemblages. Even the most vigorously imposed traditional Tiwi management may be ineffective against such recently-arrived environmental modifiers.

Detailed consideration of management isssues, especially in relation to the development of forestry, is addressed elsewhere (G. Flanagan DPIF, K. Hadden, Tiwi Land Council). However, here we provide some brief comment on issues related to biodiversity conservation.

Note that in this section and the next we offer some recommendations, indicated within boxes within the text below. We do not specify the organisation responsible for implementing these recommendations, nor do we consider that it is obligatory to enact them. In some cases, the recommendations may be achieved over the course of the proposed NHT project following the work reported on here. In other cases, the recommended actions may be taken incrementally in concert with the staged expansion of plantation development.

8.1. Fire

There has been substantial research examining the impacts of different fire regimes upon biodiversity in the Top End of the Northern Territory (e.g. Bowman *et al*. 1988; Fesnham 1990*b*; Andersen *et al*. 1998). Unfortunately this research has not produced clearcut results, and there is a complex variation in responses between different species and in relation to environment and the many parameters of fire regimes (e.g. timing, extent and frequency of fires).

Figure 19 summarises the recent (1993-99) fire history of the Tiwi Islands. Large areas of western Melville Island and central Bathurst Island are burnt almost every year. In contrast, the far less accessible eastern half of Melville Island is burnt appreciably less frequently. Burning is concentrated along roads and in more frequently visited areas. In contrast to much of the Territory mainland, there is no aerial burning.

Lands burnt every year may be expected to suffer gradual erosion of some of their conservation values - simplifying the structure of eucalypt forests, diminishing the number of hollow logs and hollow-bearing trees, shrinking back rainforest boundaries, and increasing the prevalence of fire-tolerant and fire-promoting grasses. Lands burnt less frequently tend to eventually produce more structurally complex forests, expansion of rainforests, and be less prone to invasion by exotic plants. But these generalities need to be tempered by recognition that some early burning may break the country up, reducing the likelihood of more destructive and extensive late dry season fires, that the extent of fires may be at least as important as the frequency, and that the survival of many animals may require local access to a range of fire histories rather than all areas within their range being subjected to the same fire history.

Forest clearance and development of plantation forestry will affect fire regimes. Because of their lack of connection, remnant patches of retained forest will be likely to have more extreme fire regimes than formerly, typically being completely burnt more frequently or else quarantined from fire. Fire exclusion will obviously be the aim for plantation areas, and will involve the establishment of cleared peripheral fire breaks, probably surrounded by a buffer of native forest which is subjected to annual fuel suppression fires. This regime will gradually degrade those buffered forests. There may also be a danger that rigorous enforcement of fire exclusion around plantation areas will discourage Tiwi people from burning more generally across their lands.

We offer three suggestions about fire:

*8.1.1. **Preferred regime**. A fire regime which maximises the probability of retention of most biodiversity elements would comprise fine-scale burning in the early to mid dry season, with probably around one-third of every clan estate burnt each year, but with the locations burnt varying substantially from year to year.*

*8.1.2. **Forestry area**. Fire management in any area devoted to forestry should be carefully and clearly distinguished from fire management for the rest of the Islands. If native forests surrounding the plantation area are managed primarily to minimise fire risks to plantation (e.g. by annual fuel suppression fires), they should be clearly recognised as sacrifice or impact areas rather than assumed to be wildlife corridors or conservation zones.*

*8.1.3. **Fire mapping**. The accompanying fire map (Fig. 19) is based on relatively coarse resolution NOAA imagery. Far more detailed and precise mapping is available through LANDSAT TM imagery (which gathers information at a pixel size of 30m x 30m). In order to better understand and manage contemporary fire regimes on Melville Island, and to document and monitor changes due to forestry development, more frequent reporting of fire occurrence, using LANDSAT TM, should be instituted.*

8.2. Weeds

Because of their isolation and relative lack of modification, the Tiwi Islands have a relatively low incidence of weeds, and notably have been affected far less than many nearby mainland areas by some particularly virulent and noxious environmental weeds. Indeed, Fensham and Cowie (1998) noted that "the vast majority of the native vegetation on the Tiwi Islands is free of exotic plants", a highly significant and relatively unusual conservation attribute.

Nonetheless, a series of surveys over the last decade (mostly in association with the North Australian Quarantine Strategy) has resulted in the documentation of 100 species of exotic plants on the Tiwi Islands (Leach 1992; Fensham and Cowie 1998; Flanagan 2000). While many of these are garden ornamentals, food crops or plantation timber species, some are clearly less benign. Fensham and Cowie (1998) outlined the current and potential environmental problems associated with these weeds, and provided a series of recommendations, which are paraphrased below:

- the relatively small populations of mission grass at Milikapiti, Pirlingimpi and Yapilika should be removed, and subsequent introduction prohibited (most of these populations have since been removed);
- the small populations of the declared noxious weeds, para grass *Brachiaria mutica* and prickly mimosa *Mimosa pigra* (one individual only) at Nguiu, should be removed and subsequent introduction prohibited;
- for three other declared species, coffeebush *Leuceana leucocephala,* lantana *Lantana camara* and sicklepod *Senna obtusifolia* - the relatively small populations should be targetted for eradication;
- watching briefs, and opportunistic control, should be maintained for other declared species mossman river grass *Cenchrus echinatus*, hyptis *Hyptis suaveolens*, coffee senna *Senna occidentalis*, spiny head sida *Sida acuta*, flannel weed *S. cordifolia*, paddy's lucerne *S. rhombifolia* and snakeweed *Stachytarpheta cayennensis*.

Subsequent to that report, the serious environmental weed gamba grass *Andropogon gayanus* has been recorded from two locations on the Tiwi Islands, and the elimination of these small populations is clearly a major priority (Flanagan 2000).

Management of weeds on the Tiwi Islands requires:

> *8.2.1. the development and maintenance of adequate quarantining procedures* (checking and cleaning materials shipped or flown to the Islands);
>
> *8.2.2. training Tiwi people in the identification of (and costs associated with) weeds*;
>
> *8.2.3. the establishment of a strategic weed plan, reporting process and control strategy*; and
>
> 8.2.4. *the provision of adequate resources and information for safe and long-term weed control*.

8.3. Feral animals

Isolation has protected the Tiwi Islands from invasion by some of the feral animals which have affected much of the rest of Australia. Nonetheless, there are some significant problems associated with feral animals on Bathurst and Melville Islands.

Introduced with the establishment of the ill-fated Fort Dundas in 1829, **water buffalo** *Bubalus bubalis* are now common and widespread on Melville Island. They supported a meat and skin industry from about 1890 to 1920, but are now not controlled in any systematic manner. Their numbers have built up to exceptionally high densities (>10 individuals/km^2: Bayliss 1985) in the southeast of Melville Island. Feral buffalo have a range of impacts upon conservation values, including trampling and degradation of wetlands; killing rainforest and paperbark trees through rubbing; and spread of weeds (especially *Hyptis*).

Feral **horses** *Equus caballus* also occur on Melville Island, particularly in the western half, but the total population is much smaller than for buffalo. The range of impacts is generally similar to, but less substantial than, that of buffalo.

Feral **pigs** *Sus scrofa* are common on Bathurst Island and apparently still absent from Melville Island. Environmental damage caused by pigs is widespread and prominent in wet rainforests, riparian areas and wetlands. Pig rooting disturbs the ground across extensive areas of rainforests and wetlands, affecting the quality and flow of water, and depleting the recruitment of rainforest plants (and especially yams). Pigs are also predators of ground-nesting birds and other small terrestrial vertebrates and a wide range of terrestrial invertebrates.

Feral **cattle** *Bos taurus* occur on both Bathurst and Melville Island, although in far smaller numbers than for buffalo.

Feral **cats** are widespread but not especially common on Bathurst and Melville Island. They are voracious predators which may be reducing the abundance of some native Tiwi mammals, birds and reptiles.

There are also populations of the exotic Asian house gecko *Hemidactylus frenatus* (Bathurst and Melville Islands) and flowerpot blind snake *Ramphotyphlops braminus* (reported from Melville Island). Neither of these is likely to have a major impact on conservation values.

Isolation may protect the Tiwi Islands from invasion by the **cane toad** *Bufo marinus*, which is rapidly colonising the mainland Top End. However, this species has spread to many islands off the Queensland coast, to Groote Eylandt and to islands in the Sir Edward Pellew group, mainly through inadvertent shipment on fishing boats and barges. In order to prevent the accidental shipment of toads, inspection and washdown procedures will be needed for boats travelling to the Tiwi Islands.

As with the management of weeds, the management of exotic animal pests on the Tiwi Islands will require considerable discussion about the costs and benefits of pests; the establishment of a reporting process and control strategy; and the provision of adequate resources and information for long-term control.

The most immediate steps for this process are:

> *8.3.1. Participative development of a feral animal strategic plan for the Tiwi Islands*, which should include
>
> *8.3.2. No introduction of pigs to Melville Island*;
>
> *8.3.3. Control of pigs on Bathurst Island*, including reduction in numbers and, where appropriate, exclusion fencing for susceptible rainforest patches;
>
> *8.3.4. Reduction in numbers of buffalo on Melville Island*, and particularly in the eastern half (where the population is at highest density);
>
> *8.3.5. Establishment of quarantine procedures to prevent cane toads travelling to or between the Islands*.

8.4. Forestry

Management standards and programs and industry guidelines for plantation forestry are being developed elsewhere and are outside the scope of this report. We restrict ourselves here to brief comment on some issues related to biodiversity.

Inevitably, the transformation of extensive areas of tall open eucalypt forest to short-rotation plantations of exotic trees will disadvantage many components of Tiwi biodiversity. Excluding from consideration here any assessment of whether the plantation project should proceed, what management practices can be adopted which minimise this loss?

A large plantation development project will bring increased traffic to and around the Islands, greatly increased amounts of disturbed lands, and more infrastructure. These changes will increase the likelihood of transhipment and spread of weeds. A weed management plan, which is well-resourced, diligently applied and regularly reviewed, will be needed (and is being developed) in order to combat these increased threats.

The plantation species currently preferred, *Acacia mangium*, has some weed potential. Unchecked, it may colonise native vegetation adjacent to plantations, and it can hybridise with the native *Acacia auriculiformis*. This may be a problem especially for the margins of rainforest patches and for riparian areas (environments in which *A. auriculiformis* is most prevalent, and which provide suitable sites for feral *A. mangium*). Prospectively, the very vigour and rapid growth which makes *A. mangium* such a valued plantation crop may then render feral populations capable of exerting substantial impacts on these typically small or restricted environments. The problem can, and should, be eliminated with the exclusive use of sterile crop stock.

The retained buffers of native vegetation around watercourses that we propose in section 6.2. above should be adequate to retain water quality and protect riparian vegetation. Such retained riparian buffers will also provide dispersal routes for many animal species through and across much of an otherwise highly modified landscape. Landscape-wide hydrological integrity will also be least jeopardised if poorly drained

areas (such as some of the treeless plains) are avoided for plantations, if the area of bare ground exposed is minimised in the early wet season (when heavy rain falls may transport large quantities of soil); if plantations are restricted to essentially flat areas; and if the application of fertilisers and pesticides is minimised and "leakage" beyond the plantation area is prevented. ForSci (1999) notes that "*The high growth rate of the plantations will mean that the water demand will be very much greater than for the existing native vegetation. Such a demand will be provided from soil water. (In some locations) … there is a potential to reduce groundwater recharge in low rainfall years. The impact could be reduced flow in springs in the dry*". Such an effect would have most impacts on the spring-dependent wet rainforest patches, which have the highest concentrations of significant biodiversity, especially so for those highly restricted species which are most reliant upon year-round access to water or saturated soils. While our proposed buffer of 500m around wet rainforest patches should provide protection against such impacts, we note that groundwater flows may be spatially highly complicated and indirect, such that the location of aquifer/groundwater impacts may not be easily predictable and may be substantially distant from the factor(s) causing the impact.

ForSci (1999) notes that the total area needed for economically viable plantation may be composed of a few very large blocks or many more smaller more dispersed blocks. We have no direct information which can be used to assess the relative biodiversity costs and benefits of these options, and there is little succour in the translation of generally poorly-established biodiversity guidelines from very different forestry systems elsewhere. The option of more dispersed small plantations probably comes at the cost of a substantial expansion in the sphere of ecological influence of development (e.g. across more sub-catchments), and increased roading and associated infrastructure, compared with a more concentrated set of larger plantations; and so, we'd guess it to be less preferable.

Again, we have no direct information on the need for, or preferred characteristics of, any biodiversity corridors within the plantation area; and the application of generally poorly-justified criteria from forestry schemes elsewhere is pretty tenuous. In an area with substantial plantation development, we would suspect that linear non-riparian corridors will not substantially increase the landscape-wide persistence of species above and beyond the measures we have already proposed (retention of rainforests and watercourses and their buffers). One exception may be for maintaining connectivity between otherwise isolated rainforest patches. Another exception may be where strips of retained eucalypt forests may provide the means for forest-dependent species (such as red goshawk) to disperse between, and hence use and retain populations in, eucalypt forest patches which (with broadacre clearing around them) have become too small to by themselves support viable populations. But this is as much imagination as science. A far better solution is to maintain a large region relatively disturbance-free, and to ensure that, in regions where disturbance is concentrated, reasonably large areas of habitat are maintained in a continuous extent around the developments.

Soils, topography and rainfall dictate that environments suitable for plantation development are restricted largely to tall open forests dominated by *Eucalyptus tetrodonta, E. miniata* and/or *E. nesophila*, and, to a lesser extent, treeless plains (ForSci 1999). In terms of biodiversity conservation, the treeless plains should be avoided as they are a far more distinctive and restricted environment. In order to minimise biodiversity costs, it is also far preferable to first absorb into new plantation projects all areas which have already been subject to modification (such as plantations of exotic timbers under previous failed forestry schemes).

Forest development will bring some resources and labour focused on environmental management issues associated with the plantations (including fire and weed management). There are few such resources available now to manage these issues on the Tiwi Islands. If some of the forestry staff and resources available for environmental management can contribute also to management problems in native vegetation beyond the plantation area, the management of those areas may well improve above the current level. Indeed, management of environmental issues in plantations alone will likely fail unless it is integrated appropriately with management across the Islands as a whole.

In summary, we offer the following recommendations from our brief consideration of these forestry issues:

8.4.1. Only non-fertile plantation stock should be permitted.

8.4.2. The proposed 500m buffers around wet rainforests should be regarded as a minimum, and these will need reviewing in light of an ongoing monitoring program for ground water and rainforest condition near plantation areas.

8.4.3. Should plantation proceed, a few large sites devoted to plantation is probably preferable to the same area made up of many smaller more diffuse plantations.

8.4.4. We have no evidence for or against the need for corridors to connect retained vegetation. Our proposed buffers around watercourses and rainforest patches are more likely to be important for dispersal and maintenance of populations, except that some connections of native vegetation should be maintained for rainforest patches which would otherwise be isolated.

8.4.5. Plantations should not be developed on treeless plains. New plantations should first use areas which have already been subject to modification (especially those sites which now support abandoned plantations of other exotic species).

8.4.6. Environmental management strategies developed for plantation areas need to be integrated with consideration of management issues across the Islands as a whole, and some resources and training made available by forestry development should be used to manage related issues on a whole of Islands level.

8.5. Monitoring

A range of factors unrelated to forestry or any other development projects is already causing changes to biodiversity on the Tiwi Islands, as for northern Australia as a whole (Franklin 1999; Woinarski 1999, 2000). These factors include the spread of feral pest animals, the invasion and spread of weeds, changes in the previously long-established pattern of burning, changes in the intensity and practices of hunting,

changing climate and possibly changes in the incidence, prevalence and types of diseases and parasites. Typically, these factors have complex impacts, each benefitting and disadvantaging different sets of species, and sometimes acting synergistically or in a compensating manner. Recent evidence suggests that these changes are leading to a gradual winnowing of some of the most distinctive fauna of northern Australia (notably including the granivorous rodents, finches, quails and some pigeons) and relatively subtle but pervasive and insidious changes in vegetation. Typically, these changes have been least, and most delayed, on islands. But there is some evidence (e.g. for hooded robin and for *Burmannia* DNA61177 "Melville Island") for recent and current decline for some species on the Tiwi Islands. Unfortunately, the lack of previous biodiversity sampling on the Tiwi Islands limits our capability to assess this "background" level of change (although many Tiwi people may have an accurate assessment of which species are becoming either more or less common).

Establishment of a substantial forestry industry is likely to create more acute at least localised changes in biodiversity. In terms of assessing the impact of that industry and maintaining best quality environmental management standards, it is desirable to segregate the impacts due to forestry from the more pervasive "background" changes due to other factors. Those components of the Tiwi environments which are most likely to be affected by forestry development, and/or those for which it is least desirable to suffer even minor impacts comprise:

- *aquatic biota*, potentially disadvantaged by changes to water quality (e.g., increased sedimentation), flows (e.g. due to increased use by plantations of groundwater) and pollution (by fertilizers or pesticides).
- *riparian vegetation*, for the same reasons as above;
- *wet rainforests*, largely because of plantation use of groundwater;
- *wide-ranging vertebrates for which the eucalypt forests form a major habitat component* (notably including red goshawk, masked owl, hooded robin, partridge pigeon, brush-tailed rabbit-rat and black-footed tree-rat), which are unlikely to persist in areas transformed from eucalypt forest to plantations, may not persist in retained areas fragmented or diminished by plantations, and possibly may have their total Tiwi populations reduced so much that their longer-term Islands-wide persistence is jeopardised;
- *a small set of threatened and/or endemic plants in the understorey of eucalypt forests* (notably *Typhonium jonesii, T. mirabile* and *Desmodium tiwiense*).

These elements should form the focus of the biodiversity component of monitoring associated with plantation development. Such monitoring should also include ongoing assessment of any spread of weeds and other exotic plants, and of the effectiveness (and collateral damage) of weed control measures.

There are obvious problems in providing any more detailed prescriptions for monitoring, given that uncertainty remains about the location and configuration of any plantation development. We would suggest that monitoring for biodiversity may be achieved most efficiently if it is based on a comparison of five sites (of about 5-20ha) of retained vegetation in different subcatchments either bordering or fragmented by plantations in the western half of Melville Island, and five sites in different subcatchments in the extensive unmodified landscapes on the eastern half. The sites should be matched as closely as possible for vegetation composition (which should include eucalypt forest, rainforest patches and riparian vegetation), geology and topography. Intensive sampling of all ten sites should be conducted to provide population estimates for all of the species listed above (or for the species within the environments listed). The five

sites in the disturbed western half should be sited to represent a range of plantation management scenarios (e.g. adjacent to small or large plantations; or in fragments with and without connecting corridors) or impact intensities (e.g. by varying the distance of the monitoring site from plantation edge). Sites selected should be sampled before plantation development in order to provide a baseline, and to examine for pre-existing differences between the set of eastern and set of western sites. Sites then should be sampled annually. In addition, specific monitoring studies should be conducted for red goshawk (involving radio-tracking to assess the fate of birds in territories subject to some plantation development, and to assess whether corridors are used) and for wet rainforests (specifically including assessments of any changes in groundwater characteristics and any accompanying changes in floristics or health).

9. UNCERTAINTY AND SHORTCOMINGS

This report distils a large amount of information collated for and collected during this study. But this amount is still meagre relative to other conservation planning exercises in the Northern Territory (e.g. the recently completed conservation plan for the Daly Basin (Price *et al*. 2000) took several years of field work and included nearly three times as many fauna records as that available for the Tiwi Islands), and in the CRA/RFA forest use and assessment processes conducted recently in southern Australia.

Our most serious information shortcomings (and hence interpretative uncertainty) relate to:

- a small group of ground layer plants which occur in eucalypt open forests and which are evident only in the wet season and early dry season (specifically including *Typhonium mirabile* and *T. jonesi*);
- a group of animal species which have low populations but which are or may be especially associated with eucalypt open forests (red goshawk, butler's dunnart, hooded robin);
- verification of our preliminary vegetation map; and
- relative lack of information for Bathurst Island.

There are three processes for ameliorating or remedying these deficiencies: additional specifically targetted studies; intensive pre-clearing searches or studies in areas proposed for development; and use of the precautionary principle in conservation planning.

9.1. Additional targetted studies

<u>seasonal bias in sampling</u>

Our main field work (and that of most previous environmental studies on the Tiwi Islands) occurred in the mid to late dry season. The relative lack of wet season sampling:

- prevented us from obtaining (substantial) information on wet season migratory birds (such as the CAMBA and JAMBA listed oriental cuckoo). In our opinion this is not a major problem, as these species typically have a reasonably broad habitat range and the Tiwi Islands do not hold a significant proportion of total populations for any migratory land bird taxon.
- prevented us from examining any seasonal change in habitat use for vertebrate animals. For example, it is possible that some species recorded here (based on dry season surveys) as habitat generalists may become more specialised in their habitat use in the wet season, and hence more vulnerable to land use changes than is apparent from our data. Again, in our opinion this is not likely, based on our experience with seasonal variation in habitat use by vertebrates on the Top End mainland.
- prevented us from adequately delineating the status and distribution of some plant species which are evident for only part of the year. We recognise that this is a

substantial problem, that can be properly resolved only with supplementary sampling during the wet season.

> *9.1.1. Undertake supplementary wet season sampling to provide a more comprehensive assessment of the abundance and distribution of some annual plants occurring in the eucalypt open forest, particularly* Typhonium jonesii *and* T. mirabile.

vertebrate species whose status remains poorly known

Our intensive field sampling attempted to address two aims, that of deriving as much information as possible about all species across as much of Melville Island as we could access, and that of attempting to obtain as much information as possible about some pre-selected species. We would claim to be reasonably successful in both aims, but with the significant exceptions for three of the pre-selected species - red goshawk, butlers dunnart and hooded robin. The information that we collected and collated for these three species is insufficient to allow confidence in conservation planning for these species. The difficulty with collecting data for these species (and paradoxically the reason why it is of concern that we should have inadequate information) is that all probably have only very low population totals. There is need for additional studies on each of these species, in order to better clarify status (total population size, distribution, threats and habitat preferences). Such studies may usefully incorporate the traditional knowledge of these species possessed by Tiwi people, to a greater extent than was possible in our study.

> *9.1.2. Undertake supplementary studies of the distribution and abundance of red goshawk, hooded robin and butler's dunnart.*

While we attained substantially more information about masked owl, brush-tailed rabbit-rat and black-footed tre-rat, our data are insufficient to confidently assess the impacts upon longer-term population viability of loss of a substantial proportion of their preferred eucalypt forest habitat. More detailed autecological studies are required for these taxa, in order to provide data for population modelling, and hence provide a more informed assessment of impacts of a range of land-use options, and management actions which may best ameliorate those impacts.

> *9.1.3. Undertake supplementary autecological studies of the masked owl, brush-tailed rabbit-rat and black-footed tre-rat, in order to provide adequate population viability models.*

refinement of vegetation mapping

Vegetation patterning on the Tiwi Islands is generally subtle and gradational, providing complex floristic and structural variation in association with minor changes in drainage, lithology and topography (Wilson and Fensham 1994; Fensham and Kirkpatrick 1992),

rather than markedly pronounced changes coinciding with well-defined environmental disjunctions. This hinders the development of fine-scale environmental mapping. The map that we produced should be regarded as a preliminary product still requiring field verification, and subsequent refinement.

> *9.1.4. Field test and refine the vegetation map associated with this report*.

Bathurst Island

All of the field work which we undertook for this survey was on Melville Island, and most of the data that we collated from previous studies refers mainly to Melville Island. While this is not unreasonable given that the explicit focus of this study was conservation planning on Melville Island, the relative scarcity of information from Bathurst Island is a deficiency, as many environments are shared between the two islands, many species occur across both, and many conservation management issues are common to both Islands. This shortcoming can only be addressed adequately with a specific biodiversity survey program on Bathurst Island.

> *9.1.5. Undertake supplementary studies of biodiversity on Bathurst Island*.

9.2. "Pre-clearing" surveys

The data that we have assembled relates to about 1000 sites for plants and 350 sites for animals (Fig. 6 above), a total sampled area of around 0.025% of the Tiwi Islands. While we can extrapolate from this small base for some species through distributional modelling, we can obviously never be certain about what biota is in any given unsampled area. This uncertainty is generally especially problematical for rarely recorded species. One obvious response is to ensure that additional "pre-clearing" surveys are undertaken across a set of possible sites proposed for development, and that any from this set which are found to have significant conservation attributes are then accorded lowest priority for development. This response will be workable when there is some flexibility for developers to choose from among a set of sites which together occupy a larger area than that needed for development.

> *9.2.1. Before any clearing, reconnaisance surveys should be undertaken to examine for the presence of the threatened and other species considered here (Table 10) to be of higher priority. Sites containing such species should be accorded the lowest priority for clearing.*

9.3. Precautionary conservation planning

In northern Australia, there is very little information concerning the short-term (let alone long-term) environmental consequences of extensive clearing of native vegetation and

the development of plantation forestry. It is responsibly prudent to stage development well within safe bounds, and to link staged expansion of development to an ongoing assessment derived from a carefully designed environmental monitoring programs.

Given the uncertainty described above for the status of some conservation attributes on the Tiwi Islands, it is also important that conservation planning minimises risks. Reduction in the "rules" that we use to define retained areas (notably for buffer widths) will increase such risks.

9.3.1. Developments should be staged, with carefully designed monitoring programs accompanying development, and results from these programs used to refine the assessment of impacts of any further extensions.

9.3.2. The conservation "rules" that we recommend for retained areas (e.g. buffers) should not be weakened, without explicit recognition that such action will increase the risks of loss of biodiversity.

10. TOWARDS A COMPROMISE: ASSESSMENT OF A NEGOTIATED CONSERVATION-DEVELOPMENT OUTCOME

Section 6 above describes a desktop exercise in which a comprehensive and adequate "retained area" system is developed *tabula rasa*, essentially without regard to any other land-use demands or preferences. It is not the ideal reserve system in that it "sacrifices" up to 25% of the population of some threatened and/or endemic taxa. But it is developed in a logical, clear, prioritised and repeatable manner, and it would provide acceptable levels of conservation security for all known conservation attributes on Melville Island.

But our "solution" is likely to severely constrain land use options for the Tiwi landowners, and will remain a futile desk-top exercise without broad acceptance by the Tiwi people. The Tiwi Land Council, representing all Tiwi landowners, has clearly enunciated a wish to develop a plantation forestry industry on their lands. They have also indicated that they may seek to provide explicitly for biodiversity conservation values through setting aside a substantial area on the eastern part of Melville Island.

Here, we provide an assessment of the biodiversity costs and benefits of a land-use plan (labelled here as "Scenario 2") which leaves room for commercial forestry development but commits part of Melville Island to biodiversity conservation.

The Tiwi Land Council has described this land use choice thus:

"Having accepted a required Tiwi development land use of 100,000 ha on Melville Island, there are continuing discussions among Tiwi landowners to set aside a corresponding area to biodiversity conservation. However, the conservation area being discussed may extend in size to over 3000 km^2 or half of Melville Island. It can be anticipated, with reasonable confidence, that the landowners will agree to set aside a significant area for a National Park" (John Hicks *pers. comm*.)

To investigate the values of such a concept, we consider the area marked in Fig. 20, recognising that this is merely an indication of a possible boundary to a possible conservation area.

We consider the values in this area within an assessment of a package which also includes a reduced area (compared to the "solution" developed in Section 6) of native vegetation retained in the western half of Melville Island. For that western half, we weaken our conservation guidelines to:

- retain all rainforest patches (i.e. no change);
- buffer all wet rainforest patches by 400m (a reduction from 500m);
- buffer all other rainforest patches by 200m (a reduction from 250m);
- buffer rivers by 150m [from each bank] (a reduction from 200m), creeks by 100m (no change), drainage lines by 50m (no change), and wetlands by 150m (a reduction from 200m);
- buffer all the known occurrences of 6 localised threatened plant species (*Typhonium jonesii, T. mirabile, Calochilus caeruleus, Dendrobium*

trilamellatum, Lindernia cowiei and *Spermacoce* D132770 Piper Head) by 250m (a reduction from 500m);
- buffer all the known occurrences of hooded robin and butlers dunnart by 500m (a reduction from 1km) and of red goshawk by 1km (a reduction from 2 km); and
- make no additional attempt to explicitly set land aside for those three species, and also for masked owl, brush-tailed rabbit-rat and black-footed tree-rat (a reduction from the guideline of retaining 75% of the population and/or preferred habitat for each of these species).

Maps of the western half of Melville Island showing the resulting retained area network (compared to that derived in Section 6) are given in Fig. 21. Of 1,918 km^2 of eucalypt open forest in the western half of Melville Island, the weakened conservation criteria leave 1,520 km^2 (79%) outside buffers or other retained areas, compared with 759 km^2 (40%) left outside the retained area network derived in Section 6.

Our assessment of the package (of weakened conservation criteria on western Melville Island plus National Park covering the eastern half of Melville Island (scenario 2) against that derived (in Section 6) without consideration of other land uses (scenario 1, labelled as the "unconstrained" network) is detailed in Table 13.

Table 13. Assessment of a realistic package of conservation area for eastern Melville Island and weakened conservation guidelines for western Melville Island, against a retained land network unconstrained by other land use considerations. All values given relate to Melville Island only (i.e. do not consider Bathurst Island). All areas are in km^2.

conservation value	**measure**	**unconstrained network**	**eastern conservation area (plus western weaker criteria) =total**
area of retained lands		4,208	3,779
comprehensive representation of all environments	area [% of its extent] of wet rainforest in retained area	22 [100%]	22 [100%]
	area [% of its extent] of dry rainforest in retained area	104 [100%]	104 [100%]
	area [% of its extent] of mangal forest (mangroves) in retained area	430 [85%]	429 [85%]
	area [% of its extent] of exposed sand and saltflats in retained area	111 [96%]	112 [98%]
	area [% of its extent] of grasslands & sedgelands in retained area	135 [85%]	141 [88%]
	area [% of its extent] of *Melaleuca* open forests in retained area	45 [97%]	45 [96%]
	area [% of its extent] of *Melaleuca* low woodland in retained area	9 [74%]	9 [73%]
	area [% of its extent] of treeless plains in retained area	117 [73%]	46 [29%]
	area [% of its extent] of *Eucalyptus* open forests (dense) in retained area	1019 [74%]	862 [62%]
	area [% of its extent] of *Eucalyptus* open forest (mid density) in retained area	1627	1425 [67%]

	area [% of its extent] of *Eucalyptus* open forests (open) in retained area	653 [75%]	559 [64%]
	area [% of its extent] of *Eucalyptus oligantha* woodland in retained area	92 [97%]	26 [27%]
wet rainforest patches	no. present in retained area network	244	244
	no. buffered by at least 500m.	244	216
other rainforest patches	no. present in retained area network	715	715
	no. buffered by at least 500m	420	465
	no. buffered by at least 250m.	715	715
rivers, wetlands and riparian vegetation	rivers: total length (km) in retained area network.	1448	1448
	rivers: length buffered by at least 200m.	1448	920
	creeks: total length in retained area network.	2625	2625
	creeks: length buffered by at least 100m.	2625	2625
	wetlands: total area in retained area network	197	197
	wetlands: area buffered by at least 200m.	197	138
localised threatened plants	*Typhonium jonesii*: no. sites included in retained area network	2	2
	Typhonium jonesii: no. sites with at least 500m buffer	2	0
	Typhonium mirabile: no. sites included in retained area network	5	5
	Typhonium mirabile: no. sites with at least 500m buffer	5	1
	Calochilus caeruleus: no. sites included in retained area network	2	2
	Calochilus caeruleus: no. sites with at least 500m buffer	2	0
	Dendrobium trilamellatum: no. sites included in retained area network	2	2
	Dendrobium trilamellatum: no. sites with at least 500m buffer	1	1
	Lindernia cowiei: no. sites included in retained area network	1	1
	Lindernia cowiei: no. sites with at least 500m buffer	1	1
	Spermacoce D132770 Piper Head: no. sites included in retained area network	1	1
	Spermacoce D132770 Piper Head: no. sites with at least 500m buffer	1	0
threatened vertebrates	butler's dunnart: no. known sites included in retained area network	3	3
	butler's dunnart: no. known sites with at least 1km buffer	3	2
	butler's dunnart: area of suitable habitat retained	3460	2936
	red goshawk: no. known sites included in retained area network	6	6
	red goshawk: no. known sites with at least 2km buffer	6	1
	red goshawk: area of suitable habitat retained	3298	2845
	hooded robin: no. known sites included in retained area network	1	1
	hooded robin: no. known sites with at least 1km buffer	1	0

	hooded robin: area of suitable habitat retained.	3415	2891
	masked owl: estimated % of existing population in retained area	75%	65%
	brush-tailed rabbit-rat: estimated % of existing population in retained area	75%	65%
	partridge pigeon: estimated % of existing suitable habitat in retained area	75%	64%
	false water-rat: no. known sites included in retained area network	2	1
	false water-rat: estimated % of existing suitable habitat in retained area	91%	92%
endemic vertebrates	black-footed tree-rat: estimated % of existing population in retained area	75%	68%
endemic plants (other than rainforest spp.)	*Desmodium tiwiense*: no. known sites included in retained area	3	1
	Desmodium tiwiense: area of suitable habitat retained	3298	2845
	Scleria carphiformis: no. known sites included in retained area	1	1
	Scleria carphiformis: area of suitable habitat retained	117	46

Obviously, in retaining a smaller area than for Scenario 1, Scenario 2 provides less security for some of the Tiwi conservation attributes. However, in general, it provides reasonable levels of representation for most attributes and some representation for all attributes. The Scenario has some conservation advantages over Scenario 1, in that it is generally less bitsy (i.e. the retained area is largely consolidated into an achievably manageable whole). It is also more likely that this solution will draw in more resources for appropriate management of the retained areas. The weakening of the buffer areas proposed in Scenario 2 for western Melville Island should be matched by more intensive monitoring of the fate of these retained areas, as these weakened criteria have clearly exposed these retained areas to greater risk of degradation.

11. CONCLUSIONS

We describe an area with outstanding value for biodiversity conservation, highly significant at a Territory and national scale, and arguably qualifying for international significance at World Heritage level (see Appendix F for relevant criteria).

Is this hyperbole? The most direct comparison we make is with our recently completed conservation plan for the Daly Basin bioregion (Price *et al*. 2000). Some relevant statistics about biodiversity conservation values are given in Table 14 below.

Table 14. A summary table comparing species richness and biodiversity conservation values for the Daly basin bioregion and the Tiwi Islands.

		DALY BASIN	TIWI ISLANDS
area (km^2)		20,800	7,490
no. native species	*animals*	412	334
	plants	1240	1180
no. listed vulnerable or endangerd taxa	*animals*	4	6
	plants	2	14
no. endemic taxa	*animals*	0	7
	plants	11*	10 (+14)**

* this tally includes total endemics and species which occur nowhere else in the Northern Territory (but also occur beyond the Territory).
** 10 species are total endemics, and a further 14 occur nowhere else in the Territory, but are reported from beyond the Territory.

This simple comparison suggests that despite a substantially smaller area, the Tiwi Islands have nearly as many species, but, more importantly, substantially more species of conservation significance, than the Daly Basin. Many other comparisons are of course possible, but we consider that there would be very few other locations in Australia which compress so many conservation values into one area.

Accepting then that the biodiversity conservation values of the Tiwi Islands are important, a series of inter-related questions follow:

- are those values secure?
- if not, do they need more deliberate conservation management attention?
- where should this attention be directed?
- what mechanisms should be used for the management and protection of these values?
- how can these mechanisms be supported?

We have attempted to answer these questions over the course of this report.

Unfortunately, the Tiwi conservation values cannot be assumed to be secure. This is despite the isolation of the Islands from many of the factors threatening biodiversity on the mainland, and the maintenance over most of the Islands' area of land management

which at least partly continues that long practised by the Tiwi people. Insecurity is an inevitable fear for species occurring only in small populations at a few sites. But the insecurity is greatly magnified with ongoing and apparently inexorable increase in the impacts of feral animals and weeds, and gradual transformation of traditional burning practices. To this gradual change is added the uncertainty surrounding more acute and pronounced impacts of the proposed extension of plantation forestry, the catalyst for the present study. Without some formal attention to the identification and management of biodiversity conservation values, the proposed plantation developments would be likely to diminish at least some of those values, in some cases possibly irrevocably.

Hence, we argue that the conservation values do need management attention, in the form of landscape wide control of the impacts of weeds, feral animals and fire, but also more sharply in terms of defining areas which should be set aside and excluded from clearing or other form of development.

In Section 6 of this report we develop a framework for identifying areas which should be retained, and provide maps which meet the conservation criteria so developed. We recognise that for some of these conservation values, there may be many geographic options which equally well fufill the conservation goals. We conclude that our conservation criteria cannot be met without retaining as natural vegetation around 73% of the Tiwi Islands. This high proportion is due mainly to our use of the target of retention of at least 75% of the population or extent of preferred habitat for six endemic and/or threatened vertebrate species (masked owl, brush-tailed rabbit-rat, black-footed tree-rat, red goshawk, hooded robin, and butlers dunnart).

We recognise that this outcome ("Scenario 1") is likely to remain a hypothetical desk-top exercise, as it is unlikely to provide the Tiwi landowners with sufficient land-use flexibility.

Accordingly, we examine the conservation costs and benefits of a more realistic land-use model ("Scenario 2") which leaves a higher proportion of eucalypt forest on western Melville Island available for other purposes, but treats a large area of eastern Melville Island as a significant conservation area. Recognising that the boundaries of any such area remain unresolved, and that the Tiwi Land Council has not committed to such an outcome, our analysis of an indicative area for consideration suggests that this outcome is likely to achieve much of the conservation targets that are appropriate for the Tiwi environments and biota.

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Appendix A:

terms of reference for this study.

Terms of agreement between Parks and Wildlife Commission of the Northern Territory and the Tiwi Land Council, for consultancy on the assessment of conservation values on Melville Island.

The Commission agrees to provide the following, by end of October 2000*:*

1. *Collation of available information on the distribution of all plant and animal species on Melville Island.*

2. *A comprehensive 1:50 000 vegetation map covering Melville Island.*

3. *An extensive field sampling of Melville Island to estimate the total population size, population density in different habitats, and distribution of all threatened and endemic plant and vertebrate species.*

4. *Also from this field sampling, records of the distribution and abundance of all other vascular plant and vertebrate species.*

5. *Where appropriate, information about ecological knowledge from Tiwi landowners.*

6. *Provision of population and distributional modelling for all threatened and endemic plant and vertebrate species, which will indicate the area(s) required to maintain long-term viable populations.*

7. *A series of mapped options for habitat retention which will safeguard all threatened and endemic plant and vertebrate species, and include adequate representation of all other vascular plant and vertebrate species.*

8. *An evaluation of the uncertainty associated with lack of sampling in the wet season, and a discussion of proposed mechanisms for remedying this shortcoming.*

9. *An evaluation of the potential off-site effects upon biodiversity of plantation development, with specific reference to impacts of fire management, water use and spread of weeds (with the recognition that more detailed assessment of weed and fire management will be undertaken by other parties).*

10. *A proposed biodiversity monitoring program in plantation and retained native forest, which will provide adequate warning of variation from predicted impacts.*

11. *An evaluation of options for funding and other support to maintain the retained native forests.*

Appendix B:

extracts from relevant national strategies and initiatives concerning forest conservation and use.

National Strategy for Ecologically Sustainable Development
December 1992

Forest Resource Use and Management

Challenge

To ensure Australia continues to refine and improve mechanisms for the ecologically sustainable management and use of its forests, by bringing together the commercial and non-commercial values of forests in such a way as to improve the material and non-material welfare of all Australians, and to ensure all forest values can be utilised on a sustainable basis.

Strategic Approach

One important way in which governments will pursue this will be by implementing the National Forests Policy Statement with its focus on achieving the best mix of conservation and commercial uses of native and plantation forests, in an integrated planning and management framework. Key approaches to forest management will include: setting a sustainable management framework for the use of native forests in order to achieve social and environmental objectives; recognising that commercial uses of forests which are based on ecologically sustainable practices are legitimate activities; and seeking complementary management of forests for all uses through integrated, strategic planning and operational management.

Objective 3.1

to manage and utilise Australia's forest estate for all forest values on an ecologically sustainable basis

Governments will:

- maintain a permanent native forest estate based on the current area of native forest which covers all land tenures and manage it in an ecologically sustainable manner
- promote complementary management in State and Territory reserves and sympathetic management by private forest owners
- encouraging ecologically sustainable management of private native forests by:
- encouraging the application of Codes of Practice covering wood production and other uses;
- providing incentives, information and technical advice;
- promoting sustainable forest management through Landcare groups; and
- ensuring future land development is in line with soundly-based regional conservation and development strategies
- work through the IGAE to develop a land use decision-making process which reduces fragmentation and duplication between all levels of government
- improve interaction between forest management agencies by adopting an approach which takes all forest values into account, in order to achieve agreed and durable land-use allocations

Objective 3.2

to maintain ecological processes within the forests, maintain biodiversity, and optimise benefits to the community from all uses, within ecological constraints

Governments will:

- determine agreed criteria for a comprehensive and representative reservation system
- protect old growth forest in a representative reserve system as the primary means of protection, supported by complementary management outside reserves
- protect all forest wilderness areas in reserves
- develop a dedicated and secure nature conservation reserve system, containing comprehensive, replicated, adequate and representative areas of all major native forest ecosystems and other listed values
- address biological threats to forests; introduce strict guidelines for the use of agricultural and veterinary chemicals; and provide adequate quarantine measures and monitor and control feral animals and exotic pests
- foster community understanding of, and support for, ecologically sustainable forest management in Australia, and provide opportunities for effective public participation in decision making
- produce 'state of the forests' reviews every five years for public information

Objective 3.3

to enhance the quality of life for successive generations of Australians by protecting and enhancing all of the values available from Australia's forests, and development of an ecologically sustainable and internationally competitive forest products industry

Governments will:

- increase Australia's plantation resource so as to provide a commercial wood resource for industry
- lift export controls on private and public plantation woodchips, subject to satisfactory codes of practice, and facilitate domestic value adding industries
- adopt national environmental guidelines for new bleached eucalypt kraft pulpmills
- promote forest industry development initiatives and continue skills up-grading, workplace reform and occupational health and safety programs
- further develop pricing and allocation arrangements for public forests which:
- are market based;
- at least cover the full cost of efficient management (including regeneration) attributable to wood production;
- include a fair return on capital;
- provide adequate return to the community from wood production operations in public forests;
- are well defined and fully transferable when this does not result in the creation of excessive market power; and
- are flexible and involve competitive bidding arrangements

- establish a Forest and Wood Products Research and Development Corporation; undertake additional research into conservation and environmental aspects of forests, and plantations research; and continue support for the national pulpmill research program

National Forests Policy Statement 1992

The NFPS was endorsed by the Commonwealth and all State/Territory governments and provided a series of goals, objectives and policies for Australian forest environments.

The NFPS noted that the goals "*should be pursued within a regionally based planning framework that integrates environmental and commercial objectives*".

The goals of the NFPS included:

- ***Conservation***. "*The goals are to maintain an extensive and permanent native forest estate in Australia and to manage that estate in an ecologically sustainable manner so as to conserve the full suite of values that forests can provide for current and future generations. These values include biological diversity, and heritage, Aboriginal and other cultural values*".
- ***Integrated and coordinated decision making and management***. "*The goals are to reduce fragmentation and duplication in the land use decision-making process …*"
- ***Water supply and catchment management***. "*The goals are to ensure the availability of reliable, high-quality water supplies from forested land and to protect catchment values*."

The NFPS noted that

"*the protection of the full range of forest ecosystems and other environmental values is fundamental to ecologically sustainable forest management. It entails the maintenance of the ecological processes that sustain forest ecosystems, the conservation of the biological diversity associated with forests (particularly endangered and vulnerable species and communities), and the protection of water quality and associated aquatic habitat …*"

and that the Governments will

"*manage for the conservation of all species of Australia's indigenous forest fauna and flora throughout those species' ranges, and they will maintain the native forest cover where a reduction in this cover would compromise regional conservation objectives, consistent with ecologically sustainable management*."

These objectives are to be pursued in three ways.

> "*First, parts of the public native forest estate will continue to be set aside in dedicated nature reserve systems to protect native forest communities, based on the principles of comprehensiveness, adequacy and representativeness*. The reserve system will safeguard endangered and vulnerable species and communities. Other areas of forest will also be protected to safeguard special areas and to provide links where possible between reserves or other protected areas … In developing the nature conservation reserve system and forest management approaches in other public native forests, each Government will, where possible, ensure that effective corridor systems link reserves, refuges*

> *and areas with a relatively large range of altitudinal and other geographic variation so as to take into account the possible impacts of climate change*."
>
> "*Second, there will be complementary management outside reserves, in public native forests that are available for wood production and other commercial uses and in forests on unallocated or leased Crown land*."
>
> "*Third, the management of private forests in sympathy with nature conservation goals will be promoted*."

* These terms were defined as:

Comprehensiveness: "includes the full range of forest communities recognised by an agreed national scientific classification at appropriate hierarchical levels".

Adequacy: "the maintenance of ecological viability and integrity of populations, species and communities"

Representativeness: "those sample areas of the forest that are selected for inclusion in reserves should reasonably reflect the biotic diversity of the communities".

On climate change, the NFPS recognised the need "*to manage forests so as to maintain or increase their 'carbon sink' capacity and to minimise the emission of greenhouse gases from forest activities*".

On clearance of forested areas in public land, the NFPS noted:

> "*The Governments agree that it is desirable to maintain and protect the extent and ecological integrity of native forest on public land. Accordingly, the Governments will adopt the policy that further clearing of public native forests for non-forest use or plantation establishment will be avoided or limited, consistent with ecologically sustainable management, to those instances in which regional conservation and catchment management objectives are not compromised*",

and for private lands

> "… *native forests on private lands contain some ecosystems and species that are not well represented in nature conservation reserves. They also help to maintain environmental and aesthetic values and basic ecological processes, and under conditions of climate change they may provide refuges or corridors for the movement of native species.*
>
> *Accordingly, the objectives in relation to private native forests are to encourage the maintenance of existing private native forest cover and to facilitate the ecologically sustainable management of such forests for nature conservation, catchment protection, wood production of other economic pursuits*.
>
> … *While encouraging the retention of native forests, the Governments acknowledge that private forest owners may wish to clear native forest for a range of economic uses. They agree that land clearing can be permitted provided it complies with State and regional conservation management objectives, relevant planning schemes and legislation*."

***The Nationally Agreed Criteria for the establishment of a comprehensive, adequate and representative reserve system for forests in Australia*, a report by the Joint ANZECC/MCFFA National Forest Policy Statement Implementation Sub-committee** (JANIS 1996).

This agreement provided detailed criteria for the implementation of the NFPS, specifically concerning the development of a national forest reserve system. It recognised that

"*the objectives of biodiversity conservation for forests are:*

- *to maintain ecological processes and the dynamics of forest ecosystems in their landscape context;*
- *to maintain viable examples of forest ecosystems throughout their natural ranges;*
- *to maintain viable populations of native forest species throughout their natural ranges; and*
- *to maintain the genetic diversity of native forest species.*

These objectives will be most efficiently and effectively achieved through the development of integrated regional conservation strategies, which provide for the establishment and effective management of conservation reserves and complementary management of adjoining forest areas."

JANIS (1996) provided considerable operational development for the delivery of the NFPS conservation goals, including specific criteria for the development of a forest comprehensive, adequate and representative reserve system:

The main set relates to biodiversity criteria.

> "(1) *As a general criterion, 15% of the pre-1750 distribution of each forest ecosystem should be protected in the CAR reserve system with flexibility considerations applied according the regional circumstances*
>
> *(2) Where forest ecosystems are recognised as vulnerable, then at least 60% of their remaining extent should be reserved. A vulnerable forest ecosystem is one which is:*
>
> *i) approaching a reduction in areal extent of 70% within a bioregional context and which remains subject to threatening processes; or*
> *ii) not depleted but subject to continuing and significant threatening processes which may reduce its extent.*
>
> *Vulnerable ecosystems include those where threatening processes have caused significant changes in species composition, loss or significant decline in species that play a major role within the ecosystem, or significant alteration in ecosystem processes.*

(3) All remaining occurrences of rare and endangered forest ecosystems should be reserved or protected by other means as far as is practicable … A rare ecosystem is one where its geographic distribution involves a total range of generally less than 10,000 ha, a total area of generally less than 1000 ha or patch sizes of generally less than 100 ha, where such patches do not aggregate to significant areas. This criterion is to be applied within a bioregional context having cognisance of distribution in adjoining bioregions … An endangered ecosystem is one where its distribution has contracted to less than 10% of its former range or the total area has contracted to less than 10% of its former area, or where 90% of its area is in small patches which are subject to threatening processes and unlikely to persist.

(4) Reserved areas should be replicated across the geographic range of the forest ecosystem to decrease the likelihood that chance events such as wildfires or disease will cause the forest ecosystem to decline.

(5) The reserve system should seek to maximise the area of high quality habitat for all known elements of biodiversity wherever practicable, but with particular reference to:

- *the special needs of rare, vulnerable or endangered species;*
- *special groups of organisms, for example species with complex habitat requirements, or migratory or mobile species;*
- *areas of high species diversity, natural refugia for flora and fauna, and centres of endemism; and*
- *those species whose distributions and habitat requirements are not well correlated with any particular forest ecosystem.*

(6) Reserves should be large enough to sustain the viability, quality and integrity of populations.

(7) To ensure representativeness, the reserve system should, as far as possible, sample the full range of biological variation within each forest ecosystem, by sampling the range of environmental variation typical of its geographic range and sampling its range of successional stages.

(8) In fragmented landscapes, remnants that contribute to sampling the full range of biodiversity are vital parts of a forest reserve system. The areas should be identified and protected as part of the development of integrated regional conservation strategies.

There is also a set of old-growth forest criteria and wilderness criteria. However JANIS noted that their criteria "*apply to all forested regions except those in the Northern Territory where the vast areas involved mean a different set of criteria will need to be developed*". Similarly, JANIS noted that the criteria developed for wilderness "*apply to all forested regions except those in northern Australia where the vast areas involved mean a different set of criteria will need to be developed*".

JANIS also developed a set of criteria for the design and management of individual reserves:

- *reserves should be set in a landscape context with strong ecological integrity, such as catchments;*

- *large reserved areas are preferable to small reserved areas, though a range of reserve sizes may be appropriate to adequately sample conservation values;*
- *boundary-area ratios should be minimised and linear reserves should be avoided where possible except for riverine systems and corridors identified as having significant value for nature conservation;*
- *reserves should be developed across the major environmental gradients if feasible, but only if these gradients incorporate key conservation attributes which should be incorporated in the CAR system;*
- *each reserve should contribute to satisfying as many reserve criteria as possible;*
- *reserve design should aim to minimise the impact of threatening processes, particularly from adjoining areas;*
- *reserves should be linked through a variety of mechanisms, wherever practicable, across the landscape*.

JANIS also provided interpretation of the application of these criteria. On the conservation reserve network, JANIS noted that:

> "*All reasonable effort should be made to provide for biodiversity and old-growth forest conservation and wilderness in the dedicated reserve system on public land … In situations where it is not possible or practicable to include conservation values into dedicated reserves, it is appropriate for areas to be reserved under other secure tenure or management arrangements. In practice such areas should be set aside specifically for conservation purposes and meet the following principles:*
>
> - *they are established in approved management plans and managed accordingly;*
> - *there is an opportunity for public comment on changes to reserve boundaries;*
> - *they are able to be accurately identified on maps;*
> - *they are of an area and design sufficient to maintain the values they seek to protect.*
>
> *Where the nature of a forest value that is needed to contribute to the CAR reserve system makes inclusion in either dedicated or informal reserves impractical (for example, very rare values, values with fragmented distributions, or values naturally occurring in linear form such as riparian vegetation), then protection may be prescribed in Codes of Practice or Management Plans and where appropriate, identified on maps.*"

On the contribution of private lands, JANIS noted that:

> "*The NFPS establishes that the CAR reserve system should in the first instance be selected from public land. However, in many regions it will need to include private land …. A number of strategies are appropriate for protecting biodiversity on private land, ranging from purchase of priority areas to the development of incentives for the establishment of mechanisms to ensure protection, such as covenants on leasehold and freehold lands*".

JANIS also provided interpretation of the biodiversity criteria developed:

> "*The biodiversity criteria … relate primarily to biodiversity at the forest ecosystem and species level*" and,

"*the focus … should be on those species that depend on reservation for protection … It is not necessary to ensure that every element of biodiversity that occurs within a forest ecosystem is reserved within that ecosystem. Many species may be well represented in one forest ecosystem in a region and infrequent in another, and it is not necessary to distort reserve boundaries to ensure that they are reserved in each ecosystem occurrence.*"

"*The priority for reservation at the forest ecosystem is related to how much remains relative to its initial distribution and its vulnerability to threatening processes … 15% of pre-European distribution is seen as a desirable objective, however some flexibility is both acceptable and desirable. For instance, where socio-economic impacts are not acceptable, or where biodiversity conservation objectives can be demonstrably achieved, such as for forest ecosystems which are extensive, a lower level of reservation (e.g., 10%) may prove adequate*".

"*The criteria should generally be applied within a biogeographic regional framework based upon IBRA regions, but it is important to consider the distribution of a species or forest ecosystem in adjacent regions when applying the criteria*".

"*Mapping of forest ecosystems at 1:100 000, or 1:250 000 is considered to be an appropriate scale for planning a reserve system*".

"(These criteria should) *be considered as guidelines rather than mandatory targets. Though all forest species and ecosystems should be represented in the reserve system, the effort to achieve this for the last few percent of communities and habitats may reach a point of diminishing return, and in these situations nature conservation objectives may be more efficiently and effectively achieved through other strategies … In the final selection of reserves, biodiversity, old-growth forest and wilderness values will be considered iteratively to most effectively capture the range of values within the proposed CAR reserve system. Provided that all criteria are considered when making the final reserve design, biodiversity should take precedence*."

On socio-economic considerations. "*It should be recognised that the extent of potential social and economic impacts may limit the ability to meet reserve criteria. Determination of the CAR reserve system will therefore require a comprehensive planning approach which integrates conservation requirements with social and economic considerations. The analytical processes which integrate the application of the reserve criteria with social and economic considerations should be transparent. The principle of least cost should be used and, where different configurations of reserves can be identified as meeting the criteria, the option which imposes the least cost on the community should be adopted*".

Environment Protection and Biodiversity Conservation Act 1999

(extracts from) Administrative Guidelines for determining whether an action has, will have, or is likely to have a significant impact on a matter of national environmental significance.

Introduction

Purpose of these Guidelines

Under the *Environment Protection and Biodiversity Conservation Act 1999* (the Act), an action will require approval from the Environment Minister if:

- the action has, will have, or is likely to have a significant impact on a matter of national environmental significance*; and
- the action is not subject to one of the exceptions identified below.

The matters of national environmental significance are:

- World Heritage properties,
- Ramsar wetlands of international importance,
- listed threatened species and communities,
- migratory species protected under international agreements,
- nuclear actions, and
- the Commonwealth marine environment.

The purpose of these guidelines is to assist in determining whether an action should be referred to the Environment Minister for a decision on whether approval is required. In particular, they are intended to provide guidance on whether a proposed action is likely to have a significant impact on any of the matters of national environmental significance.

The guidelines will be subject to review following experience with operation of the Act in order to improve the guidance available to proponents, industry, conservation groups and other members of the community.

A person who proposes to take an action should consider whether the action is covered by one of the exceptions identified below. If an action qualifies for one of these exceptions then it does not require approval under the Act and it is not necessary to refer the action to the Environment Minister.

The Referral Process – Triggering the Act

If a proposed action is not covered by one of the exceptions identified below, a person proposing to take an action that he or she thinks will have, or is likely to have, a significant impact on a matter of national environmental significance must refer that action to the Minister for the Environment.

The Minister will decide whether the action will, or is likely to, have a significant impact on a matter of national environmental significance.

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* In addition to actions having a significant impact on a matter of national environmental significance, the Act provides that certain actions taken by the Commonwealth, and actions affecting Commonwealth land, also require approval. These guidelines do not seek to deal with actions in these categories.

- If the Minister decides that the action is likely to have a significant impact on a matter of national environmental significance, then the action requires approval under the EPBC Act.
- If the Minister decides that the action is *not* likely to have a significant impact on a matter of national environmental significance, then the action does not require approval under the Act.

The Minister is generally required to make a binding decision on whether an action requires approval within 20 business days of receiving a referral (in some cases the decision must be made within 10 business days). If the Minister's decision is that an action does not require approval, a person will not contravene the Act if the action is taken in accordance with that decision.

If the Minister decides that an action requires approval, then an environmental assessment of the action must be carried out. The Minister decides whether to approve the action, and what conditions (if any) to impose, after considering the environmental assessment.

Determining whether an action is likely to have a significant impact on a matter of national environmental significance

The guidelines set out below include criteria which are intended to assist in determining whether the impact of an action on any matter of national environmental significance is likely to be significant.

Criteria are set out for each matter of national environmental significance.

The guidelines are intended to provide general guidance on the types of actions that will require approval and the types of actions that will not require approval. They are not intended to be exhaustive or definitive. The particular facts and circumstances of a proposed action will need to be taken into account in determining whether that action will have a significant impact on a matter of national environmental significance.

In order to decide whether an action is likely to have a significant impact, it is necessary to take into account the nature and magnitude of potential impacts.

In determining the nature and magnitude of an action’s impact, it is important to consider matters such as:

- all on-site and off-site impacts,
- all direct and indirect impacts,
- the frequency and duration of the action,
- the total impact which can be attributed to that action over the entire geographic area affected, and over time,
- the sensitivity of the receiving environment, and

- the degree of confidence with which the impacts of the action are known and understood.

The Act provides that the Minister must, in deciding whether an action is likely to have a significant impact on a matter of national environmental significance, take account of the precautionary principle. Accordingly, the fact that there is a lack of scientific certainty about the potential impacts of an action will not itself justify a decision that the action is not likely to have a significant impact on a matter of national environmental significance.

The Act provides that in deciding whether the action is a controlled action, the Minister must not consider any beneficial impacts that the action has, will have or is likely to have. Therefore, activities which will have only beneficial impacts will not be captured by the Act.

Exceptions

An action does not require approval from the Environment Minister under the Act if:

- the action is approved under, and taken in accordance with, a State management plan that is accredited by the Commonwealth for the purposes of a bilateral agreement (see section 46 of the Act), or

- the action is approved under, and taken in accordance with, a Commonwealth management plan that is accredited by the Environment Minister for the purposes of a Ministerial declaration (see section 33 of the Act), or

- the action is a forestry operation taken in a Regional Forest Agreement region (see Part 4, Division 2 of the Act), or

- the action is taken in the Great Barrier Reef Marine Park and is authorised by certain instruments issued under the Great Barrier Marine Park Act 1975 (see section 43 of the Act), or

- the action has been authorised by a Government decision on which the Minister's advice has been sought (see section 160 of the Act).

In addition, an approval is not required for an action if:

- the action was authorised by the Commonwealth, a State or a Territory prior to the EPBC Act commencing (16 July 2000), and

- at the time the EPBC Act commences, no further authorisation is required to allow the action to be lawfully taken.

Finally, the EPBC Act provides that approval is not required for an action that is a lawful continuation of a use of land, sea or seabed that was occurring immediately before the commencement of the Act. (This exception does not apply to an enlargement, intensification or expansion of an existing use.)

Listed Threatened Species and Ecological Communities

An action will require approval from the Environment Minister if the action has, will have, or is likely to have a significant impact on a species listed in any of the following categories:

- extinct in the wild,

- critically endangered,

- endangered, or
- vulnerable.

An action will also require approval from the Environment Minister if the action has, will have, or is likely to have a significant impact on an ecological community listed in any of the following categories:

- critically endangered, or
- endangered.

An action does not require approval if it is covered by one of the exceptions identified above.

Some of the criteria below refer to the concept of 'habitat critical to the survival of a species or ecological community'. This habitat includes the critical habitat for many species and community identified in recovery plans for those species/communities and the critical habitat on the Register maintained by the Minister for the Environment under the Act. However, there may not be recovery plans in place for all listed species and communities, as plans take some time to prepare. Similarly, the Register may not be comprehensive. The absence of a recovery plan or the fact that an area may not be listed on the Register of Critical Habitat does not mean that there is no habitat critical to the survival of the species or community.

Habitat critical to the survival of a species or ecological community may include areas that are necessary:

- for activities such as foraging, breeding, roosting, or dispersal,
- for succession,
- to maintain genetic diversity and long term evolutionary development, or
- for the reintroduction of populations or recovery of the species / community.

Habitat critical to the survival of a species or ecological community will depend largely on the particular requirements of the species/community in question. For example, areas only incidentally used by a vulnerable species, and which the species is unlikely to be dependent upon for its survival or recovery, are not areas of habitat critical to the survival of a species or ecological community.

Some of the criteria below refer to actions likely to lead to a "long-term decrease" in the size of a population or a "long-term adverse affect" on a community. Depending on the level of endangerment and the nature of the action, not all actions which create an immediate decrease in the population of a nationally listed threatened species or impact on a community will have long-term consequences. For example, an action which causes injury or death to only one or a very small number of a species will not, except in the case of the most endangered of species, generally lead to a long-term or irreversible decrease in the population that normal processes, rates of mortality and recruitment could not buffer.

Critically endangered and endangered species

Criteria

An action has, will have, or is likely to have a significant impact on a critically endangered or endangered species if it does, will, or is likely to:

- lead to a long-term decrease in the size of a population, or
- reduce the area of occupancy of the species, or
- fragment an existing population into two or more populations, or
- adversely affect habitat critical to the survival of a species, or
- disrupt the breeding cycle of a population, or
- modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline, or
- result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat*, or
- interfere with the recovery of the species.

(*Introducing an invasive species into the habitat may result in that species becoming established. An invasive species may harm a critically endangered or endangered species by direct competition, modification of habitat, or predation.)

Vulnerable species

Criteria

An action has, will have, or is likely to have a significant impact on a vulnerable species if it does, will, or is likely to:

- lead to a long-term decrease in the size of an *important population* of a species, or
- reduce the area of occupancy of an *important population*, or
- fragment an existing *important population* into two or more populations, or
- adversely affect habitat critical to the survival of a species, or
- disrupt the breeding cycle of an *important population*, or
- modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline, or
- result in invasive species that are harmful a vulnerable species becoming established in the vulnerable species' habitat*, or
- interferes substantially with the recovery of the species.

(* Introducing an invasive species into the habitat may result in that species becoming established. An invasive species may harm a vulnerable species by direct competition, modification of habitat, or predation.)

An *important population* is one that is necessary for a species' long-term survival and recovery. This may include populations that are:

- key source populations either for breeding or dispersal,
- populations that are necessary for maintaining genetic diversity, and/or

- populations that are near the limit of the species range.

Listed Migratory Species

An action will require approval from the Environment Minister if the action has, will have, or is likely to have a significant impact on a listed migratory species. (However, an action does not require approval if it is covered by one of the exceptions identified above.)

Note that some migratory species are also listed as threatened species. The criteria below are relevant to migratory species that are not threatened.

Criteria

An action has, will have, or is likely to have a significant impact on a migratory species if it does, will, or is likely to:

- substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of *important habitat* of the migratory species, or

- result in invasive species that is harmful to the migratory species becoming established* in an area of *important habitat* of the migratory species, or

- seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an *ecologically significant proportion* of the population of the species.

(* Introducing an invasive species into the habitat may result in that species becoming established. An invasive species may harm a migratory species by direct competition, modification of habitat, or predation.)

An area of *important habitat* is:

1. habitat utilised by a migratory species occasionally or periodically within a region that supports an *ecologically significant proportion* of the population of the species, or

2. habitat utilised by a migratory species which is at the limit of the species range, or

3. habitat within an area where the species is declining.

Listed migratory species cover a broad range of species with different life cycles and population sizes. Therefore, what is an *ecologically significant proportion* of the population varies with the species (each circumstance will need to be evaluated).

Appendix C:

Relevant sections of the *Territory Parks and Wildlife Conservation Amendment Act* 2000.

"**37. Declaration of area of essential habitat**
"(1) Subject to section 38, if there is an area of land that, on its own or together with another area of land or other areas of land, is a habitat that is essential for the survival in that area or those areas of wildlife generally or a species of wildlife, the Administrator may, by notice in the *Gazette*, declare the area to be an area of essential habitat.
"(2) The Administrator must not make a declaration under subsection (1) unless -

(a) he or she is satisfied that the Director has consulted with the owner and, if not the same person, the occupier of the land and any other person who, in the opinion of the Director, has an interest that is likely to be adversely affected by the declaration; and

(b) the Minister recommends the making of the declaration under section 38(3)(a).

"(3) Despite subsection (1), if, in the opinion of the Minister, there is an area of land in which there is a species of wildlife that is likely to become extinct if not immediately protected, the Minister may, by notice in the *Gazette*, declare the area to be an area of essential habitat.
"(4) The area of land referred to in subsection (1) or (3) may be -

(a) land that has been alienated from the Crown, including Aboriginal land but not including other freehold land; or

(b) land that is reserved or dedicated under a law in force in the Territory.

"(5) In a declaration under this section, the Administrator or Minister, as the case may be, must -

(a) describe the area of land declared to be an area of essential habitat;

(b) specify the wildlife to which the declaration relates;

(c) give the reasons for making the declaration;

(d) give details of the proposed management of the area the subject of the declaration, including specification of the objectives of making the declaration and any management programs, co-operative management programs and by-laws made under section 71 that apply to the land; and

(e) state that the land the subject of the declaration is to be used and enjoyed in a manner that is consistent with the objectives of the declaration.

"(6) In a declaration under this section, the Administrator or the Minister, as the case may be, may specify -

(a) an article, thing, animal or plant that may not be taken into or out of the area of essential habitat the subject of the declaration; or

(b) the activities that may not be carried out in the area of essential habitat the subject of the declaration,

unless authorised in writing by the Director.
"(7) The land the subject of a declaration under this section is to be used and enjoyed in a manner that is consistent with the declaration.

"**38. Submissions regarding declaration of area of essential habitat**
"(1) Before the Administrator makes a declaration under section 37(1) and on the making by the Minister of a declaration under section 37(3), the Minister must invite written submissions in respect of the declaration from -

(a) the owner and, if not the same person, the occupier of the land that is or is proposed to be the subject of the declaration and any other person who, in the opinion of the Director, has an interest that is likely to be adversely affected by the declaration by serving a written notice on each of those persons; and

(b) any other interested person by giving public notice.

"(2) Notice under subsection (1) is to -

(a) include a description of the terms of the declaration; and

(b) specify the date not more than 28 days after the date of the notice by which submissions are to be received by the Minister.

"(3) The Minister must consider each submission made to the Minister under this section and any other matter that comes to his or her attention in relation to the declaration and may -

(a) if the declaration is proposed to be made under section 37(1) - make the recommendation he or she thinks appropriate to the Administrator in relation to the making of the declaration or refuse to recommend the making of the declaration; or

(b) if the Minister made the declaration under section 37(3) - vary (including by the imposition of conditions) or revoke the declaration as he or she thinks appropriate.

"**39. Notification of declaration of area of essential habitat**

"The Director must, not later than 7 days after the date a declaration of an area of essential habitat is made under section 37 or the date the Minister varies or revokes a declaration under section 38(3)(b) -

(a) serve written notice of the making or variation of the declaration and its terms or the revocation of the declaration on the persons on whom written notice was served under section 38(1)(a); and

(b) give public notice of the making or variation of the declaration and its terms or the revocation of the declaration.

"**41. Notification of area of essential habitat on title**

"Where a declaration of an area of essential habitat has the effect of imposing a restriction on the use and enjoyment of land, the declaration is a restriction for the purposes of section 191B of the *Real Property Act*.

"**42. Conservation officer may carry out certain work**

"(1) A conservation officer may carry out the work in an area of essential habitat that the Director considers necessary to attain the objectives of the declaration of the area of essential habitat.

"(2) The conservation officer may, after giving the person in lawful occupation of land in the area of essential habitat reasonable notice of his or her intention to do so, enter the land with the assistance, plant, machinery and equipment as the Director considers appropriate to carry out the work.

"(3) The Commission is liable to pay reasonable compensation for any damage or loss suffered in consequence of work being done under this section.

These proposed amendments were explained further in the Minister's second reading speech. Relevant extracts are cited below:

"*Declaration of essential habitats is critical to the long term conservation of the Territory's biodiversity. Many species and some entire assemblages of wildlife such as patches of rainforest depend on the continued existence of one or a few often relatively small habitats. These include areas used for roosting and feeding by migrant waders during their travels between Northern Asia and Australia, areas used for breeding by sea birds, some water birds and bats, as well as patches of habitat that represent the last one or few habitats containing endangered species such as the palm, Ptychosperma bleeseri.*

There is no way in which it is possible for all such habitats be included in the system of national parks. Indeed, the special conservation needs of these habitats was discussed in the recently approved NT Parks master plan. Nor is it possible for the officers of the Parks and Wildlife Commission to attend to the needs of all such habitats requiring some form of management. In the Territory, we remain fortunate in that many of these habitats are sufficiently remote and intact not to need management intervention at this stage. Essential habitats provide a significant opportunity for community groups to become involved in conservation management and for government to devolve the responsibility in a responsible way. It is already happening with groups such as those that have been involved in the management of Ptychosperma bleeseri over the years. These amendments will formalise these responsibilities through co-operative management agreements with public accountability and quality control provided through management programs and their associated monitoring.

There are two ways in which essential habitats may be declared. The first is by the Administrator on the recommendation of the minister. This is the way in which most such habitats will be declared. The Parks and Wildlife Commission will consult with landholders and other parties whose interests may be affected by a declaration of an essential habitat. The habitat must be one that is essential to the survival in that area or those areas of wildlife in general or a particular species of wildlife. Upon receiving a proposal from the director, the minister must seek submissions from the land owners or occupier, any other person who may have an interest in the land or any other interested party. The minister must consider these submissions and any other matter that comes to his/her attention and may make a recommendation to the Administrator.

The declaration must describe the land, the species of wildlife of concern, the reasons for the declaration, details of proposed management and state the land is to be used and enjoyed in a manner consistent with the objectives of the declaration. Alternatively, the minister may make such a declaration in circumstances where the minister believes that extinction will occur if the land is not protected. The declaration is made by a notice in the Gazette and the minister must immediately call for submissions as occurs with declarations undertaken by the Administrator.

Areas of essential habitat impose a restriction on the use and enjoyment of land for the purpose of section 191(b) of the Real Property Act. Landholders may receive just compensation for such restriction and this may be determined by an appropriate court."

Appendix D:

Summary of standard wildlife survey methods (Parks & Wildlife Commission of the Northern Territory).

FAUNA SURVEY

Fauna sampling (and habitat and vegetation description) is based on quadrats. Some incidental observations are made outside quadrats, and some special methodologies may be adopted in particular projects.

Quadrats

In the Top End, the quadrats used are 50m x 50m but rectangular quadrats, with an equivalent area, may be used to sample narrow patches e.g. riparian strips. Birds are sampled in a 100m x 100m quadrat centred on the core 50m x 50m quadrat.

Quadrats are located within substantial areas of relatively homogeneous vegetation and landform, and not near boundaries, e.g. fences or roads. The exception is when a deliberate decision is made to sample a small patch, edge or ecotone. Quadrats should be well separated (i.e. 500m + apart) except where sampling adjacent contrasting land types.

Survey sites are selected to represent land units, vegetation types and land condition in the project area, along with a geographic spread. The number of habitats sampled and the number of quadrats sampled per habitat depend on the size and diversity of the study area and the time and resources available, as well as the aims of the study.

The location of each quadrat is determined as precisely as possible, preferably using averaged GPS reading.

Traps

Each quadrat is sampled using:

- 4 cage traps – one in each corner
- 20 Elliott traps around the perimeter – 5 on each side, c. 8m apart
- 4 pit traps scattered within the quadrat. Two pits are 20 litre plastic buckets and two are 10 litre plastic buckets, and each pit has 10m of drift-fence. Pits are located in different microhabitats in the quadrat e.g. in open ground; in dense grass; close to trees; in rocky areas.

All traps are marked clearly with flagging tape so they can be easily located and are opened for 3 nights. Traps are checked early each morning and rechecked at midday. Elliott and cage traps are rebaited each afternoon. The bait is a mixture of oats, peanut butter & honey. Vanilla essence, cat biscuits and tuna can be added. Cage traps may be baited with fruit or meat scraps. Trapped animals are identified and released near the capture point, or retained for as short a time as possible for identification or for taking measurements.

Bird counts

Eight daylight bird counts are carried out in each quadrat. In addition, birds are recorded during two nocturnal visits – see below. The majority of bird counts are done in the early morning, with a few spread through the day.

Each bird count is theoretically an instantaneous count of all the birds within the quadrat. In practice this involves briefly walking through the quadrat but it is not a count over an extended period of time. The number of individuals of each species is recorded for each count. Only birds that are using the quadrat are recorded – birds merely flying across overhead are not included. Raptors, wood-swallows, etc are included if they are observed hunting overhead.

Searches

Each quadrat is actively searched five times for reptiles, amphibians, mammals, scats and signs. Three searches are carried out during the day (morning, midday, late afternoon) and two searches at night using spotlights. Each search takes about 10 minutes and involves turning rocks and logs, raking through leaf litter, looking under bark or in rock crevices. The number of

individuals of each species seen is recorded. Scats, bones and other signs are recorded where these can confidently be attributed to species. Carnivore scats are collected for hair analysis.

Incidental records

Species that are seen in the vicinity of the quadrat and in the sampled environment are recorded as incidental records for that site, with an abundance of zero to indicate they were not within the quadrat

Other species seen in the general area are recorded on a separate list for the general area. Where possible, the exact location and brief habitat details for the species are noted. This is most important for species that have some significance (e.g. rare or vulnerable species or species for which the record may be a range extension)

Data recording

Each species from the quadrat is recorded on a proforma, along with a total abundance (the sum of all records from captures, searches, bird counts). Incidental records adjacent to the quadrat are given an abundance of zero. Data are transferred from proformas to electronic databases (primarily FoxPro).

Specimens

For all species that cannot be positively identified in the field, an individual is euthanased and preserved for later identification.

Bat Sampling

A systematic method for censusing bats includes timed recordings using Anabat equipment in each quadrat.

Bats are also opportunistically sampled using harp traps and mist nets, by sightings or captures in caves, and identification of audible calls for a few species. For each record the location and brief habitat description are noted. When traps are used the trapping time is also recorded. It is usual procedure to take basic measurements of all bats trapped. Reference calls on Anabat may be recorded from captured individuals.

HABITAT DESCRIPTION

The proforma is designed to collect ecologically meaningful data about the sample sites. Self-evident cells are not explained below.

Environmental variables

quad	unique label for each quadrat e.g. TIPP1
survey	bioregional survey e.g, Daly Basin
region/station	usually park name, station name or sample region
observer	the person deciding what data values go onto the sheet (not necessarily the scribe)
location	explicit details about the site location – in relation to roads, tracks, creeks, landscape features etc –sufficient for someone else to relocate it
lat/long	precise location from GPS. Use averaged readings from large Magellans if possible
x/y	AMG easting and northings – alternative reading from GPS
landscape position	brief description of landscape setting of site. Use the format of the "Yellow Book" e.g: narrow valley in sandstone plateau; midslope on low hills

landunit	where available, from land unit mapping
run on/off	run off sites shed rainfall (e.g hill crests, upper slopes); run-on sites receive run-off e.g. swamps, base of hills; plains are extensive flat areas
patch size	contiguous area of sampled habitat type. Most relevant for restricted habitats e.g: rainforest, lancewood, rock outcrop.
slope	measured in degrees using a clinometer – estimate a mean slope for heterogeneous quadrats
aspect	the direction the slope faces – leave blank for zero slope
altitude	from topo map
perm water	estimated distance to nearest permanent water (including artificial sources)
curr water	distance to nearest water at time of survey
disturbance	various disturbance are scored on a scale of zero to 5, for major impact affecting all of quadrat. This will be somewhat subjective. 1 should mean that the disturbance is present but has had virtually no effect, 3 that there is a low level of disturbance throughout the quadrat, or a moderate effect concentrated in patches
last fire	estimate form fire scars and regeneration whether the site was burnt during the current year; the previous year; fire scars present but apparently old; or no sign of fire or its effects
rock cover	the total cover of rocks within the quadrat is estimated using cover classes for different size classes of rocks (see the "Yellow Book" for examples). Rock sizes refer to the longest dimension on the rock. ** includes rock cover underneath vegetation or litter**
rock type	broad classifications of the principal rock types – add others if you can determine them
lithology	an optional field for the underlying lithology from a geological map
soil texture	broad texture classes relating to the amount of clay in the soil – see Yellow Book
termite mounds	estimate the total number in the quadrat, the maximum height and whether they are tall & thin, squat & wide or magnetic mounds
ground cover	** these variables are quantified by stretching out a 100m tape through the quadrat (use a V-shape). Walk along the tape, looking vertically down and at each 1m score which feature is directly below the mark. The measures should add to 100%, so a piece of grass above litter or rocks would be scored only as grass**.

hummock grass is spinifex (Triodia or Plectrachne)
annual grasses can easily be pulled out and have very short root systems; perennial grasses are more firmly rooted in the ground and mostly form distinct tussocks
other forbs are herbs, ferns and small shrubs
** only score vegetation in the ground layer i.e: below c. 50cm tall

Vegetation structure

canopy height	mode height of canopy trees (not the tallest), using a clinometer
canopy cover	estimation of projective foliage cover of canopy. Best done objectively, using a device which we will try out shortly
veg profile	estimate the cover of vegetation (using cover classes) in different height zones. The same plant could contribute cover to more than one zone
structural formation	classification of the upper storey (in the quadrat and the surrounding vegetation it represents) as closed forest, open forest, woodland, open woodland, scattered trees or none. Canopy cover and crown separation are given as guides. A crown separation of 0.25 means the mean distance between the crowns of adjacent trees is one-quarter of the mean crown width
Bitterlich sweeps.	Basal area is estimated using sweeps with a Bitterlich measure. The number of sweeps is ideally four, from the 4 corners of the quadrat – fewer sweeps could be used in very open homogeneous vegetation.

	Unless the tree layer is very dense or trees are very large, use the smallest slot (multiplier = 0.25). ** record the number of sweeps and the slot size (multiplier) used ** For each individual tree scored, visually estimated the DBH class it falls into. All tree species registering a hit are scored separately. The total is the number of hits for each species over all the sweeps
Dominant species	Record the species with at least 5% cover in the three strata of the vegetation in decreasing order of cover. Only enter a max. of 5 species per strata. If there is a tall shrub layer and no tree layer, regard this as the mid layer. ** except in monsoon forests, few species have >5% cover in a 50m quadrat **

Floristic data

The aim is that all quadrats used in bioregional surveys will also have a full floristic inventory done. This will usually be done by a botanist, concurrently with the fauna survey or on a separate trip. The botanist should record the following:

- all plant species present in the 50x50m quadrat
- for each species, an estimate of cover (projective foliage cover) as <1%, 1%, 2%, 5%, 10% or to the nearest 10%. It is recommended that a point-intercept or wheel-point measure is used for the ground layer species

If the floristic inventory is to be done separately, the quadrat must be marked in such a way that the botanist can find both the location and at least approximately the boundaries.

PWCNT Bioregional Surveys quadrat environmental description pro-forma

QUAD:	**survey**:	**quad. size:** 50x50 100x100 other:

region / station:	**date**:	**observer**
location details:		

lat:	**long**:	**x**:	**y**:

landscape position:		**photo ref. no.**
land unit:	**run:** on off plain	**patch size (ha):** <1 1-5 5-50 50-500 500+
edge: ecotone or distance:	**adj. unit:**	
slope (°):	**aspect:** N NE E SE S SW W NW	herbarium plot ref. no.
perm water: 0 <50m 50-500m 0.5-5km >5km	**curr water:** 0 <50m 50-500m 0.5-5km >5km	

disturbance 0=no visible impact -> 5= major impact affecting all of quadrat		
fire impact: 0 1 2 3 4 5	**last fire:** this year last year 2+ years ago long unburnt	
pig damage: 0 1 2 3 4 5	**cow/horse/donkey:** 0 1 2 3 4 5	**weeds:** 0 1 2 3 4 5
other: 0 1 2 3 4 5 **describe**:		

rock cover (%)		**rock type**
pebbles (<0.6cm):	0 <2 2-10 10-20 20-50 50-90 >90	sandstone
small stones (0.6-2cm):	0 <2 2-10 10-20 20-50 50-90 >90	laterite
stones (2-6cm):	0 <2 2-10 10-20 20-50 50-90 >90	limestone
small rocks (6-20cm):	0 <2 2-10 10-20 20-50 50-90 >90	basalt
rocks (20-60cm):	0 <2 2-10 10-20 20-50 50-90 >90	other:
big rocks (60cm-2m)	0 <2 2-10 10-20 20-50 50-90 >90	
boulders (>2m):	0 <2 2-10 10-20 20-50 50-90 >90	**lithology:**
outcrop:	0 <2 2-10 10-20 20-50 50-90 >90	

soil texture: sand sandy-loam loam clay-loam clay cracking clay peat rock		
soil depth (cm): 0 <10 10-40 >40	**soil colour:**	
termite mounds - no:	**max ht (m)**:	**profile**: tower dome magnetic

ground cover (measured along 100m point-intercept tape)		**total**
bare ground		
rock		
litter		
hummock grass		
perennial grass		
annual grass		
sedge		
other forbs		
logs >5cm		

QUAD:	**canopy ht (m):**	**canopy cover (%):**

veg. profile (% cover in height classes)

>10m:	0	<5	5-10	10-25	25-50	50-75	>75
5-10m:	0	<5	5-10	10-25	25-50	50-75	>75
3-5m:	0	<5	5-10	10-25	25-50	50-75	>75
1-3m:	0	<5	5-10	10-25	25-50	50-75	>75
0.5-1m:	0	<5	5-10	10-25	25-50	50-75	>75
0-0.5:	0	<5	5-10	10-25	25-50	50-75	>75

structural formation (upper storey)

	cover	*crown separation*
CF	70-100%	overlapping
OF	30-70%	0 - 0.25
W	10-30%	0.25 – 1
OW	<10%	> 1
ST	scattered isolated trees	
none	ground layer only	

Bitterlich sweeps **number**: 1 2 3 4 **multiplier**: 0.25 0.5 0.75 1.0

species	**flower-fruit (0->5)***	**<5cm**	**Σ**	**5-20cm**	**Σ**	**20-50cm**	**Σ**	**>50cm**	**Σ**	**Total**
dead tree										
totals										
total basal area	(=sum total) x width of wedge hole used/no. of sweeps made =									

Dominant species (>5% cover only)

upper	mid	ground

* for flowers (FL): 0=no plants in flower (FL) or fruit (FR); 1=isolated plants with few flowers; 2=isolated plants with moderate no. of flowers *or* most plants with few flowers; 3=many plants with moderate no. flowers; 4=most plants with many flowers; 5=all plants with many flowers. Comparable score for fruit (FR).

Appendix E:

Descriptions of vegetation types mapped for the Tiwi Islands.

In Section 3 of the body of this report, we briefly describe and map broad vegetation (land cover) types for Bathurst and Melville Islands. Here we provide more detailed descriptions of these environments, and relate them to environmental descriptions and classifications described previously by others. Note that our descriptions here are preliminary: we have not yet fully analysed the vegetation information collected from our 200+ quadrats.

wet rainforest

Wet rainforests comprise many small patches of tall (canopy height 10-25m), dense (canopy cover 50-100%) and floristically diverse vegetation, typically occurring around springs and some sheltered watercourses. The most common canopy trees normally include *Calophyllum soullatri* and *Syzygium minutuliflorum*.

These rainforests are floristically distinguished from other (drier) rainforest groups on the Tiwi Islands by the presence of the trees *Melicope elleryana, Fagraea racemosa, Planchonella xerocarpum, Rapanea* sp. DNA 45975, the palm *Hydriastele wendlendiana* and the ground fern *Dicranopteris linearis*.

More detailed descriptions are given in Russell-Smith (1991) and Fensham and Woinarski (1992). This class corresponds exactly to group 4b ("'wet' monsoon forests" of Brocklehurst 1998), and includes both groups 3 and 5 of Russell-Smith (1991), which match exactly *"Complex Evergreen Monsoon Forest" and "Wet Evergreen Monsoon Forest"* of Fensham and Woinarski (1992).

Patch sizes for these rainforest groups are typically small (mean=1.1 ha, range 3-45ha for Group 3; and mean=0.8ha, range=0.3-100ha for Group 5: Russell-Smith 1991).

dry rainforest

Dry rainforests include coastal thickets and patches on the dry slopes of broken plateau edge. They are floristically diverse, typically larger than for wet rainforest patches, generally have moderate to closed canopies (cover 30-100%) and vary in canopy height from 4 to 20m. Many plants in many patches are deciduous or semi-deciduous.

Characteristic tree species include *Glochidium xerocarpum, Mallotus nesophilus, Sterculia quadrifida, Croton habrophyllus, Hibiscus tiliaceus, Drypetes deplanchei, Ixora klanderana, Pouteria sericea, Strychnos lucida, Canarium australianum, Bombax ceiba, Polyalthia australis, Terminalia microcarpa* and *Syzygium forte*.

This vegetation type corresponds to group 9 of Russell-Smith (1991) and vegetation type 4a (*dry monsoon vine thicket*) in Brocklehurst (1998), and three types described by Fensham and Woinarski (1992): *dry deciduous monsoon thicket, dry semi-deciduous monsoon thicket* and *dry evergreen monsoon forest*.

mangroves

Mangrove vegetation includes a mosaic of vegetation types varying from tall closed forests to low open woodlands, and with a range of dominant canopy species, occurring around much of the coast and lower reaches of waterways around the Tiwi Islands.

Variation is described and mapped in Messel *et al*. (1979), and related to the frequency and extent of tidal indundation. Brocklehurst (1998) summarises the floristic variation and considers 7 subdivisions of his group 3 ("*mangrove closed forests/low closed forests*"):

- *Sonneratia alba* open forests and woodlands, as the most seaward zone, on accreting mudbanks and in downsteam sections of tidal watercourses;
- *Rhizophora stylosa* closed forests, typically around river mouths;
- *Bruguiera parviflora* closed forests, along the banks of tidal creeks;
- *R. stylosa - Diospyros ferrea - Xylocarpus mekongensis* open forests in the middle and upper reaches of tidal creeks;
- *R. stylosa - R. apiculata* open forests, in the upstream portions of tidal creeks;
- *Ceriops tagal* closed forests, on the landward side of mangrove complexes;
- *Sonneratia caseolaris - Lumnitzera racemosa* woodlands and low open forests, along tidal reaches and extending into freshwater creeks.

sand & salt flats

Areas of saline clay flats occur intermixed with mangals in areas subjected to tidal inundation. Although typically denuded, some areas support a sparse cover of succulent herbs (saltbushes) including *Halosarcia indica* and *Tecticornia australasica*, and grasses (most comonly *Sporobolus virginicus*). This corresponds to "*saline coastal flats*" (map unit 8) described by Brocklehurst (1998)

We also include beach and relatively unvegetated sand dune complexes ("*beaches/chenier ridges/grasslands*" (map unit 7) of Brocklehurst 1998) within this unit.

sedgelands & grasslands

These are seasonally indundated areas, typically dominated by the sedges *Eleocharis dulcis* and *Scirpus litoralis* (in low-lying flats around Goose Creek) and the grass *Sporobolus virginicus* on seasonally inundated low coastal plains. They correspond to the "*grassland/sedge lands*" (map unit 6) of Brocklehurst (1998).

***Melaleuca* open forests**

Forests dominated by a range of *Melaleuca* spp. (typically including *M. leucadendra* and *M. viridiflora*) occur in riparian areas and swamplands. Typically these are tall (15-30m) and structurally relatively simple (little shrub layer). They occur on a range of soil types from alluvial sands to light clays and duplex soils. In some areas, they grade into wet rainforests, *Melaleuca* low woodlands or sedgelands/grasslands.

This community matches that described by Brocklehurst (1998) as "*2a. Melaleuca viridiflora and M. cajaputi open forest - woodland with tussock grassland understorey*").

Melaleuca low woodlands

This community includes woodlands, low woodlands and shrublands, typically on poorly drained clay or sand/clay duplex soils, dominated by *M. nervosa* and/or *M. viridiflora*. *Pandanus spiralis* may be common, and the ground layer typically includes sedges *Fimbristylis* spp. and the grass *Eriachne burkittii*.

This community may grade into treeless plains, sedgelands/grasslands, and *Melaleuca* open forest communities.

This community generally matches those described by Brocklehurst (1998) as "*2b1.* Melaleuca viridiflora *woodland/low woodland with* Eriachne burkittii *open-grassland understorey*" and "*2.b2.* Melaleuca viridiflora *and* M. nervosa *low open woodland with tussock grassland understorey*".

treeless plains

The distinctive treeless plains comprise low open woodlands typically dominated by *Acacia* spp., *Grevillea pteridolia, Lophostemon lactifluus* and *Banksia dentata*, typically with a shrub layer including *Grevillea goodii, Hibbertia cistifolia, Jacksonia dilatata, , Pachynema complanatum, Persoonia falcata, Planchonia careya* and *Syzygium eucalyptoides*, and a dense low understorey including *Alloteropsis semialata, Aristida holathera, Drosera petiolaris, Eragrostis cumingii, Eriachne avenacea, E. burkittii, E. ciliata, E. obtusa, E. squarrosa, E. triseta, Eulalia mackinlayi, Mitrasacme exserta, Polygala orbicularis, Rhychospora heterochaeta, Sorghum plumosum, Spermacoce breviflora* and *Thaumastochloa major*.

In general, this community corresponds with map unit 5 (sparsely wooded plains) of Brocklehurst (1998), which is there he subdivided (following Wilson and Fensham 1994) to *5a Acacia open shrubland* (=group 2 of Wilson and Fensham), *5b Grevillea pteridifolia low woodland* (=group 4 of Wilson and Fensham), *5c Lophostemon lactifluus low woodland* (=group 5 of Wilson and Fensham), *5d Acacia shrubland* (=group 6 of Wilson and Fensham), and *5e Banksia low woodland* (=group 7 of Wilson and Fensham). This variation is subtle and follows minor variations in topography, moisture availability and soil texture.

Brocklehurst (1998) also describes an additional , *type 1h.* Grevillea pteridifolia *low open woodland/tall shrubland with* Eriachne burkittii *grassland understorey*, which appears to be consistent with this community.

eucalypt forest (dense)

This community mostly comprises tall (canopy height 15 to 25m) relatively dense (canopy cover 15-30%) forest dominated by *Eucalyptus miniata, E. tetrodonta* and/or *E. nesophila* (often with ironwood *Erythrophleum chlorostachys* subdominant), typically with dense tall shrub understorey (variably including *Acacia* spp., *Gronophyllum*, *Livistona*) over a tussock grass ground layer. It occus on sandy red earths to sandy loams.

This community corresponds to vegetation types "*1a.* E. miniata, E. tetrodonta, E. nesophila *open-forest with* Chrysopogon fallax *grassland understorey", "1b* E. miniata, E. tetrodonta *open forest/woodland with tussock grassland understorey", "1e.* E. miniata *woodland with* Eriachne triseta *tussock grassland understorey",* and *"1i* Callitris

intratropica *open-forest/woodland with mixed eucalyptus species"* of Brocklehurst (1998).

In addition to forests dominated by *E. miniata, E. nesophila* and/or *E. tetrodonta*, we include within this unit some smaller forest areas (with similar spectral signature) in sandy drainage depressions, dominated by *E. nesophila, Lophostemon lactifluus* and/or *E. ptychocarpa*. This vegetation type matches "*1d* Lophostemon lactifluus, Eucalyptus nesophila *and* E. ptychocarpa *open forest/woodland with tussock grass understorey*" of Brocklehurst (1998).

eucalypt forest (mid-open)

This community is similar to, and intergrades with, the last, though typically with more open canopy (15-25%) and far more open shrub layer. The dominant canopy trees are *Eucalyptus miniata, E. tetrodonta* and/or *E. nesophila*, and the understorey is typically grassy (including *Sorghum* spp., *Eriachne* spp., and *Chrysopogon* spp.).

This community probably matches part of Brocklehurst's type 1e described above, and "*1f.* Eucalyptus polycarpa *open forest with open grassland understorey*".

eucalypt forest (open)

This open forest/woodland community is typically dominated by *Eucalyptus bleeseri* and/or *E. tetrodonta* with open grassy understorey. Canopy height is 10-20m and canopy cover 10-20%. The community typically grows on relatively shallow sandy and loamy laterised soils on hill slopes and crests.

This community matches vegetation type "*1c.* E. bleeseri, E. tetrodonta *woodland with tussock grassland understorey*" of Brocklehurst (1998).

eucalypt woodland

This woodland community (canopy height typically 10-15m; canopy cover 10-20%) is dominated variably by *Eucalyptus oligantha*, *E. latifolia*, *E. alba* and/or *E. confertiflora*, typically with a grassy understorey (including *Eriachne* spp., *Chrysopogon fallax, Alloteropsis semialata, Aristida* spp, *Sorghum* spp and *Themeda australis*), with scattered low shrubs (including *Planchonia careya, Acacia* spp., *Gardenia megasperma* and *Grevillea decurrens*). The community typically grows on loamy sand and gravelly clay loam soils, on lower slopes and drainage flats.

This community matches vegetation type "*1g.* Eucalyptus oligantha, Erythrophleum chlorostachys *open forest/woodland with* Chrysopogon fallax *tussock grassland understorey*" of Brocklehurst (1998).

plantations

This land cover type includes older plantations (>20 yrs old), typically of *Callitris intratropica* and *Pinus carribaea*, with smaller areas of *Eucalyptus* and *Acacia* spp, as well as younger plantations (<10 yrs old) of *Acacia mangium*, other *Acacia* spp., and *Eucalyptus* spp.

This community matches vegetation type "*9. Plantations*" of Brocklehurst (1998).

built-up area

This includes small urban areas, airstrips and other infrastructure.

Extent of vegetation types on the Tiwi Islands: comparison between the results reported here and those reported by ForSci (1998) (based on Edmeades & Brocklehurst 1996).

ForSci (1998)			**this report**		
vegetation type		**area (km^2)**	**vegetation type**		**area (km^2)**
eucalypt forests & woodlands	eucalypt forests & woodlands	5,127	**eucalypt forests & woodlands**	eucalypt forest (dense)	1,995
	Callitris - mixed hardwood forest	121		eucalypt forest (mid-open)	2,609
				eucalypt forest (open)	1,026
				eucalypt woodland	95
	total	**5,248**		**total**	**5,724**
mangroves		**839**	**mangroves**		**791**
treeless plains		**790**	**treeless plains**		**183**
rainforests		**177**	**rainforests**		**158**
estuary		**150**	-		-
saline coastal flats		**150**	**saline coastal flats**		**130**
***Melaleuca* forests and woodlands**		**67**	***Melaleuca* forests and woodlands**		**77**
plantation		**43**	**plantation**		**79**
sedgelands & grasslands	swamps & sedgelands	42	**sedgelands & grasslands**		
	grasslands and low open forests	22			
	total	**64**		**total**	**173**
miscellaneous		**5**	**built-up areas**		**26**
TOTAL AREA		**7,533**	**TOTAL AREA**		**7,481**

Appendix F:

Criteria for the inclusion of natural properties in the World Heritage List

43. In accordance with Article 2 of the Convention, the following is considered as "natural heritage":
"natural features consisting of physical and biological formations or groups of such formations, which are of outstanding universal value from the aesthetic or scientific point of view;
geological and physiographical formations and precisely delineated areas which constitute the habitat of threatened species of animals and plants of outstanding universal value from the point of view of science or conservation;
natural sites or precisely delineated natural areas of outstanding universal value from the point of view of science, conservation or natural beauty."
44. A natural heritage property - as defined above - which is submitted for inclusion in the World Heritage List will be considered to be of outstanding universal value for the purposes of the Convention when the Committee finds that it meets one or more of the following criteria and fulfils the conditions of integrity set out below. Sites nominated should therefore:

i. be outstanding examples representing major stages of earth's history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features; or
ii. be outstanding examples representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals; or
iii. contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance; or
iv. contain the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation;

and

a. also *fulfil the following conditions of integrity*:

i. The sites described in 44(a)(i) should contain all or most of the key interrelated and interdependent elements in their natural relationships; for example, an "ice age" area should include the snow field, the glacier itself and samples of cutting patterns, deposition and colonization (e.g. striations, moraines, pioneer stages of plant succession, etc.); in the case of volcanoes, the magmatic series should be complete and all or most of the varieties of effusive rocks and types of eruptions be represented.
ii. The sites described in 44(a)(ii) should have sufficient size and contain the necessary elements to demonstrate the key aspects of processes that are essential for the long-term conservation of the ecosystems and the biological diversity they contain; for example, an area of tropical rain forest should include a certain amount of variation in elevation above sea-level, changes in topography and soil types, patch systems and naturally regenerating patches; similarly a coral reef should include, for example, seagrass, mangrove or other adjacent ecosystems that regulate nutrient and sediment inputs into the reef.
iii. The sites described in 44(a)(iii) should be of outstanding aesthetic value and include areas that are essential for maintaining the beauty of the site; for example, a site whose scenic values depend on a waterfall,

should include adjacent catchment and downstream areas that are integrally linked to the maintenance of the aesthetic qualities of the site.

iv. The sites described in paragraph 44(a)(iv) should contain habitats for maintaining the most diverse fauna and flora characteristic of the biographic province and ecosystems under consideration; for example, a tropical savannah should include a complete assemblage of co-evolved herbivores and plants; an island eocsystem should include habitats for maintaining endemic biota; a site containing wide-ranging species should be large enough to include the most critical habitats essential to ensure the survival of viable populations of those species; for an area containing migratory species, seasonal breeding and nesting sites, and migratory routes, wherever they are located, should be adequately protected; international conventions, e.g. the Convention of Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar Convention), for ensuring the protection of habitats of migratory species of waterfowl, and other multi- and bilaterial agreements could provide this assurance.

v. The sites described in paragraph 44(a) should have a management plan. When a site does not have a management plan at the time when it is nominated for the consideration of the World Heritage Committee, the State Party concerned should indicate when such a plan will become available and how it proposes to mobilize the resources required for the preparation and implementation of the plan. The State Party should also provide other document(s) (e.g. operational plans) which will guide the management of the site until such time when a management plan is finalized.

vi. A site described in paragraph 44(a) should have adequate long-term legislative, regulatory, institutional or traditional protection. The boundaries of that site should reflect the spatial requirements of habitats, species, processes or phenomena that provide the basis for its nomination for inscription on the World Heritage List. The boundaries should include sufficient areas immediately adjacent to the area of outstanding universal value in order to protect the site's heritage values from direct effects of human encroachment and impacts of resource use outside of the nominated area. The boundaries of the nominated site may coincide with one or more existing or proposed protected areas, such as national parks or biosphere reserves. While an existing or proposed protected area may contain several management zones, only some of those zones may satisfy criteria described in paragraph 44(a); other zones, although they may not meet the criteria set out in paragraph 44(a), may be essential for the management to ensure the integrity of the nominated site; for example, in the case of a biosphere reserve, only the core zone may meet the criteria and the conditions of integrity, although other zones, i.e. buffer and transitional zones, would be important for the conservation of the biosphere reserve in its totality.

vii. Sites described in paragraph 44(a) should be the most important sites for the conservation of biological diversity. Biological diversity, according to the new global Convention on Biological Diversity, means the variability among living organisms in terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part and includes diversity within species, between species and of ecosystems. Only those sites which are the most biologically diverse are likely to meet criterion (iv) of paragraph 44(a).

45. In principle, a site could be inscribed on the World Heritage List as long as it satisfies one of the four criteria and the relevant conditions of integrity. However, most

inscribed sites have met two or more criteria. Nomination dossiers, IUCN evaluations and the final recommendations of the Committee on each inscribed site are available for consultation by States Parties which may wish to use such information as guides for identifying and elaborating nomination of sites within their own territories.

Appendix G:

List of vertebrate animals recorded from the Tiwi Islands.

Mammals.

FAWN ANTECHINUS *Antechinus bellus*.
Bathurst Island: --
Melville Island: Horner and Griffiths (1998). [MAGNT].
No. of quadrats:
Notes: A single record from woodland near Taracumbi (Horner and Griffiths 1998), and a "few" recorded in forest at 17 Mile by P. Baverstock (*pers. comm.*) in around 1987.

BRUSH-TAILED PHASCOGALE *Phascogale tapoatafa*.
Bathurst Island: --
Melville Island: this survey.
No. of quadrats:
Notes: Not previously recorded from the Tiwi Islands. Two individuals were trapped in eucalypt open forest in this survey.

RED-CHEEKED DUNNART *Sminthopsis virginiae*.
Bathurst Island: --
Melville Island: Parker (1973); Fensham & Woinarski (1992). [MAGNT; BRS; South Australian Museum].
No. of quadrats:

BUTLER'S DUNNART *Sminthopsis butleri*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Woinarski *et al*. (1996); Horner and Griffiths (1998) (as *S. virginae*). [MAGNT; South Australian Museum].
No. of quadrats:

NORTHERN BROWN BANDICOOT *Isoodon macrourus*.
kipwapi, **tukwatukuni** (m) / **tukwatukwa** (f).
Bathurst Island: Fensham & Woinarski (1992). [BRS]
Melville Island: Fensham & Woinarski (1992); Horner and Griffiths (1998). [MAGNT; BRS; South Australian Museum].
No. of quadrats:

SUGAR GLIDER *Petaurus breviceps*.
? jiritinga.
Bathurst Island: Parker (1973); Fensham & Woinarski (1992). [South Australian Museum]
Melville Island: Parker (1973); Fensham & Woinarski (1992); Horner and Griffiths (1998). [MAGNT; South Australian Museum].
No. of quadrats:

COMMON BRUSHTAIL POSSUM *Trichosurus vulpecula*.
puratuwuka, nguninga, wuriwantinga.
Bathurst Island: Parker (1973); Fensham & Woinarski (1992). [MAGNT; South Australian Museum; Australian Museum]
Melville Island: Parker (1973); Fensham & Woinarski (1992); Horner and Griffiths (1998). [MAGNT; South Australian Museum; BRS]
No. of quadrats:

AGILE WALLABY *Macropus agilis*.
teraka, tepwaturinga, antora (m) / **alitiwi** (f).
Bathurst Island: Parker (1973); Fensham & Woinarski (1992). [MAGNT].
Melville Island: Fensham & Woinarski (1992); Horner and Griffiths (1998). [MAGNT; BRS].
No. of quadrats:

BLACK FLYING-FOX *Pteropus alecto*.
tarnikini.
Bathurst Island: Fensham & Woinarski (1992); Palmer (199.). [BRS]
Melville Island: Fensham & Woinarski (1992).
No. of quadrats:

LITTLE RED FLYING-FOX *Pteropus scapulatus*.
tarnikini.
Bathurst Island: -
Melville Island: Horner and Griffiths (1998).
No. of quadrats:

NORTHERN BLOSSOM-BAT *Macroglossus minimus*.
Bathurst Island: --
Melville Island: Parker (1973); Fensham & Woinarski (1992); Horner and Griffiths (1998). [MAGNT; South Australian Museum].

YELLOW-BELLIED SHEATHTAIL-BAT *Saccolaimus flaviventris*.
Bathurst Island: --
Melville Island: Horner and Griffiths (1998). [MAGNT].

BARE-RUMPED SHEATHTAIL BAT *Saccolaimus saccolaimus*.
Bathurst Island: --
Melville Island: ForSci (1999) [?unconfirmed].

COMMON SHEATHTAIL-BAT *Taphozous georgianus*.
Bathurst Island: --
Melville Island: ForSci (1999).

NORTHERN FREETAIL BAT *Chaerophon jobensis*.
Bathurst Island: --
Melville Island: ForSci (1999).

BECCARI'S FREETAIL BAT *Mormopterus beccarii*.
Bathurst Island: --
Melville Island: ForSci (1999).

LITTLE NORTHERN FREETAIL BAT *Mormopterus loriae*.
Bathurst Island: --
Melville Island: ForSci (1999).

GOULD'S WATTLED BAT *Chalinolobus gouldii*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Fensham & Woinarski (1992).

HOARY BAT *Chalinolobus nigrogriseus*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Fensham & Woinarski (1992).

CAPE YORK PIPISTRELLE *Pipistrellus adamsi*.
Bathurst Island: --
Melville Island: ForSci (1999).

NORTH-WESTERN PIPISTRELLE *Pipistrellus westralis*.
Bathurst Island: --
Melville Island: Horner and Griffiths (1998); ForSci (1999). [MAGNT].

WESTERN CAVE EPTESICUS *Vespadelus caurinus*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Fensham & Woinarski (1992).

LARGE-FOOTED MOUSE-EARED BAT *Myotis moluccarum*.
Bathurst Island: --
Melville Island: Thomson (1989).

ARNHEM LAND LONG-EARED BAT *Nyctophilus arnhemensis*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Fensham & Woinarski (1992). [MAGNT].

NORTH QUEENSLAND LONG-EARED BAT *Nyctophilus bifax*.
Bathurst Island: --
Melville Island: Parker (1973).

LITTLE BROAD-NOSED BAT *Scotorepens greyi*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Fensham & Woinarski (1992).

NORTHERN BROAD-NOSED BAT *Scotorepens sanborni*.
Bathurst Island: --
Melville Island: ForSci (1999).

WATER-RAT *Hydromys chrysogaster*.
Bathurst Island: Watts & Aslin (1981). [Australian Museum]
Melville Island: Thomas (1921); Parker (1973).

GRASSLAND MELOMYS *Melomys burtoni*.
Bathurst Island: Parker (1973); Fensham & Woinarski (1992). [Australian Museum]
Melville Island: Parker (1973); Fensham & Woinarski (1992); Horner and Griffiths (1998). [MAGNT; South Australian Museum; BRS].
No. of quadrats:

BRUSH-TAILED RABBIT-RAT *Conilurus penicillatus*.
Bathurst Island: Parker (1973); Fensham & Woinarski (1992). [MAGNT].
Melville Island: Thomas (1921); Parker (1973); Fensham & Woinarski (1992); Kemper and Schmitt (1992). [MAGNT; South Australian Museum].
No. of quadrats:

BLACK-FOOTED TREE-RAT *Mesembriomys gouldii*.
jintimunga, **petunguruwuka**.
Bathurst Island: Watts & Aslin (1981).
Melville Island: Hayman (1936); Parker (1973); Fensham & Woinarski (1992); Horner and Griffiths (1998). [MAGNT; South Australian Museum].
No. of quadrats:

WESTERN CHESTNUT MOUSE *Pseudomys nanus*.
Bathurst Island: --
Melville Island: Fensham & Woinarski (1992). [South Australian Museum; BRS]
No. of quadrats:

DELICATE MOUSE *Pseudomys delicatulus*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Fensham & Woinarski (1992); Horner and Griffiths (1998). [MAGNT; South Australian Museum; BRS]
No. of quadrats: .

DUSKY RAT *Rattus colletti*
Bathurst Island: -
Melville Island: [BRS]

BLACK RAT *Rattus rattus*.

Bathurst Island: Watts & Aslin (1981).
Melville Island: Watts & Aslin (1981).
Notes: Introduced species.

PALE FIELD-RAT *Rattus tunneyi*.
Bathurst Island: Fensham & Woinarski (1992). [MAGNT].
Melville Island: Thomas (1921); Parker (1973); Fensham & Woinarski (1992); Horner and Griffiths (1998). [MAGNT; South Australian Museum].
No. of quadrats:

FALSE WATER-RAT *Xeromys myoides*.
Bathurst Island: -
Melville Island: Magnusson *et al*. (1976). [Australian Museum].

DUGONG *Dugong dugon*
Bathurst Island: -
Melville Island: [BRS].

DINGO *Canis familiaris*.
tajamini (m) / **tajama** (f).
Bathurst Island: Dodd (1935).
Melville Island: Fensham & Woinarski (1992); Horner and Griffiths (1998). [BRS]

FERAL CAT *Felis catus*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Fensham & Woinarski (1992). [BRS].
Notes: Introduced.

HORSE *Equus caballus*.
Bathurst Island: --
Melville Island: Bayliss (1985); Fensham & Woinarski (1992); Horner and Griffiths (1998).
Notes: Introduced.

FERAL PIG *Sus scrofa*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: --
Notes: Introduced, absent from Melville Island.

FERAL CATTLE *Bos taurus*.
Bathurst Island: small herds present.
Melville Island: --
Notes: Introduced.

FERAL WATER BUFFALO *Bubalus bubalis*.
Bathurst Island: --
Melville Island: Bayliss (1985); Fensham & Woinarski (1992); Horner and Griffiths (1998)..
Notes: Introduced, absent from Bathurst Island.

Birds.

AUSTRALIAN PELICAN *Pelecanus conspicillatus*.
alikampwarmi, alipiura, tintama, tampawunga.
Bathurst Island: -
Melville Island: Mathews (1914); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS; RAOU.]

BROWN BOOBY *Sula leucogaster*.

Bathurst Island: -
Melville Island: Fensham & Woinarski (1992).

DARTER *Anhinga melanogaster*.
Bathurst Island: Fensham & Woinarski (1992). [RAOU].
Melville Island: Mathews (1914); Mason and Schodde (1997). [RAOU].

LITTLE BLACK CORMORANT *Phalacrocorax sulcirostris*.
Bathurst Island: -
Melville Island: [BRS].

LITTLE PIED CORMORANT *Phalacrocorax melanoleucos*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Mason and Schodde (1997). [RAOU, BRS].

LESSER FRIGATEBIRD *Fregata ariel*.
Bathurst Island: [RAOU].
Melville Island: Fensham & Woinarski (1992).

GREAT-BILLED HERON *Ardea sumatrana*.
Bathurst Island: -
Melville Island: Mathews (1914). [BRS].

INTERMEDIATE EGRET *Ardea intermedia*.
Bathurst Island: [RAOU].
Melville Island: Fensham & Woinarski (1992); Mason and Schodde (1997).

WHITE-NECKED HERON *Ardea pacifica*.
pawunga.
Bathurst Island: -
Melville Island: -
Notes: recorded by Osborne (1974) for the Tiwi Islands.

PIED HERON *Ardea picata*.
Bathurst Island: -
Melville Island: Mathews (1914); Mason and Schodde (1997). [RAOU.]

GREAT EGRET *Ardea alba*.
Bathurst Island: -
Melville Island: Mathews (1914); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS; RAOU.]
No. of quadrats:

LITTLE EGRET *Egretta garzetta*.
Bathurst Island: -
Melville Island: Mathews (1914); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS; RAOU].

WHITE-FACED HERON *Egretta novaehollandiae*.
Bathurst Island: -
Melville Island: Mason and Schodde (1997). [RAOU]

EASTERN REEF EGRET *Egretta sacra*.
Bathurst Island: Fensham & Woinarski (1992). [BRS; RAOU].
Melville Island: Mathews (1914).
Notes: recorded also from Buchanan Island (Mathews 1912; RAOU).

STRIATED HERON *Butorides striatus*.
Bathurst Island: -

Melville Island: Mathews (1914); Zietz (1914a); Fensham & Woinarski (1992); Mason and Schodde (1997). [RAOU].
No. of quadrats:

NANKEEN NIGHT HERON *Nycticorax caledonicus*.
kararunga.
Bathurst Island: Fensham & Woinarski (1992). [RAOU].
Melville Island: Mathews (1914); Fensham & Woinarski (1992); Mason and Schodde (1997). [RAOU].
No. of quadrats:

BLACK BITTERN *Ixobrychus flavicollis*.
Bathurst Island: -
Melville Island: Mathews (1914); Fensham & Woinarski (1992); Mason and Schodde (1997).
No. of quadrats:

BLACK-NECKED STORK (JABIRU) *Ephippiorhynchus asiaticus*.
arntongi.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Fensham & Woinarski (1992); Mason and Schodde (1997). [RAOU].

AUSTRALIAN WHITE IBIS *Threskiornis molucca*.
Bathurst Island: Fensham & Woinarski (1992). [RAOU].
Melville Island: Mathews (1914); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS; RAOU.]

STRAW-NECKED IBIS *Threskiornis spinicollis*.
Bathurst Island: -
Melville Island: [BRS].

GLOSSY IBIS *Plegadis falcinellus*
Bathurst Island: -
Melville Island: Mason and Schodde (1997).

ROYAL SPOONBILL *Platalea regia*.
ararini.
Bathurst Island: -
Melville Island: Mathews (1914); Fensham & Woinarski (1992).

YELLOW-BILLED SPOONBILL *Platalea flavipes*.
Bathurst Island: -
Melville Island: Fensham & Woinarski (1992); Mason and Schodde (1997).

MAGPIE GOOSE *Anseranas semipalmata*.
***mayimampi, awurnanka, narringari, pukumwaka, wurrikiliki**.
Bathurst Island: -
Melville Island: Mathews (1914); Zietz (1914*a*); Mason and Schodde (1997). [BRS, CRA].
Notes: Aerial counts have reported up to 6000 birds, mostly at Andranangoo Creek (CRA).

WANDERING WHISTLING-DUCK *Dendrocygna arcuata*.
***jurriyi**.
Bathurst Island -
Melville Island: Mathews (1914); Fensham & Woinarski (1992). [BRS; RAOU].

PLUMED WHISTLING-DUCK *Dendrocygna eytoni*.
Bathurst Island: -
Melville Island: Mathews (1914).

RADJAH SHELDUCK *Tadorna radjah*.
***tirrintirri**.
Bathurst Island: [R. Chatto (*pers. comm.*).]

Melville Island: Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS; RAOU].

PACIFIC BLACK DUCK *Anas superciliosa*
Bathurst Island: -
Melville Island: Mason and Schodde (1997).

HARDHEAD *Aythya australis*.
Bathurst Island: -
Melville Island: Mathews (1914).

GREEN PYGMY-GOOSE *Nettapus pulchellus*.
Bathurst Island: -
Melville Island: Mathews (1914); Mason and Schodde (1997). [RAOU].

OSPREY *Pandion haliaetus*.
puruti, **mumterini, peparanini**.
Bathurst Island: [BRS; RAOU.]
Melville Island: Mathews (1914); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].
Notes: Also recorded for Buchanan Island (RAOU).

BLACK-SHOULDERED KITE *Elanus axillaris*.
Bathurst Island: [RAOU].
Melville Island: -

BLACK-BREASTED BUZZARD *Hamirostra melanosternon*.
Bathurst Island: -
Melville Island: [BRS; RAOU].

BLACK KITE *Milvus migrans*.
mutati.
Bathurst Island: -
Melville Island: Mathews (1914). [BRS].

BRAHMINY KITE *Haliastur indus*.
tirinini.
Bathurst Island: Fensham & Woinarski (1992). [BRS; RAOU].
Melville Island: Mathews (1914); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS; RAOU].
Notes: recorded also for Buchnanan Island (RAOU).

WHISTLING KITE *Haliastur sphenurus*.
? **jimpernika**.
Bathurst Island: [RAOU].
Melville Island: Mathews (1914); Zietz (1914*a*); Dodd (1935); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS; RAOU].

BROWN GOSHAWK *Accipiter fasciatus*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [RAOU].

COLLARED SPARROWHAWK *Accipiter cirrhocephalus*.
Bathurst Island: Storr (1977).
Melville Island: Storr (1977).

GREY GOSHAWK *Accipiter novaehollandiae*.
Bathurst Island: -
Melville Island: Mathews (1914); Zietz (1914*a*); Mason and Schodde (1997). [BRS].

RED GOSHAWK *Erythrotriorchis radiatus*.

Bathurst Island: Zietz (1914*b*); Storr (1977); Fensham & Woinarski (1992).
Melville Island: Fensham & Woinarski (1992); Mason and Schodde (1997).

WHITE-BELLIED SEA-EAGLE *Haliaeetus leucogaster*.
jerekati, tankenanki.
Bathurst Island: Fensham & Woinarski (1992). [BRS; RAOU].
Melville Island: Mathews (1914); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS; RAOU].

WEDGE-TAILED EAGLE *Aquila audax*.
jeremeru, kutulakini.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

SPOTTED HARRIER *Circus assimilis.*
Bathurst Island: -
Melville Island: Mathews (1914).

AUSTRALIAN HOBBY *Falco longipennis*.
Bathurst Island: -
Melville Island: Mathews (1914); Mason and Schodde (1997). [CSIRO].

BROWN FALCON *Falco berigora*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

NANKEEN KESTREL *Falco cenchroides*.
Bathurst Island: -
Melville Island: Mathews (1914).

ORANGE-FOOTED SCRUBFOWL *Megapodius reinwardt*.
***kirilima/kirilimunga**
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS; CSIRO].

BROWN QUAIL *Coturnix ypsilophora*.
Bathurst Island: -
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

KING QUAIL *Coturnix chinensis*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: -

RED-BACKED BUTTON-QUAIL *Turnix maculosa*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Fensham & Woinarski (1992).

CHESTNUT-BACKED BUTTON-QUAIL *Turnix castanota*.
Bathurst Island: [Victorian Museum].
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [CSIRO].

CHESTNUT RAIL *Eulabeornis castaneoventris*.
Bathurst Island: Fensham & Woinarski (1992); BRS.
Melville Island: Mathews (1914); Zietz (1914*a*); Dodd (1935); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

SPOTLESS CRAKE *Porzana tabuensis*.

Bathurst Island: -
Melville Island: Fensham & Woinarski (1992).

WHITE-BROWED CRAKE *Porzana cinerea*.
Bathurst Island: -
Melville Island: Mathews (1914). [Australian Museum].

BROLGA *Grus rubicunda*.
tilati.
Bathurst Island: -
Melville Island: Mathews (1914); Fensham & Woinarski (1992); Mason and Schodde (1997). [RAOU].

AUSTRALIAN BUSTARD *Ardeotis australis*.
***kaukawini (kawukawuni/kawukawunga)**.
Bathurst Island: -
Melville Island: Mathews (1914). [RAOU].

COMB-CRESTED JACANA *Irediparra gallinacea*.
Bathurst Island: -
Melville Island: Mathews (1914); Zietz (1914*a*).

BUSH STONE-CURLEW *Burhinus grallarius*.
***wayayi/ pima**.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

BEACH STONE-CURLEW *Esacus neglectus*.
Bathurst Island: Fensham & Woinarski (1992). [BRS].
Melville Island: Mathews (1914); Storr (1977); Fensham & Woinarski (1992); Mason and Schodde (1997).

PIED OYSTERCATCHER *Haematopus longirostris*.
Bathurst Island: [RAOU; BRS].
Melville Island: Mathews (1914).
Notes: recorded also at Buchanan Island (RAOU).

SOOTY OYSTERCATCHER *Haematopus fuliginosus*.
Bathurst Island: -
Melville Island: [R. Chatto (*unpubl.*)].

MASKED LAPWING *Vanellus miles*.
peraperama.
Bathurst Island: Fensham & Woinarski (1992). [BRS].
Melville Island: Mathews (1914); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS; RAOU].

GREY PLOVER *Pluvialis squatarola*.
Bathurst Island: Fensham & Woinarski (1992). [BRS].
Melville Island: Mathews (1914); Fensham & Woinarski (1992).

PACIFIC GOLDEN PLOVER *Pluvialis fulva*.
Bathurst Island: -
Melville Island: Mathews (1914). [RAOU, as *P.dominica*].

RED-KNEED DOTTEREL *Erythrogonys cinctus*.
Bathurst Island: -
Melville Island: Mathews (1914).

LESSER SAND PLOVER *Charadrius mongolus*.

Bathurst Island: Fensham & Woinarski (1992). [BRS].
Melville Island: Mathews (1914); Fensham & Woinarski (1992).

GREATER SAND PLOVER *Charadrius leschenaultii*.
Bathurst Island: Fensham & Woinarski (1992). [BRS].
Melville Island: Mathews (1914).

RED-CAPPED PLOVER *Charadrius ruficapillus*.
Bathurst Island: Fensham & Woinarski (1992). [RAOU].
Melville Island: Mathews (1914); Fensham & Woinarski (1992).
Notes: recorded also at Buchanan Island (RAOU).

BLACK-WINGED STILT *Himantopus himantopus*.
Bathurst Island: -
Melville Island: Fensham & Woinarski (1992).

RUDDY TURNSTONE *Arenaria interpres*.
Bathurst Island: [RAOU; BRS].
Melville Island: Mathews (1914); Fensham & Woinarski (1992).
Notes: recorded also at Buchanan Island (RAOU).

EASTERN CURLEW *Numenius madagascariensis*.
Bathurst Island: Fensham & Woinarski (1992). [BRS; RAOU].
Melville Island: Mathews (1914); Fensham & Woinarski (1992).
Notes: recorded also at Buchanan Island (RAOU).

WHIMBREL *Numenius phaeopus*.
Bathurst Island: Fensham & Woinarski (1992). [BRS; RAOU].
Melville Island: Mathews (1914); Fensham & Woinarski (1992). [RAOU].
Notes: recorded also at Buchanan Island (RAOU).

LITTLE CURLEW *Numenius minutus*.
karuritinga.
Bathurst Island: -
Melville Island: Fensham & Woinarski (1992).

GREY-TAILED TATTLER *Heteroscelus brevipes*.
Bathurst Island: [BRS; RAOU].
Melville Island: Mathews (1914).
Notes: recorded also at Buchanan Island (RAOU).

COMMON SANDPIPER *Actitis hypoleucos*.
Bathurst Island: Fensham & Woinarski (1992). [BRS].
Melville Island: Mathews (1914); Fensham & Woinarski (1992); Mason and Schodde (1997).

COMMON GREENSHANK *Tringa nebularia*.
Bathurst Island: [BRS].
Melville Island: Mathews (1914); Fensham & Woinarski (1992).

MARSH SANDPIPER *Tringa stagnatilis*.
Bathurst Island: -
Melville Island: Fensham & Woinarski (1992).

TEREK SANDPIPER *Xenus cinereus*.
Bathurst Island: [BRS; RAOU].
Melville Island: Mathews (1914).
Notes: recorded also at Buchanan Island (RAOU).

SWINHOE'S SNIPE *Gallinago megala*.
Bathurst Island: Fensham & Woinarski (1992).

Melville Island: Mathews (1914); Fensham & Woinarski (1992).

BAR-TAILED GODWIT *Limosa lapponica*.
Bathurst Island: [BRS].
Melville Island: Mathews (1914).

BLACK-TAILED GODWIT *Limosa limosa*.
Bathurst Island: [RAOU].
Melville Island: -
Notes: recorded at Buchanan Island (RAOU).

RED KNOT *Calidris canutus*.
Bathurst Island: -
Melville Island: Mathews (1914); Fensham & Woinarski (1992).

GREAT KNOT *Calidris tenuirostris*.
Bathurst Island: [R. Chatto (*unpubl.*)].
Melville Island: Mathews (1914).

SHARP-TAILED SANDPIPER *Calidris acuminata*.
Bathurst Island: [RAOU].
Melville Island: Fensham & Woinarski (1992).
Notes: recorded also at Buchanan Island (RAOU).

RED-NECKED STINT *Calidris ruficollis*.
Bathurst Island: Fensham & Woinarski (1992). [RAOU].
Melville Island: Mathews (1914).
Notes: recorded also at Buchanan Island (RAOU).

CURLEW SANDPIPER *Calidris ferruginea*.
Bathurst Island: -
Melville Island: Mathews (1914).

SANDERLING *Calidris alba*.
Bathurst Island: -
Melville Island: Mathews (1914).

BROAD-BILLED SANDPIPER *Limicola falcinellus*.
Bathurst Island: -
Melville Island: Mathews (1914).

AUSTRALIAN PRATINCOLE *Stiltia isabella*.
Bathurst Island: -
Melville Island: Mathews (1914).

SILVER GULL *Larus novaehollandiae*.
martapani.
Bathurst Island: Fensham & Woinarski (1992). [RAOU].
Melville Island: Mathews (1914); Mason and Schodde (1997).
Notes: recorded also at Buchanan Island (RAOU); nesting on Seagull Island.

WHISKERED TERN *Chlidonias hybridus*
Bathurst Island: -
Melville Island: [R. Chatto (*unpubl.*)].

WHITE-WINGED BLACK TERN *Chlidonias leucopterus*.
Bathurst Island: [R. Chatto (*unpubl.*)].
Melville Island: [R. Chatto (*unpubl.*)].
Notes: In groups of several thousands (Ray Chatto *unpubl.*).

GULL-BILLED TERN Sterna *nilotica*.
Bathurst Island: [RAOU].
Melville Island: [R. Chatto (*unpubl.*)].
Notes: recorded also at Buchanan Island (RAOU).

CASPIAN TERN *Sterna caspia*.
Bathurst Island: Fensham & Woinarski (1992). [RAOU].
Melville Island: [R. Chatto (*unpubl.*)].

COMMON TERN *Sterna hirundo*.
Bathurst Island: -
Melville Island: [R. Chatto (*unpubl.*)].

LITTLE TERN *Sterna albifrons*.
Bathurst Island: [RAOU].
Melville Island: Mathews (1914).
Notes: recorded also at Buchanan Island (RAOU).

CRESTED TERN *Sterna bergii*.
Bathurst Island: Fensham & Woinarski (1992). [RAOU; BRS].
Melville Island: Mathews (1914).
Notes: recorded also at Buchanan Island (RAOU); nesting on Seagull Island (CRA).

LESSER CRESTED TERN *Sterna bengalensis*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Fensham & Woinarski (1992).

ROSE-CROWNED FRUIT-DOVE *Ptilinopus regina*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Zietz (1914*a*); Dodd (1935); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

PIED IMPERIAL-PIGEON (TORRES STRAIT PIGEON) *Ducula bicolor*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Zietz (1914*a*); Dodd (1935); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

PEACEFUL DOVE *Geopelia striata*.
Bathurst Island: Fensham & Woinarski (1992). [BRS; RAOU].
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

BAR-SHOULDERED DOVE *Geopelia humeralis*.
Bathurst Island: Fensham & Woinarski (1992). [BRS; RAOU].
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS; RAOU].

EMERALD DOVE *Chalcophaps indica*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

COMMON BRONZEWING *Phaps chalcoptera*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [CSIRO].

PARTRIDGE PIGEON *Geophaps smithii*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Zietz (1914*a*); Mason and Schodde (1997). [CSIRO].

RED-TAILED BLACK-COCKATOO *Calyptorhynchus banksii*.
ngaringa.
Bathurst Island: Fensham & Woinarski (1992). [RAOU].
Melville Island: Mathews (1914); Zietz (1914*a*); Goodfellow (1935); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].
Notes: recorded also at Buchanan Island (RAOU).

LITTLE CORELLA *Cacatua sanguinea*.
jikjikini, pepungeliri.
Bathurst Island: -
Melville Island: Mathews (1914); Zietz (1914*a*); Goodfellow (1935); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS; RAOU].

SULPHUR-CRESTED COCKATOO *Cacatua galerita*.
jingkaka.
Bathurst Island: Fensham & Woinarski (1992). [RAOU].
Melville Island: Mathews (1914); Zietz (1914*a*); Goodfellow (1935); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS; RAOU].

RAINBOW LORIKEET *Trichoglossus haematodus*.
Bathurst Island: Fensham & Woinarski (1992). [BRS].
Melville Island: Mathews (1914); Zietz (1914*a*); Goodfellow (1935); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS; RAOU].

VARIED LORIKEET *Psitteuteles versicolor*.
? **anterengarika**.
Bathurst Island: Fensham & Woinarski (1992). [RAOU].
Melville Island: Mathews (1914); Zietz (1914*a*); Goodfellow (1935); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

RED-WINGED PARROT *Aprosmictus erythropterus*.
? **materapuratu**.
Bathurst Island: Fensham & Woinarski (1992). [BRS; RAOU].
Melville Island: Mathews (1914); Zietz (1914*a*); Goodfellow (1935); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS; RAOU].

NORTHERN ROSELLA *Platycercus venustus*.
Bathurst Island: Storr (1977); Fensham & Woinarski (1992). [RAOU; Victorian Museum; MAGNT].
Melville Island: Mathews (1914); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

HOODED PARROT *Psephotus dissimilis*.
Bathurst Island: -
Melville Island: Goodfellow (1935)
notes: recorded by Goodfellow as present in the wet season to March but not thereafter. No subsequent records.

PALLID CUCKOO *Cuculus pallidus*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Fensham & Woinarski (1992).

ORIENTAL CUCKOO *Cuculus saturatus*.
Bathurst Island: -
Melville Island: Mathews (1914); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

BRUSH CUCKOO *Cuculus variolosus*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

HORSFIELD'S BRONZE-CUCKOO *Chrysococcyx basalis*.
Bathurst Island: -
Melville Island: Mathews (1914); Fensham & Woinarski (1992); Mason and Schodde (1997).

LITTLE BRONZE-CUCKOO *Chrysococcyx minutillus*.
Bathurst Island: Fensham & Woinarski (1992). [Victorian Museum].
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS; Australian Museum].

COMMON KOEL *Eudynamis scolopacea*.
***alarpiningwani**
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

CHANNEL-BILLED CUCKOO *Scythrops novaehollandiae*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914).

PHEASANT COUCAL *Centropus phasianinus*.
mijonga.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS; RAOU].

RUFOUS OWL *Ninox rufa*.
Bathurst Island: -
Melville Island: [BRS].

SOUTHERN BOOBOOK *Ninox novaeseelandiae*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997).

BARKING OWL *Ninox connivens*.
Bathurst Island: -
Melville Island: [BRS].

BARN OWL *Tyto alba*.
Bathurst Island: -
Melville Island: Fensham & Woinarski (1992).

MASKED OWL *Tyto novaehollandiae*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Fensham & Woinarski (1992); Mason and Schodde (1997).

TAWNY FROGMOUTH *Podargus strigoides*.
kukuwini.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

AUSTRALIAN OWLET-NIGHTJAR *Aegotheles cristatus*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

SPOTTED NIGHTJAR *Eurostopodus guttatus*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Fensham & Woinarski (1992); Mason and Schodde (1997).

LARGE-TAILED NIGHTJAR *Caprimulgus macrurus*.

Bathurst Island: -
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

WHITE-THROATED NEEDLETAIL *Hirundapus caudacutus*.
Bathurst Island: -
Melville Island: Mason and Schodde (1997).

FORK-TAILED SWIFT *Apus pacificus*.
Bathurst Island: BRS.
Melville Island: Mathews (1914).

AZURE KINGFISHER *Alcedo azurea*.
***pipijirraringa**
Bathurst Island: BRS.
Melville Island: Mathews (1914); Zietz (1914*a*); Dodd (1935); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS; RAOU].

LITTLE KINGFISHER *Alcedo pusilla*.
Bathurst Island: -
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [RAOU].

BLUE-WINGED KOOKABURRA *Dacelo leachii*.
***jorrijorringa**.
Bathurst Island: Fensham & Woinarski (1992); [Victorian Museum; RAOU].
Melville Island: Mathews (1914); Zietz (1914*a*); Dodd (1935); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS; RAOU].

FOREST KINGFISHER *Todirhampus macleayii*.
Bathurst Island: Fensham & Woinarski (1992). [Victorian Museum].
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

SACRED KINGFISHER *Todiramphus sancta*.
Bathurst Island: -
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

COLLARED KINGFISHER *Todiramphus chloris*.
***payampuna**
Bathurst Island: -
Melville Island: Mathews (1914); Zietz (1914*a*); Dodd 91935); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS; RAOU].

RAINBOW BEE-EATER *Merops ornatus*.
wutirriwutirri.
Bathurst Island: [RAOU].
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS; RAOU].

DOLLARBIRD *Eurystomus orientalis*.
Bathurst Island: -
Melville Island: Mathews (1914); Mason and Schodde (1997). [BRS].

RAINBOW PITTA *Pitta iris*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

SINGING BUSHLARK *Mirafra javanica*.

Bathurst Island: -
Melville Island: Mathews (1914); Fensham & Woinarski (1992). [Victorian Museum].

TREE MARTIN *Hirundo nigricans*.
Bathurst Island: [BRS; RAOU].
Melville Island: Mathews (1914); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

FAIRY MARTIN *Hirundo ariel*.
Bathurst Island: -
Melville Island: Mason and Schodde (1997). [RAOU].

RICHARD'S PIPIT *Anthus novaeseelandiae*.
Bathurst Island: -
Melville Island: Mathews (1914).

BLACK-FACED CUCKOO-SHRIKE *Coracina novaehollandiae*.
***arlipunyika**.
Bathurst Island: RAOU.
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS; RAOU].

WHITE-BELLIED CUCKOO-SHRIKE *Coracina papuensis*.
Bathurst Island: Fensham & Woinarski (1992). [RAOU].
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS; RAOU].

CICADABIRD *Coracina tenuirostris*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

WHITE-WINGED TRILLER *Lalage sueurii*.
Bathurst Island: -
Melville Island: Mathews (1914); Mason and Schodde (1997).

VARIED TRILLER *Lalage leucomela*.
putini.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

HOODED ROBIN *Melanodryas cucullata*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992).

MANGROVE ROBIN *Eopsaltria pulverulenta*.
Bathurst Island: [BRS].
Melville Island: Mathews (1914); Zietz (1914*a*); Dodd 91935); Fensham & Woinarski (1992); Mason and Schodde (1997).

LEMON-BELLIED FLYCATCHER *Microeca flavigaster*
Bathurst Island: -
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

MANGROVE GOLDEN WHISTLER *Pachycephala melanura*.
Bathurst Island: [BRS].
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997).
Notes: recorded also from Buchanan Island (Mathews 1915).

GREY WHISTLER *Pachycephala simplex*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

RUFOUS WHISTLER *Pachycephala rufiventris*.
Bathurst Island: Fensham & Woinarski (1992). [RAOU].
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS; RAOU].

WHITE-BREASTED WHISTLER *Pachycephala lanioides*.
Bathurst Island: -
Melville Island: Mathews (1914); Mason and Schodde (1997). [BRS].
Notes: Mathews (1914) recorded it also from Buchanan Island.

LITTLE SHRIKE-THRUSH *Colluricincla megarhyncha*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

GREY SHRIKE-THRUSH *Colluricincla harmonica*.
Bathurst Island: Fensham & Woinarski (1992). [Victorian Museum].
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997).

BROAD-BILLED FLYCATCHER *Myiagra ruficollis*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

LEADEN FLYCATCHER *Myiagra rubecula*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS; RAOU].

SHINING FLYCATCHER *Myiagra alecto*.
pepiteraringa.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

RESTLESS FLYCATCHER *Myiagra inquieta*.
Bathurst Island: -
Melville Island: [BRS].

RUFOUS FANTAIL *Rhipidura rufifrons*.
Bathurst Island: -
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

MANGROVE GREY FANTAIL *Rhipidura phasiana*.
Bathurst Island: -
Melville Island: Mathews (1914); Fensham & Woinarski (1992)
Notes: Mathews (1914) recorded it also from Buchanan Island.

NORTHERN FANTAIL *Rhipidura rufiventris*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS; RAOU].

WILLIE WAGTAIL *Rhipidura leucophrys*.
Bathurst Island: -
Melville Island: Mathews (1914). [BRS]

GREY-CROWNED BABBLER *Pomatostomus temporalis*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

ORIENTAL REED-WARBLER *Acrocephalus orientalis*.
Bathurst Island: -
Melville Island: Mathews (1914).

TAWNY GRASSBIRD *Megalurus timoriensis*.
Bathurst Island: -
Melville Island: Mathews (1914); Zietz (1914*a*); Storr (1977).

GOLDEN-HEADED CISTICOLA *Cisticola exilis*.
Bathurst Island: -
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997).

RUFOUS SONGLARK *Cinclorhamphus mathewsi*.
Bathurst Island: -
Melville Island: Mathews (1914).

RED-BACKED FAIRY-WREN *Malurus melanocephalus*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

WEEBILL *Smicrornis brevirostris*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997).

LARGE-BILLED GERYGONE *Gerygone magnirostris*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS; RAOU]

MANGROVE GERYGONE *Gerygone levigaster*.
Bathurst Island: Fensham & Woinarski (1992). [BRS].
Melville Island: Fensham & Woinarski (1992). [BRS].
Notes: recorded also from Buchanan Island (Mathews (1914)).

GREEN-BACKED GERYGONE *Gerygone chloronota*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

VARIED SITTELLA *Daphoenositta chrysoptera*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992).

HELMETED FRIARBIRD *Philemon buceroides*.
Bathurst Island: Fensham & Woinarski (1992). [BRS; RAOU].
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

SILVER-CROWNED FRIARBIRD *Philemon argenticeps*.
***juruwa**
Bathurst Island: Fensham & Woinarski (1992). [Victorian Museum].
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

LITTLE FRIARBIRD *Philemon citreogularis*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

BLUE-FACED HONEYEATER *Entomyzon cyanotis*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Zietz (1914*a*); Goodfellow (1935); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

YELLOW-THROATED MINER *Manorina flavigula*.
Bathurst Island: -
Melville Island: Mathews (1914); Fensham & Woinarski (1992); Mason and Schodde (1997).

SINGING HONEYEATER *Lichenostomus virescens*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997).

WHITE-GAPED HONEYEATER *Lichenostomus unicolor*.
Bathurst Island: Fensham & Woinarski (1992). [RAOU].
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS; RAOU].

YELLOW-TINTED HONEYEATER *Lichenostomus flavescens*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [CSIRO]

WHITE-THROATED HONEYEATER *Melithreptus albogularis*.
Bathurst Island: Storr (1977); Fensham & Woinarski (1992). [RAOU].
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

BROWN HONEYEATER *Lichmera indistincta*.
Bathurst Island: Fensham & Woinarski (1992). [BRS].
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS; RAOU].

BAR-BREASTED HONEYEATER *Ramsayornis fasciatus*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Zietz (1914*a*). [BRS; Victorian Museum].

RUFOUS-BANDED HONEYEATER *Conopophila albogularis*.
Bathurst Island: [BRS].
Melville Island: Mathews (1914); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

DUSKY HONEYEATER *Myzomela obscura*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

RED-HEADED HONEYEATER *Myzomela erythrocephala*.
Bathurst Island: Fensham & Woinarski (1992). [BRS].

Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS; RAOU].

MISTLETOEBIRD *Dicaeum hirundinaceum*.
Bathurst Island: Fensham & Woinarski (1992). [RAOU].
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS; RAOU].

STRIATED PARDALOTE *Pardalotus striatus*.
Bathurst Island: Fensham & Woinarski (1992). [RAOU].
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

YELLOW WHITE-EYE *Zosterops luteus*.
Bathurst Island: Storr (1977); Fensham & Woinarski (1992). [BRS].
Melville Island: Mathews (1914); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS; RAOU].

DOUBLE-BARRED FINCH *Taeniopygia bichenovii*.
Bathurst Island: -
Melville Island: [BRS].

LONG-TAILED FINCH *Poephila acuticauda*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: -

CRIMSON FINCH *Neochmia phaeton*.
Bathurst Island: -
Melville Island: Dodd (1935).
Notes: recorded by BRS.

CHESTNUT-BREASTED MANNIKIN *Lonchura castaneothorax*.
Bathurst Island: Storr (1977).
Melville Island: Mathews (1914); Mason and Schodde (1997).

YELLOW ORIOLE *Oriolus flavocinctus*.
Bathurst Island: Fensham & Woinarski (1992). [BRS; RAOU].
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS; RAOU].

OLIVE-BACKED ORIOLE *Oriolus sagittatus*.
Bathurst Island: -
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

FIGBIRD *Sphecotheres viridis*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

SPANGLED DRONGO *Dicrurus bracteatus*.
Bathurst Island: Fensham & Woinarski (1992). [BRS; Victorian Museum].
Melville Island: Mathews (1914); Zietz (1914*a*); Dodd 91935); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS; RAOU].

GREAT BOWERBIRD *Chlamydera nuchalis*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS; RAOU].

MAGPIE-LARK *Grallina cyanoleuca*.

Bathurst Island: [RAOU].
Melville Island: Mathews (1914); Mason and Schodde (1997). [BRS].

WHITE-BREASTED WOOD-SWALLOW *Artamus leucorhynchus*.
Bathurst Island: [RAOU].
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS; RAOU].
Notes: recorded also at Buchanan Island (RAOU).

BLACK BUTCHERBIRD *Cracticus quoyi*.
Bathurst Island: Fensham & Woinarski (1992). [BRS].
Melville Island: Mathews (1914); Zietz (1914*a*); Dodd (1935); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

GREY BUTCHERBIRD *Cracticus torquatus*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: -

PIED BUTCHERBIRD *Cracticus nigrogularis*.
Bathurst Island: Fensham & Woinarski (1992). [RAOU].
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS].

TORRESIAN CROW *Corvus orru*.
wakuwakini, kilirampani.
Bathurst Island: Fensham & Woinarski (1992). [BRS; RAOU].
Melville Island: Mathews (1914); Zietz (1914*a*); Fensham & Woinarski (1992); Mason and Schodde (1997). [BRS; RAOU].

Reptiles.

SALTWATER CROCODILE *Crocodylus porosus*.
jerengkepai, jerenkepituni, takampunga, tajuni.
Bathurst Island: --
Melville Island: Fensham & Woinarski (1992).

GREEN TURTLE *Chelonia mydas*.
Bathurst Island: [CRA; MAGNT].
Melville Island: Fensham & Woinarski (1992). [CRA].
Notes: CRA lists at least ten main breeding sites for this species on sandy beaches of Bathurst, Melville and Buchanan Islands.

FLATBACK TURTLE *Natator depressus*.
Bathurst Island: [CRA, MAGNT].
Melville Island: [CRA].
Notes: CRA lists at least ten main breeding sites for this species on sandy beaches of Bathurst, Melville and Buchanan Islands.

OLIVE RIDLEY *Lepidochelys olivacea*.
Bathurst Island: Guinea (1990).
Melville Island: [Ray Chatto *pers. comm.*]

HAWKSBILL TURTLE *Eretmochelys imbricata*.
Bathurst Island: [BRS; CRA].
Melville Island: [BRS, CRA].
Notes: CRA lists several breeding sites for this species on Bathurst and Melville Islands.

NORTHERN SNAKE-NECKED TURTLE *Chelodina rugosa*.
Bathurst Island: -
Melville Island: Davis (1983); Horner and Griffiths (1998)..

NORTHERN SHORT-NECKED TURTLE *Emydura victoriae*.
Bathurst Island: -
Melville Island: Davis (1983); Horner and Griffiths (1998). [BRS]

NORTHERN DTELLA *Gehyra australis*.
Bathurst Island: Fensham & Woinarski (1992). [MAGNT]
Melville Island: Fensham & Woinarski (1992); Horner and Griffiths (1998).
No. of quadrats:

ASIAN HOUSE GECKO *Hemidactylus frenatus*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Fensham & Woinarski (1992); Horner and Griffiths (1998).
No.of quadrats: .
Notes: Introduced species.

BYNOE'S GECKO *Heteronotia binoei*.
Bathurst Island: Fensham & Woinarski (1992). [MAGNT]
Melville Island: Fensham & Woinarski (1992); Horner and Griffiths (1998). [MAGNT; Australian Museum; Victorian Museum]
No. of quadrats:

ZIG-ZAG VELVET GECKO *Oedura rhombifera*.
Bathurst Island: Fensham & Woinarski (1992). [MAGNT]
Melville Island: Fensham & Woinarski (1992); Horner and Griffiths (1998). [MAGNT]
No. of quadrats:

XX *Delma borea*.
Bathurst Island: Fensham & Woinarski (1992). [MAGNT]
Melville Island: Fensham & Woinarski (1992).
No. of quadrats:

BURTON'S LEGLESS LIZARD *Lialis burtonis*.
Bathurst Island: [MAGNT; CSIRO]
Melville Island: Fensham & Woinarski (1992); Horner and Griffiths (1998). [MAGNT].

FRILL-NECKED LIZARD *Chlamydosaurus kingi*.
kuripurani.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Fensham & Woinarski (1992); Horner and Griffiths (1998). [BRS; South Australian Museum; Victorian Museum]

NORTHERN TWO-LINED DRAGON *Diporiphora bilineata*.
Bathurst Island: Fensham & Woinarski (1992). [MAGNT]
Melville Island: Fensham & Woinarski (1992); Horner and Griffiths (1998). [MAGNT; Australian Museum]
No. of quadrats: .

SWAMP DRAGON *Gemmatophora temporalis*.
wulekarani.
Bathurst Island: Fensham & Woinarski (1992). [MAGNT]
Melville Island: Fensham & Woinarski (1992); Horner and Griffiths (1998). [MAGNT; Victorian Museum]
No. of quadrats:

SAND GOANNA *Varanus gouldii*.
muani, muaka.

Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Fensham & Woinarski (1992); Horner and Griffiths (1998). [BRS]
No. of quadrats:

MANGROVE MONITOR *Varanus indicus*.
Bathurst Island: -
Melville Island: -
Notes: recorded as a food source for Tiwi people by Davis (1983).

MERTEN'S WATER MONITOR *Varanus mertensi*.
pakiterati, juwarnti.
Bathurst Island: -
Melville Island: Fensham & Woinarski (1992); Horner and Griffiths (1998). [Australian Museum]

SPOTTED TREE MONITOR *Varanus scalaris*.
Bathurst Island: Fensham & Woinarski (1992). [MAGNT]
Melville Island: Fensham & Woinarski (1992); Horner and Griffiths (1998). [South Australian Museum; BRS]
No. of quadrats:

BLACK-HEADED GOANNA *Varanus tristis*.
Bathurst Island: [MAGNT]
Melville Island: Fensham & Woinarski (1992). [Victorian Museum]
No. of quadrats: .

SLENDER RAINBOW SKINK *Carlia gracilis*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Fensham & Woinarski (1992); Horner and Griffiths (1998). [Victorian Museum; BRS]
No. of quadrats:

STRIPED RAINBOW SKINK *Carlia munda*.
Bathurst Island: Fensham & Woinarski (1992). [MAGNT; Victorian Museum]
Melville Island: Fensham & Woinarski (1992); Horner and Griffiths (1998). [MAGNT; Victorian Museum; Australian Museum]
No. of quadrats:

RED-SIDED RAINBOW SKINK *Carlia rufilatus*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Fensham & Woinarski (1992); Horner and Griffiths (1998).
No. of quadrats:

THREE-SPINED RAINBOW SKINK *Carlia triacantha*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Fensham & Woinarski (1992); Horner and Griffiths (1998).
No. of quadrats:

ARBOREAL SNAKE-EYED SKINK *Cryptoblepharus plagiocephalus*.
Bathurst Island: Fensham & Woinarski (1992). [MAGNT; Victorian Museum]
Melville Island: Fensham & Woinarski (1992); Horner and Griffiths (1998). [MAGNT; CSIRO; Victorian Museum; South Australian Museum; Australian Museum]
No. of quadrats:

NORTHERN CTENOTUS *Ctenotus borealis*.
Bathurst Island: [MAGNT]
Melville Island: Horner and King (1986); Fensham & Woinarski (1992); Horner and Griffiths (1998).
No. of quadrats:

PORT ESSINGTON CTENOTUS *Ctenotus essingtonii*.
Bathurst Island: Fensham & Woinarski (1992). [MAGNT; Victorian Museum]

Melville Island: Fensham & Woinarski (1992); Horner and Griffiths (1998). [MAGNT; Victorian Museum; Australian Museum; CSIRO; South Australian Museum]
No. of quadrats:

HILL'S CTENOTUS *Ctenotus hilli*.
Bathurst Island: [Victorian Museum].
Melville Island: Horner (1991).

DARWIN SKINK *Glaphyromorphus darwiniensis*.
Bathurst Island: Fensham & Woinarski (1992). [MAGNT]
Melville Island: Fensham & Woinarski (1992); Horner and Griffiths (1998). [MAGNT; Victorian Museum]
No. of quadrats:

DOUGLAS' SKINK *Glaphyromorphus douglasi*.
Bathurst Island: Fensham & Woinarski (1992). [MAGNT]
Melville Island: Fensham & Woinarski (1992); Horner and Griffiths (1998). [MAGNT; CSIRO; Victorian Museum; Australian Museum]
No. of quadrats:

SMOOTH-SCALED SKINK *Glaphyromorphus isolepis*.
Bathurst Island: [MAGNT].
Melville Island: [Victorian Museum].

MACFARLANE'S SKINK *Lygisaurus macfarlani*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Fensham & Woinarski (1992); Horner and Griffiths (1998). [MAGNT; Queensland Museum]
No. of quadrats:

ALANA'S MENETIA *Menetia alanae*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: this survey
No. of quadrats:

GREY'S MENETIA *Menetia greyii*.
Bathurst Island: -
Melville Island: Fensham & Woinarski (1992).
No. of quadrats:

STORR'S SNAKE-EYED SKINK *Morethia storri*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Fensham & Woinarski (1992); Horner and Griffiths (1998).
No. of quadrats:.

Morethia ruficauda.
Bathurst Island: [MAGNT].
Melville Island: --

SLENDER SNAKE-EYED SKINK *Proablepharus tenuis*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Fensham & Woinarski (1992).
No. of quadrats:

COMMON BLUE-TONGUED LIZARD *Tiliqua scincoides*.
tuninga.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Fensham & Woinarski (1992); Horner and Griffiths (1998).
No. of quadrats:

BLACK-HEADED PYTHON *Aspidites melanocephalus*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: this survey

CHILDREN'S PYTHON *Bothrochilus childreni*.
Bathurst Island: -
Melville Island: Fensham & Woinarski (1992); Horner and Griffiths (1998).
No. of quadrats:

WATER PYTHON *Bothrochilus fuscus*.
Bathurst Island: -
Melville Island: Fensham & Woinarski (1992).
No. of quadrats:

CARPET PYTHON *Morelia spilota*.
jilinga, munguwuka, tumpujika.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Goodfellow (1935); Fensham & Woinarski (1992); Horner and Griffiths (1998). [Victorian Museum]
No. of quadrats:

Ramphotyphlops braminus.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Fensham & Woinarski (1992); Horner and Griffiths (1998).
No. of quadrats:

Ramphotyphlops diversus
Bathurst Island: --
Melville Island: this survey
Recorded from Buchanan Island (MAGNT).

Ramphotyphlops tovelli.
Bathurst Island: -
Melville Island: Fensham & Woinarski (1992).
No. of quadrats:

LITTLE FILE SNAKE *Acrochordus granulatus*.
Bathurst Island: -
Melville Island: [CSIRO].

JAVAN FILE SNAKE *Acrochordus arafurae*.
Bathurst Island: -
Melville Island: -
Notes: recorded for the Tiwi Islands by Davis (1983).

BROWN TREE SNAKE *Boiga irregularis*.
Bathurst Island: [MAGNT].
Melville Island: Fensham & Woinarski (1992); Horner and Griffiths (1998). [MAGNT].
No. of quadrats:

BOCKADAM *Cerberus rhynchops*
Bathurst Island: -
Melville Island: [Australian Museum; South Australian Museum; Victorian Museum].

COMMON TREE SNAKE *Dendrelaphus punctulatus*.
? **terika**.
Bathurst Island: Fensham & Woinarski (1992). [CSIRO].
Melville Island: Fensham & Woinarski (1992); Horner and Griffiths (1998). [BRS; South Australian Museum].
No. of quadrats:

MACLEAY'S WATER SNAKE *Enhydris polylepis*.
Bathurst Island: -
Melville Island: Fensham & Woinarski (1992).
No. of quadrats:

SLATY-GREY SNAKE *Stegonotus cucullatus*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: -

KEELBACK *Tropidonophis mairii*.
Bathurst Island: Fensham & Woinarski (1992). [Australian Museum].
Melville Island: Horner and Griffiths (1998).
No. of quadrats:

NORTHERN DEATH ADDER *Acanthophis praelongus*.
pwamika.
Bathurst Island: -
Melville Island: -
Notes: Not apparently reported yet from the Tiwi islands, but several Tiwi people told us that this species was present on both Bathurst and Melville islands.

BLACK WHIP SNAKE *Demansia atra*.
Bathurst Island: [CSIRO].
Melville Island: Fensham & Woinarski (1992).
No. of quadrats:

OLIVE WHIP SNAKE *Demansia olivacea*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: [Australian Museum.]

MOON SNAKE *Furina ornata*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: this survey
No. of quadrats:

TAIPAN *Oxyuranus scutellatus*.
tartiwi.
Bathurst Island: Fensham & Woinarski (1992). [CSIRO].
Melville Island: Fensham & Woinarski (1992). [MAGNT].

KING BROWN SNAKE *Pseudechis australis*.
Bathurst Island: [MAGNT; Australian Museum.]
Melville Island: Fensham & Woinarski (1992); Horner and Griffiths (1998). [BRS; CSIRO, MAGNT].
No. of quadrats:

WESTERN BROWN SNAKE *Pseudonaja nuchalis*.
Bathurst Island: [CSIRO].
Melville Island: [BRS].

NORTHERN SHOVEL-NOSED SNAKE *Simoselaps roperi*.
Bathurst Island: -
Melville Island: [Australian Museum. (nb. as *S.semifasciatus*)].

NORTHERN BANDY BANDY *Vermicella multifasciata*.
Bathurst Island: -
Melville Island: [MAGNT].

Astrotia stokesii
Bathurst Island: -

Melville Island: [MAGNT].

Disteira major
Bathurst Island: -
Melville Island: [MAGNT].

Hydrophis atriceps
Bathurst Island: -
Melville Island: [MAGNT].

Hydrophis elegans
Bathurst Island: -
Melville Island: [MAGNT; Western Australian Museum].

Hydrophis ornatus
Bathurst Island: -
Melville Island: [MAGNT].

Lapemis hardwickii
Bathurst Island: -
Melville Island: [MAGNT].

Amphibians.

REMOTE FROGLET *Crinia remota*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Tyler et al. (1991); Fensham & Woinarski (1992); Horner and Griffiths (1998). [MAGNT].
No. of quadrats: .

ORNATE BURROWING FROG *Limnodynastes ornatus*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Tyler *et al*. (1991); Fensham & Woinarski (1992); Horner and Griffiths (1998). [MAGNT; South Australian Museum].
No. of quadrats:

MARBLED FROG *Limnodynastes convexiusculus*.
Bathurst Island: -
Melville Island: Tyler *et al*. (1991); Fensham & Woinarski (1992). [MAGNT; South Australian Museum].
No. of quadrats:

NORTHERN SPADEFOOT TOAD *Notaden melanoscaphus*.
Bathurst Island: -
Melville Island: Tyler *et al*. (1991). [South Australian Museum].

Uperoleia inundata.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Tyler *et al*. (1991); Fensham & Woinarski (1992) [South Australian Museum].
No. of quadrats:

Cyclorana australis.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Tyler *et al*. (1991); Fensham & Woinarski (1992). [MAGNT; South Australian Museum].
No. of quadrats:

NORTHERN DWARF TREE FROG *Litoria bicolor*.
Bathurst Island: Fensham & Woinarski (1992).

Melville Island: Tyler *et al*. (1991); Fensham & Woinarski (1992); Horner and Griffiths (1998). [.MAGNT; South Australian Museum].
No. of quadrats:

GREEN TREE FROG *Litoria caerulea*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Tyler *et al*. (1991); Fensham & Woinarski (1992).
No. of quadrats:

Litoria inermis.
Bathurst Island: -
Melville Island: Fensham & Woinarski (1992); Horner and Griffiths (1998). [MAGNT].
No. of quadrats:

Litoria microbelos.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Tyler *et al*. (1991); Fensham & Woinarski (1992); Horner and Griffiths (1998). [.MAGNT; South Australian Museum].
No. of quadrats:

ROCKET FROG *Litoria nasuta*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Tyler *et al*. (1991); Fensham & Woinarski (1992); Horner and Griffiths (1998). [.MAGNT; South Australian Museum; Victorian Museum].
No. of quadrats:

Litoria pallida.
Bathurst Island: -
Melville Island: Tyler *et al*. (1991); Horner and Griffiths (1998). [MAGNT; South Australian Museum].

BROWN TREE FROG *Litoria rothii*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Tyler *et al*. (1991); Fensham & Woinarski (1992); Horner and Griffiths (1998). [.MAGNT; South Australian Museum].
No. of quadrats:

DESERT TREE FROG *Litoria rubella*.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Fensham & Woinarski (1992). [MAGNT].
No. of quadrats:

Litoria tornieri.
Bathurst Island -
Melville Island: Tyler *et al*. (1991); Fensham & Woinarski (1992); Horner and Griffiths (1998). [.MAGNT; South Australian Museum].
No. of quadrats:.

Sphenophryne adelphe.
Bathurst Island: Fensham & Woinarski (1992).
Melville Island: Tyler *et al*. (1991); Fensham & Woinarski (1992); Horner and Griffiths (1998). [.MAGNT; South Australian Museum].
No. of quadrats:.

Erroneous literature records

[NORTHERN QUOLL *Dasyurus hallucatus*.
Bathurst Island: Strahan (1988).
Melville Island: Strahan (1988).

Notes: These records are probably erroneous. Many Tiwi people told us that this conspicuous and distinctive species is not present on the islands, and we also failed to record it. Harney & Elkin (1942-43) also mention that it is absent from the Tiwi Islands.]

[DIADEM HORSESHOE-BAT *Hipposideros diadema*.
Bathurst Island: Strahan (1988).
Melville Island: Strahan (1988).
Note: These records are almost certainly erroneous, as no caves suitable for roosting sites for this species appear to be present on the islands.]

Diporiphora albilabris
Bathurst Island:
Melville Island: MAGNT.

[*Diporiphora magna*.
Bathurst Island:
Melville Island: MAGNT (?error).]

Gemmatophora gilberti
Bathurst Island:
Melville Island: Australian Museum.

Varanus acanthurus
Bathurst Island:
Melville Island: South Australian Museum.

[NORTHERN SAND GOANNA *Varanus panoptes*.
Bathurst Island:
Melville Island:
Notes: Reported for Melville Island by R. Fensham. An important food source for Tiwi people.] Not on island (N. Gambold)

[*Ctenotus robustus*.
Bathurst Island: NTM. (?error).
Melville Island:]

[OLIVE PYTHON *Bothrochilus olivaceus*.
Bathurst Island:
Melville Island:
Notes: recorded by Davis (1983), perhaps in error.] Not on island (N. Gambold)

GLOSSY IBIS *Plegadis falcinellus*.
Bathurst Island: --
Melville Island: --
Notes: recorded by BRS.
Status: listed on CAMBA.

CLAMOROUS REED-WARBLER *Acrocephalus stentoreus*.
Bathurst Island:
Melville Island:
Notes: recorded by BRS.

[RED-BROWED PARDALOTE *Pardalotus rubricatus*.
Bathurst Island:
Melville Island: BRS (?error).]

[CRIMSON FINCH *Neochmia phaeton*.
Bathurst Island:
Melville Island:
Notes: recorded by BRS.]

[MASKED WOOD-SWALLOW *Artamus personatus*.
Bathurst Island:
Melville Island: BRS (?error).]

APPENDIX H:

List of plant species recorded from the Tiwi Islands

The following list compiles records from all available surveys or lists of Tiwi plant species. This collation is not always straightforward as some taxonomic changes render older names ambiguous, and some names may have been misapplied and, without specimens, cannot now be resolved.

Species are listed in alphabetical order by Family. Species included without an entry in the third column (taxon_name) refer to species for which no current formal name can be readily applied.

Sources (columns):
amrad: quadrat-based surveys by the NT Herbarium over the last five years, as part of the Amrad (plant pharmaceutical survey) study;
wilson: quadrat-based surveys of the treeless plain-open forest boundary by Bruce Wilson (CCNT);
herbmq: quadrat-based surveys by the NT Herbarium over the last 5 years.
holtze: the NT Herbarium specimen register;
jrs_rf: patch-based surveys of rainforests by Jeremy Russell-Smith;
fensh: quadrat-based surveys of eucalypt forest plants, by Rod Fensham;
weed: quadrat-based surveys of plants at sites with weeds, by Rod Fensham;
this survey: quadrat-based records of woody plants collected during this survey;

Conservation status:
NT conservation status, updated from Leach *et al*. (1992). Note that this does not necessarily agree with that proposed in annexes to the *Territory Parks and Wildlife Conservation Amendment Act 2000*. Every entry has two codes:

distribution 1=known only from the type locality; 2=a very restricted distribution (maximum geographic range < 100km); 3=range >100km, but occurring only in small populations which are mainly rstricted to highly specific and localised habitats.

conservation status. E=endangered; V=vulnerable; R=rare; K=poorly known.

no.quads. The total number of quadrats from which the species has been recorded (i.e. includes all data sets other than Holtze above).