Habitat preferences of the terrestrial vertebrate fauna of Weipa, Cape York Peninsula

Thesis submitted by

Alexander J. THOMAS BSc, PGDip

in Oct 2004

Declaration

I declare that this thesis is my own work and has not been submitted in any form for another degree or diploma at any university or other institution of tertiary education. Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references is given.

A J Thomas
October 2004

STATEMENT OF ACCESS

I, the undersigned, author of this work, understand that James Cook University will make this thesis available for use within the University Library and, via the Australian Digital Theses network, for use elsewhere.

I understand that, as an unpublished work, a thesis has significant protection under the Copyright Act and;

I do not wish to place any further restriction on access to this work.

___________________________ _______________

Signature Date

ELECTRONIC COPY

I, the undersigned, the author of this work, declare that the electronic copy of this thesis provided to the James Cook University Library is an accurate copy of the print thesis submitted, within the limits of the technology available.

_______________________ Signature

_____________ Date

Contents

Preface **1**

Acknowledgments **2**

Abstract **4**

1 Introduction **7**
- 1.1 Introduction 7
- 1.2 Habitat preference 9
- 1.3 Anticipated fauna at Weipa 21
- 1.4 The orebody at Weipa 25
- 1.5 The habitats of Weipa 27
- 1.6 The mine regions 33
- 1.7 Landscape effects 34
- 1.8 Seasonality 39
- 1.9 Aims, objectives and hypotheses 46

2 Methods **50**
- 2.1 Study area 50
- 2.2 Survey design 51
- 2.3 Survey sites 53
- 2.4 Field schedules 58
- 2.5 Field methods 61
- 2.6 Data analysis 66

3 Results **74**
- 3.1 Ore value 74
- 3.2 Landscape position 86
- 3.3 Creek, Swamp and Marine habitats 103
- 3.4 Andoom and Weipa regions 114
- 3.5 Seasonal habitat observations 122
- 3.6 Microhabitat factors 125
- 3.7 Species-specific accounts 126
- 3.8 Species sampling 136

4 Discussion **141**
- 4.1 Principal conclusions 141
- 4.2 Contribution to ecological theory 144
- 4.3 Implications for practice 148
- 4.4 Unresolved issues 153

Bibliography **158**

Appendices **174**

List of Tables

Table 1 - Number of vertebrates recorded in selected major habitats at Weipa, based on Winter and Atherton (1985)....... 23

Table 2 - Thirteen endangered, vulnerable, rare or poorly known vertebrates that are known or are likely to occur on the mine lease. 25

Table 3 - Summary of the survey design factors, levels of each factor and number of replicates at each level. 52

Table 4 - Schedule of survey visits with dates of arrival and departure, and duration of each visit...................................... 59

Table 5 - Sequence of sites surveyed for each visit. 60

Table 6 - Daily site sampling schedule. 61

Table 7 – Structural habitat attributes sampled from all sites. 65

Table 8 - Terminology used to explain numerical statistical probabilities 73

Table 9 – Species diversity of woodland habitats above economic and uneconomic ore. 74

Table 10 – Results of resampling procedure for comparisons of composition of observed terrestrial vertebrates in woodland habitats above economic and uneconomic ore showed no significant differences at any level of analysis..... 78

Table 11 - The top five terrestrial vertebrates which most characterised woodland habitat above economic ore. 81

Table 12 - The top five terrestrial vertebrates which most characterised woodland habitat above uneconomic ore. 82

Table 13 - The top five terrestrial vertebrates which most characterised the difference in woodland habitats above economic and uneconomic ore. 82

Table 14 - Number of terrestrial vertebrates systematically and incidentally observed in woodland habitat sites economic

and uneconomic, and the number of these with a significant difference in incidence. 83

Table 15 – Species diversity of woodland, ecotone and riparian habitats. 86

Table 16 – Results of resampling procedure for comparisons of composition of observed terrestrial vertebrates in woodland, ecotone and riparian habitats. 93

Table 17 - Number of species used in comparison of woodland, ecotone and riparian habitat sites, and the number of these with a significant observed difference in incidence. 96

Table 18 - Taxa observed exclusively and significantly in one habitat type. 96

Table 19 – Six species accounted for the first 30% of the dissimilarity of riparian habitat. 99

Table 20 – Five species accounted for the first 30% of the dissimilarity of ecotone habitat. 100

Table 21 – Seven species accounted for the first 30% of the dissimilarity of woodland habitat. 100

Table 22 - Species considered by Winter (1989) to be locally rare and restricted to woodland habitat, and the number of observations of these made in this survey. 101

Table 23 – Species diversity of creek, swamp and marine riparian habitats. 103

Table 24 – Results of resampling procedure for comparisons of composition of observed terrestrial vertebrates in creek, swamp and marine riparian habitats. 107

Table 25 - Number of species used in comparison of creek, swamp and marine riparian habitat sites and with a significant habitat preference. 110

Table 26 - Number of species by class which were observed (significantly) for each permutation of habitat preference among creek, swamp and marine habitat sites...................... 110

Table 27 – Five species accounted for the first 30% of the dissimilarity of riparian creek habitat. 112

Table 28 – Five species accounted for the first 30% of the dissimilarity of riparian swamp habitat. 113

Table 29 – Five species accounted for the first 30% of the dissimilarity of riparian marine habitat................................ 113

Table 30 - Species diversity of the woodland habitats of the Andoom and Weipa regions. 114

Table 31 – Results of resampling procedure for comparisons of composition of observed terrestrial vertebrates in woodland habitats from Andoom and Weipa regions show no significant differences at any level of analysis. 116

Table 32 - Number of species observed (significantly) between the Andoom and Weipa regions. 120

Table 33 - Species which had a significant difference in the number of individuals between the Andoom and Weipa regions.. 121

Table 34 - Relative effort and cost-benefit of sampling methods.. 140

List of Illustrations

Figure 1 - Location of Weipa on the western coast of the Cape York Peninsula, North Queensland, Australia.......................... 8

Figure 2 – Name, duration and timing of ecological seasons at Weipa... 39

Figure 3 - Extreme and mean daily maximum and minimum temperatures in each month at Weipa based on 28 years of Bureau of Meteorology (1992) data. 42

Figure 4 - Mean total monthly rainfall for the Andoom and Weipa regions based on 74 years of Bureau of Meteorology (1992) data. 43

Figure 5 - Mean 9am and 3pm relative humidity recorded from Weipa based on 28 years of Bureau of Meteorology (1992) data.. 44

Figure 6 - Location of study sites and approximate area of operations of the Weipa bauxite mine as at 1993, the year of the study. 50

Figure 7 - Map of Andoom region showing survey sites, sampled habitats, the mineface (1993) and the edge of the economic orebody.. 54

Figure 8 - Map of Weipa region showing urban communities, survey sites, the sampled habitats, the mineface (1993) and the edge of the economic orebody... 55

Figure 9 - Timing of survey visits, compared to ecological seasons.. 59

Figure 10 - Layout of pitfence traps. 63

Figure 11 - Example of a mosaic plot showing the proportional composition of the fauna of two habitats............................... 69

Figure 12 - Cumulative number of species observed from all woodland sites, showing that a substantial proportion of the terrestrial vertebrate fauna was sampled........................... 75

Figure 13- The species richness and total abundance of the observed terrestrial vertebrate fauna of woodland habitat above economic and uneconomic ore, showing no significant differences.. 75

Figure 14 – Average species richness of the terrestrial vertebrates of woodland habitat sites above economic and uneconomic bauxite ore showed no significant differences... 76

Figure 15 – Absolute count and proportion (indicated by intensity of grey) of unique and shared terrestrial vertebrate species across woodland habitat above economic and uneconomic ore. 77

Figure 16 - Ordination (NMS) and minimum convex polygons of woodland habitat sites above economic and uneconomic ore against species presence/absence composition shows no distinguishable pattern of difference. 78

Figure 17 – No significant difference was observed in the absolute (N) or proportional composition in species richness, by class, of the terrestrial vertebrates of woodland habitats above economic and uneconomic ore....... 79

Figure 18 - Scatter plot of the abundance (Ln(N+1))of each observed terrestrial vertebrate from the combined woodland habitat sites above economic ore and uneconomic bauxite ore... 80

Figure 19 - Average abundances of systematically sampled terrestrial vertebrates from woodland habitat sites above economic and uneconomic bauxite ore show no significant difference. 81

Figure 20 - Systematic observations of the gecko *Heteronotia binoei* and a common dragon *Diporiphora bilineata*. 84

Figure 21 - Cumulative species-richness curve for all terrestrial vertebrate species observed from all woodland, ecotone

and riparian sites, indicating that for comparative purposes an adequate proportion of the fauna was sampled. 87

Figure 22 – Comparison of the terrestrial vertebrate richness and abundance (corrected for sampling effort) of woodland, ecotone and riparian habitats. 88

Figure 23 - Comparison of the mean terrestrial vertebrate richness of sites from woodland, ecotone and riparian habitats indicates no significant difference............................ 89

Figure 24 – Absolute count and proportion of unique and shared terrestrial vertebrates across woodland, ecotone and riparian habitats, showing that most species occur in all three habitats, with only birds and frogs having a preponderance of species restricted to mesic habitats. 90

Figure 25 – Non-metric multidimensional scaling plot for the standardised transformed abundance of species abundance of woodland, ecotone and riparian habitat sites shows a distinguishable difference and a gradient in their fauna composition.. 91

Figure 26 - Non-metric multidimensional scaling plot for the Log(X+1) transformed abundance of species of sites from those landunits sampled in the study, shows that while there is some overlap with woodland landunits (2b, 5k) the ecotone landunit (5e) is also clearly different in its terrestrial vertebrate fauna composition. 92

Figure 27 – No significant difference was observed in the absolute (N) or proportional composition in species richness, by class, of the terrestrial vertebrate richness of woodland, ecotone and riparian habitats. 94

Figure 28 - Scatterplots of the log of abundance (sum of individuals) of each observed terrestrial vertebrate from each two-way permutation of woodland, ecotone and riparian habitat sites. 94

Figure 29 - Comparison of the average sum of abundances of systematically observed terrestrial vertebrates from woodland, ecotone and riparian habitat sites. 95

Figure 30 - Cumulative species-richness curve for all terrestrial vertebrate species observed from all creek, swamp and marine riparian sites, indicating that for comparative purposes an adequate proportion of the fauna was sampled. 104

Figure 31 - Comparison of the richness and abundance (corrected for sampling effort) of the terrestrial vertebrate fauna of creek, swamp and marine riparian habitats. 104

Figure 32 - Comparison of the richness of terrestrial vertebrates of sites from creek, swamp and marine riparian habitats. 105

Figure 33 - Absolute count and proportion of unique and shared terrestrial vertebrates across creek, swamp and marine riparian habitats, showing that each class has a distinct pattern of beta diversity. 106

Figure 34 - Ordination (NMS) of creek, swamp and marine riparian habitat sites shows a distinguishable difference in the fauna composition of swamps, and suggests some similarity in the fauna composition of creek and marine riparian habitats. 106

Figure 35 – Differences in the proportional composition by class of terrestrial vertebrate species richness of creek, swamp and marine riparian habitats were not significant. ... 108

Figure 36 - Scatterplot matrix of the sum of individuals of each observed terrestrial vertebrate, from creek, swamp and marine riparian habitat sites. 108

Figure 37 - Comparison of the sums of abundances of terrestrial vertebrate species from creek, swamp and marine riparian habitat sites. 109

Figure 38 - Cumulative species-richness curve for all terrestrial vertebrate species observed from non-riparian sites, indicating that for comparative purposes an adequate proportion of the fauna was sampled. 115

Figure 39 – The species richness and abundance of the terrestrial vertebrate fauna of combined ecotone and woodland habitat sites of the Andoom and Weipa regions. . 115

Figure 40 – Ordination (NMS) of woodland habitat sites of the Andoom and Weipa regions show no distinguishable difference in their fauna composition. 117

Figure 41 - Species richness of Andoom and Weipa woodland habitat sites. 117

Figure 42 - Scatterplots of the sum of individuals of each species, from the combined woodland habitat sites of the Andoom and Weipa regions. 119

Figure 43 - Species abundances of Andoom and Weipa woodland habitat sites... 119

Figure 44 - The species richness of the observed fauna for each survey visit (with season). 122

Figure 45 - The distribution and dispersion of the number of bird species at all survey sites... 129

Figure 46 - The distribution and dispersion of the number of reptile species at all survey sites. 131

Figure 47 - Number of species of frogs at sites among riparian, ecotone and woodland habitat sites 135

Figure 48 - Accumulation by survey visit of observed terrestrial vertebrate richness. 137

Figure 49 - Distribution of terrestrial vertebrate richness of all thirty sites based on systematic and incidental sampling. 138

Figure 50 - Distribution of terrestrial vertebrate abundances at all sites, for all systematically observed species and all survey visits. 139

List of Appendices

Appendix A - Site list

Appendix B - Land unit descriptions

Appendix C - Species list

Appendix D - Species distribution maps

Appendix E - Species list for woodland habitats above economic and uneconomic ore

Appendix F - Species list for woodland, ecotone and riparian habitats

Appendix G - Species list for creek, swamp and marine riparian habitats

Appendix H - Species list for the Andoom and Weipa regions

Appendix I - Species abundances by visit and habitat, arranged in traditional seasonal order

Appendix J - List of specimens lodged with Queensland Museum

Preface

This detailed study of the terrestrial vertebrate fauna of an Australian tropical savanna woodland highlights the counter-intuitive biodiversity values of the open forest habitats of Weipa, and more generally the savanna habitats of Cape York Peninsula and Northern Australia.

The study is something of a rarity, in that across the full seasonal cycle it simultaneously, quantitatively and systematically recorded the observed distribution and abundance of almost two hundred terrestrial vertebrates.

Apart from the technical insights that the survey has provided, this surveying experience has introduced me to an ecology I had not previously appreciated, and many new ways of seeing. It was made possible by the staff of Comalco Aluminium Limited, and I particularly want to thank them and the traditional custodians for their support.

Alex Thomas

Acknowledgments

The following people helped in bringing this work to fruition:

- my family, who persist in loving, enduring and supporting me,
- Dr John Winter and Helen Myles of Massey Creek, for providing clarity, refuge and wisdom at all the right times,
- Paul Warren - Senior Environmental Scientist of the Safety and Environment Section at Comalco's Weipa mine - and his family, who patiently tolerated the journey that my thesis has been,
- Margaret Andrews and my brother Kim, whose voluntary assistance in the field made a significant contribution to the diversity of wildlife that was observed,
- the academic, technical and administrative staff of the Zoology Department and of the School of Biological Science, in particular my co-supervisors Associate Professor Ross Alford and Dr Chris Hill, and my Heads of Department Professor R. E. Jones and Associate Professor R. Pearson. This project has also benefited from discussions with staff and students of the Tropical Environmental Studies and Geography Department,
- the Comalco Regeneration Section staff - all of whom helped support and contribute to the study in some crucial way - and without which the study would have been all the poorer,

- Joyce Hall (Kaynayth) and Eva York (Atakani) at Napranum, for our discussion of language names and their stories of reptiles in the Weipa district, and Geoff Wharton for facilitating this and numerous other instances of support,

- my various laboratory co-habitants at James Cook University; Gilliane Brodie, David Corlis, Sheree Fickling, Yvette Buffet, Jenny Goldberg, Craig Humphries, Richard Retallick and Andrew Woolnough,

- my colleagues at the CSIRO Cotton Research Unit, the Dillons, Associate Professor Greg Constable and Dr Gary Fitt, and at Biotrack Australia, Professor Andy Beattie, Dr Mark Dangerfield, for gainfully employing me while allowing me to scrounge their resources at the time, and

- my friends Mick and Janne, Garf and Maree-Lena, Ross and Lizzie, Chris, Peter, the Lai family from Weipa, Bruce and Mimi, the Townsville tribe and Andrew and Justina.

This work was carried out under Queensland National Parks and Wildlife Service Permit Numbers T581 and T944.

Abstract

The mining of bauxite ore at Weipa on Cape York Peninsula in Australia requires total extinguishment of overlying native *Eucalyptus tetrodonta* open forest habitat, and its effect on biodiversity and ecological services is unknown. The remnant landscape consists of a mosaic of regenerating habitats, and a network of remnant and mostly protected habitat patches of rainforests, swamps and corridors of riparian habitats. Fringing these remnants is a halo (also referred to as ecotone) of otherwise extinguished woodland habitats which are located above bauxite ore that it is mostly uneconomic to recover. For some of these habitats this study compared patterns of incidence and abundance of one hundred and ninety-five species of small to medium terrestrial vertebrates - fourteen mammals, one-hundred and thirty-two birds, thirty-two reptiles and seventeen frogs. The study sampled thirty-two sites, and employed a sampling design stratified into two bauxite ore values (economic and uneconomic), three landscape positions (woodland, ecotone and riparian), three riparian habitat types (creek, swamp and marine) and two geographic regions (the operational areas to the north and south of Mission River).

On the question of the relationship of the fauna of *Eucalyptus tetrodonta* open forest habitat to underlying ore value, the results showed no significant difference in the incidence, richness, diversity or composition of the systematically surveyed fauna above economic and uneconomic bauxite. At the more detailed species-specific level, significant differences in abundance were observed for an uncommon gekko (*Heteronotia binoei*) found exclusively in open forest habitat, and a common dragon (*Diporiphora bilineata*) found in all surveyed habitats. Both of these species were more abundantly recorded in woodland habitat

above economic ore. The gekko *H. binoei* is widespread throughout the Australian continent, and is not considered threatened or vulnerable. The findings suggest that for the overwhelming proportion of the native terrestrial vertebrate fauna surveyed, in a variegated landscape the open forest habitat above uneconomic ore is most probably an effective substitute for open forest habitat above economic ore.

Unexpectedly, the survey found very strong evidence that the overall biodiversity of the fauna of the open forest habitat was as quantitatively rich as the terrestrial component of the vertebrate fauna of riparian habitats within the landscape, although overall abundances were higher in riparian habitats. The findings thus affirmed the importance of specifically and independently conserving woodland habitats in addition to riparian habitats, as part of any conservation strategy.

When analysed by class, the results confirmed that the bird, reptile and frog faunas of open forest and riparian habitats were significantly different, and that patterns of biodiversity between the classes did not coincide.

The survey further demonstrated that the vertebrate fauna of open forest habitat (ecotone) immediately adjacent to riparian habitats had a distinguishable and significantly different composition to that of woodland habitats (principally due to preferences amongst birds and the presence of mostly riparian frogs), and so it cannot simply be considered a substitute for woodland habitat being lost.

What was suggested from the detail of the survey was the particular affinity of the arboreal gekkos to open woodland habitats, which may be related to the presence of mature trees with their hollows and extensive bark sheeting. This raises concerns about the usefulness of treating areas of young regeneration as an effective habitat replacement for these species, and to what extent the degree of landscape alteration will risk the viability of existing populations.

Although no richer in species, the survey found strong evidence that swamp faunas had significantly more individuals, and a distinctive bird and reptile composition, when compared to creek or marine faunas. The observation that many species were seen significantly more frequently in particular riparian habitats reinforces the significance of independently conserving all types of riparian habitats surveyed, which is the existing policy of the minesite operator.

The two regions that were being mined - Andoom and Weipa - had no significant difference in their total species richness, abundance or composition of their terrestrial fauna, despite the Andoom region having more swamp habitat than Weipa.

The most frequently recorded species was - sadly - the introduced Cane Toad *Bufo marinus*. The ascendancy of this species to its present level of abundance almost certainly explains the only conspicuously absent mammal from this study relative to earlier studies - the Northern Quoll *Dasyurus hallucatus*. The invasion of the Cane Toad is also the most likely explanation for an anecdotal record of a significant decline in varanid abundance by a traditional custodian.

Despite intensive and extensive mining disturbance, the native terrestrial vertebrate fauna at the time of the survey was substantially present when compared to earlier surveys, and the work has provided a solid basis for identifying and measuring threatening changes in distribution and abundance in future surveys.

1 Introduction

1.1 Introduction

This review of the habitat preferences of the terrestrial vertebrate fauna of Weipa defines the ecological concept of habitat preference and summarises the methods of its study. It provides a background to the factors examined in this survey, namely:

- the nature of the bauxite ore body,
- the woodland and riparian habitats within the regional landscape of Weipa,
- what is known from prior studies of the terrestrial vertebrate fauna of the region, and
- the seasonal climate of the region.

This review does not cover the patterns of habitat preference at the microhabitat scale (e.g. which part of a tree does an animal use), nor does it review all of the principles for managing and conserving Weipa's habitats (McIntyre *et al.* 2002).

Since 1957 Comalco Aluminium Limited has been operating an open-cut bauxite and kaolin mining operation at Weipa. Weipa is situated at 12°35' S and 141°45' E, on the western coast of Cape York Peninsula in Far North Queensland, Australia (See Figure 1).

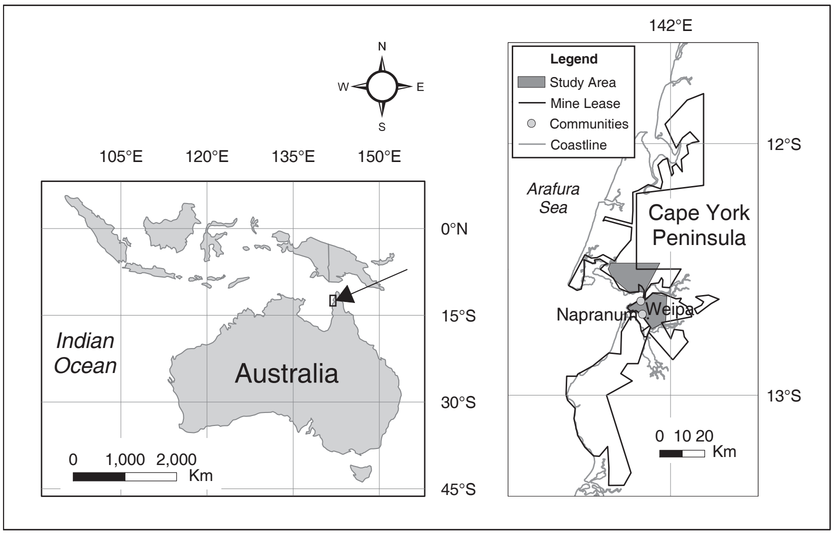


Figure 1 - Location of Weipa on the western coast of the Cape York Peninsula, North Queensland, Australia

Cape York Peninsula is a remote, isolated and sparsely settled region of tropical northern Australia. Compared with the rest of Australia, Cape York Peninsula is a relatively undisturbed wilderness (Lesslie *et al.* 1992; Glanznig 1995; Graetz *et al.* 1995), albeit with an extensive history of human occupation and modification, within which Weipa is an island of intense disturbance.

Within the peninsula land tenure includes mine leases, Deeds Of Grant In Trust (DOGIT), freehold, leasehold, Crown leasehold, nature conservation and other Crown land (Australian Surveying and Land Information Group 1993). Comalco holds two of the peninsula's mine leases - ML 7024 and ML 6024. These cover an area of 265,000 ha, and together they form a 200 km swath of land along the west coast of the Peninsula, centred on the townships of Weipa and Napranum (Figure 1).

At least twelve Aboriginal language groups occupied the Weipa area for many thousands of years prior to European settlement. In 1898 a Presbyterian mission was established at Spring Creek, then the mission was moved to Jessica Point in 1931-2 and in 1970 it began to became known as the Napranum community (Wharton 1998). Comalco operations and the Weipa and Napranum communities were described by Pearcey (1994), and the nature of the relationship between them by Howitt (1992).

Mining occurs in two regions within the lease - Andoom, to the North of Mission River, and Weipa to the South (see Figure 1). The mining process involves exploratory drilling, extensive road building, clear felling of native habitat and a lowering of the landscape. Dahle and Mulligan (1996) give a thorough account of the environmental management of the bauxite mining operations at Weipa, where mining and its associated processes is the most significant source of disturbance to the natural environment of the area (Winter 1989).

A survey of the woodland habitat within the lease (Winter and Atherton 1985) detected extensive variation in the abundance of the terrestrial vertebrate fauna. A subsequent ‘Fauna Conservation Strategy’ estimated that under the company’s 30-year mine plan for the Andoom and Weipa regions about two-thirds of their tall open woodland habitat would be lost, and also identified that it was an assumption in mine planning that remnant habitats sustain the same fauna as the habitat being mined (Winter 1989).

As a consequence, it was necessary to identify which (if any) members of the terrestrial vertebrate fauna are restricted to, or dependent upon, the tall open woodland habitat that would be lost.

1.2 Habitat preference

The habitat of an organism is defined as where it lives, or the place it can be found in (Krebs 1985), and there are often a number of inter-related factors that need to be considered when identifying a species' habitat . Living organisms exhibit a range of habitat preferences, from a high fidelity to a single habitat through to a low fidelity amongst many habitats, and may change their preferences based on a variety of factors (Odum 1959). Typically, vegetation is thought of as habitat, however Miller (2000) suggests that the two should not be considered synonymous because a species may use multiple patches of vegetation as habitat.

There are some broad patterns of habitat preference which apply to the terrestrial vertebrate fauna of the world's savannas (Bourliére 1983), such as the observation that the abundance and distribution of savanna amphibians is influenced by the nature and distribution of water bodies (Lamotte 1983). In addition to well-known habitat preference patterns such as those of the amphibians, Weipa is somewhat unique in having an especially valuable body of traditional ecological knowledge based on information contributed by the local communities (Birkin *et al.* 1988).

Patterns of habitat preference are generally determined in single-species scientific studies, which are subsequently integrated into reviews of selected faunal groups. Heatwole (1987) has observed that specific studies of whole fauna patterns of habitat preference are uncommon, and Williams (1994) identified the need for such a whole fauna study in relation to habitat preferences in the tropical savannas of northern Australia.

Extensive recent works on whole terrestrial vertebrate faunas have been completed in the landscapes of the Northern Territory - which could be considered to have some ecological similarity to Cape York Peninsula. Woinarski and Ash (2002) found that the pattern of habitat preferences varied between the four classes of vertebrates along a woodland-riparian landscape gradient, with amphibians responding most strongly to riparian habitats, reptiles having no significant preferences, birds showing strong habitat preferences in species richness and abundance, and generally weak preferences in mammals with some species specific exceptions. Woinarski *et al.* (1999) also looked at the herpetofauna of offshore Arnhem Land islands and as an indicator of the possible response to habitat fragmentation found a widespread and strong association between species incidence and island size, and that species present on the nearby mainland which have specific habitat requirements were uncommon or absent.

Assemblages of northern Australian fauna which are known to occur at Weipa and have been the subject of habitat preference studies include:

- general vertebrate assemblage (Winter and Atherton 1985; Williams *et al.* 1993; Kutt and Skull 1995; Lethbridge and Macmillan 1996),
- tropical and sub-tropical rainforest mammals (Winter 1988),
- monsoon rainforest mammals (Bowman and Woinarski 1994),
- small mammals (Friend and Taylor 1985),
- avifauna (Kikkawa 1974),
- herpetofauna (Cameron and Cogger 1992)
- wetland herpetofauna (Friend and Cellier 1990),
- ground invertebrate fauna (Plowman 1981), and

• the satyrine butterfly *Mycalesis sirius* (Braby 1995).

The assumptions in northern Australia savanna conservation (Williams 1994), are that riparian habitats:

• support a richer and more abundant fauna,

• support more habitat-dependant species,

• act as refugia for fauna during the dry and are dispersal sources during the wet,

• provide seasonally abundant resources,

• act as dispersal corridors, and

• become more significant in more arid areas.

The evidence that riparian habitats are richer than surrounding woodland habitat includes Dwyer's (1972) finding that in northern Australia the streams, swamps and rocky outcrops had a richer avifauna than surrounding woodland, and Kutt and Skull's (1995) finding that riparian habitats contained more species of birds than woodland habitats.

In contrast, other workers have found that northern Australian woodland habitats are richer than closed forest habitats for birds (Brereton and Kikkawa 1974; Williams 1994), and that the overall species richness of the terrestrial vertebrate fauna of the Comalco mine lease was highest in woodland habitat (197 species), as compared to dunefield woodland (125), gallery forest (122) and vine forest (102) habitats (Winter and Atherton 1985).

Kutt and Skull (1995) found that woodland habitats contained more species of reptiles than riparian habitats, however they attributed their result to cattle damage of the riparian zone ground layer.

A number of species-specific studies are also informative, such as Madsen and Shine's (1999) finding that suggests the demography and abundance of the tropical rodent the Dusky Rat *Rattus colletti* at Adelaide River is significantly affected by minor topographical variations of the landscape. The topographical variation in their study had an effect because the seasonal inundation of the wet led to individuals migrating to drier neighbouring habitats, and during the following retreat of flood waters it then determined habitat availability.

The study of habitat preferences has assumed a greater importance with the gradual appreciation in recent years of the subtle consequences of climate change (Hughes 2003). A thorough catalogue of possible effects on the fauna of Weipa may help identify and prioritise species that may be particularly compromised by a simultaneous combination of both landscape and climate change.

Studying habitat preference

Surveys and their compromises

Habitat preference studies typically employ surveys of the distribution of terrestrial vertebrates. Surveys are the definitive method of collecting the data needed to determine the distribution and abundance of species, and are a pre-requisite for quality conservation management decisions (Myers *et al.* 1983; Soulé 1986a; Braithwaite 1991b; Cato 1995; Underwood 1995; Smyth and James 2004). Examples of aspects of conservation management in which fauna surveys are used include park management (Reid *et al.* 1993), pre-harvest timber coupe surveys in NSW (Kavanagh and Bamkin 1995), regional management planning (Norris *et al.* 1983; McFarland 1993), conservation reserve selection (McKenzie *et al.* 1989; McKenzie *et al.* 1991) and protected area management (Reid *et al.* 1993).

In all fauna surveys there is a compromise between identification and coverage, and in determining the objectives of a fauna survey the two extremes of opportunity are to study either a single species in one habitat, or a range of species in a range of habitats (Reid *et al.* 1988). Where the survey design is biased toward covering a range of species across a range of habitats, as in the habitat preference study reported here, there will be a bias against identifying the full measure of biodiversity (Williams 1995).

Birds are a frequently studied component of ecosystems, if not the most studied, and the situation is no different at Weipa (Thompson 1935; Monteith and Thomae 1976; Wheeler and Wheeler 1977; Close and Teese 1978; Beruldson 1979; Biological Environmental Research Services 1982; Reeders 1983; Winter and Atherton 1985; Clarkson and Reeders 1988; Winter 1989). The relative frequency with which habitat preference surveys are determined by the study of birds is considerable, when compared to habitat preference surveys which sample mammals, reptiles, frogs and insects.

There are three perceived advantages of surveying vertebrates such as birds to define conservation reserves; the first is the assumption of a shared pattern of diversity within habitats (ß-diversity), the second is the precautionary bias toward concluding a need for larger reserves due to the larger body sizes of vertebrates, and the third is the bias toward surveying higher order predators whose loss may lead to a cascade of linked species extinctions (Diamond 1975).

Comparatively recently it has been strongly suggested that habitats which are diversity ‘hotspots’ for one group of organisms are not necessarily ‘hotspots’ for others (Prendergast *et al.* 1993; Hero 1998). The evidence that biodiversity is not coincident across fauna groups is accumulating, and its significance is that it means conservation decisions based on the use of single groups of species are very possibly, if not probably, going to compromise other species (Mac Nally *et al.* 2004). For example, in a study located in the tropical savannas of Townsville, Woinarski and Ash (2002) found that the four classes of vertebrates had contrasting responses along a transect from an upper slope to a riparian landscape position. For invertebrates at least there is strong evidence that biodiversity is not coincident across natural habitat edges, with taxa ‘leaking’ a taxon-dependant distance into either side of the edge (Dangerfield *et al.* 2003).

Analysis and use of habitat preference data

The literature on the analysis and use of ecological data is extensive, and includes encyclopaedic seminal works (Southwood 1978), reports accompanying software (Clarke and Gorley 2001; McCune and Grace 2002), Australian-specific texts (Burgman and Lindenmayer 1998), general works on surveying (Pielou 1984; Austin and McKenzie 1988; Busby 1991; Margules and Austin 1991; McIntyre *et al.* 2002) and method-specific texts (Manly 1997).

Comparisons between the fauna of habitats can be applied to the fauna as a whole, to subsets of the fauna (typically based on ranks within the taxonomic hierarchy) and to specific species. For each of these levels of grouping the analysis typically starts with descriptive methods, followed by tests of significance of any observed differences.

Descriptions of the entire fauna of habitats start first with tabular summaries of the number of species (richness) and number of individuals (abundance).

Comparisons of differences in species richness between habitats can be tested for significance, but because they do not account for relative differences in abundance the results are not always considered to be particularly informative.

To incorporate both richness and abundance, a variety of species richness and diversity indices have been developed (Spellerberg 1991), however indices that combine both richness and abundance into a single measure of diversity have also been criticised, because their biological meaning is unclear, they are no more sensitive than simple measures, and can be insensitive to species composition and similarity information (Stocker *et al.* 1985).

Where the abundance of a species for one habitat factor is being investigated, traditional techniques such as ANOVA are appropriately powerful and useful (Friend and Cellier 1990). However, the simultaneous analysis of the distribution and abundance of more than one species for multiple habitat factors has been severely limited.

When multiple habitat factors were included in survey designs, traditional analyses employed essentially descriptive methods (Horne 1991), such as ordination.

Ordination methods such as principal component analysis (Plowman 1981) have mostly been used as exploratory techniques for visualising the similarity amongst samples. In essence, the ordination of field survey data can use either presence/absence or abundance data, and involves projecting the sites as a cloud of data points into a space based upon that site's species composition.

Traditionally, differences were tested by grouping the sites belonging to each habitat, and measuring the distances between, for example, the group centroids. These distances were considered a measure of the similarity of the fauna of the habitats (McArdle 1994). However, these methods had problems.

The main problems were that the distance measures did not have any clear biological meaning, almost all studies that employed them suffered the more general flaw of relying on only a single ordination (Friend and Taylor 1985), and there was no test for significance.

Many analytical methods employ significance tests, in which the probability of significance is traditionally determined by looking up tables of values. The reported value of significance gives the confidence with which it can be said that a distribution of observations between some samples (e.g. habitats) conformed to a hypothesised distribution. While the probability of significance is useful if the hypothesised distribution is exactly correct, in ecological situations it is generally acknowledged that it is extremely improbable that an organism's actual distribution will exactly match a hypothetical distribution.

What is preferable, and has become possible, is to answer the simpler and more biologically meaningful question of whether an observed distribution is unlikely compared to a model of no differences. To answer this, methods known variously as exact randomisation, resampling or permutation procedures are employed (Manly 1997; McCune and Mefford 1999; Clarke and Gorley 2001).

Exact randomisation is a computationally-intensive strategy, in which all possible outcomes of the test are generated, and an estimate is made of the probable occurrence of the observed difference, based on the proportion of outcomes which are as, or more, deviant than the observed difference (Sokal and Rohlf 1995). Randomisation methods do not replace traditional analytical tests; however they do replace the method of estimating the significance of the test result. As a consequence, randomisation tests enable a null hypothesis of the form 'factor A *did* not affect the responses of the experimental units' rather than 'factor A *does* not affect the responses of the population' (Garthwaite *et al.* 1995).

Methods used in the analyses of a whole fauna can also be applied to species groupings, such as taxonomic classes or functional groupings (e.g. herbivores).

Species-specific differences in abundance between habitats are amenable to goodness-of-fit tests such as the Chi-square, however only where the observations are independent. Differences in sampling effort between habitats arise in multi-variate sampling designs, and can be dealt with by modifying the ratio used in the underlying Chi-square null hypothesis.

Traditional estimates of significance for Chi-square tests are constrained by a lower limit of five expected samples per level, which means that to compare the number of observations of a species between two habitats with an underlying sampling effort ratio of 1:1 you would have needed at least ten independent observations, and among three habitats with an underlying sampling ratio of say 1:1:2 you would have needed at least twenty independent observations (Sokal and Rohlf 1995).

This constraint has traditionally presented a problem for fauna surveys because species with strong habitat preferences are frequently rare. Thus there is a bias against observing rare species with strong habitat preferences frequently enough to detect their preference with any statistical confidence.

Using exhaustive randomisation, the chi-square statistic can be determined for a large population of all permutations of observations for less than five samples per level, enabling a test of significance for rare observations.

In diagnosing habitat preference Krebs (1985) emphasises that living means not just simply occurring but actually surviving, growing and reproducing. This aspect of the study of habitat preference means that raw comparisons of species observations between habitats make conclusions of preference particularly vulnerable to Type I and Type II errors. A scenario for making a Type I error is where a species which prefers one habitat is observed while opportunistically perching in an adjacent habitat. Being seen in both habitats, a simple comparison would erroneously conclude that, despite there actually being a difference, there was no difference in preference between habitats. A scenario for a Type II error is where a species that does not require a particular habitat is observed within it, and consequently a simple comparison concludes that there is no difference in preference between habitats.

In interpreting quantitative ecological surveys it should be borne in mind that a significant outcome of a test is not proof of a hypothesis, but simply a piece of supporting evidence (Hempel 1966). Despite the use of a formal survey design and a rigorous methodology, it is necessary to re-iterate the point that almost all of the outcomes of this study must be qualified with what Soulé (1986a) identifies as the bottom line for qualifying characterisations of complex systems - "it depends".

Habitat preference data can be used in qualitative, statistical and bioclimatic habitat models, and can assist with reserve design, selection of indicators in monitoring and assessment procedures, risk assessments of extinction likelihood and population viability analyses (Burgman and Lindenmayer 1998).

Qualitative habitat models predict species distribution and abundance using habitat suitability indices. The indices are the product of scores of a combination of biological and life history attributes selected by expert opinion (Mace and Collar 2002), and can help direct further research on species-habitat relationships. Statistical habitat models can generate testable maps of species predicted distributions, based on relating observed incidence to habitat factors that are quicker and cheaper to survey than actual animals (Boyce and McDonald 1999). Bioclimatic habitat modelling is similar to statistical habitat modelling; however it is applied at a broader scale and uses continental scale climatic factors such as rainfall.

The reserve design problem is to find the cheapest feasible solution to prescribing the use of land such that the fewest species remain unprotected. As it is not practical to survey all species, it is common practice to use available data as a surrogate for biodiversity. It is a practice with assumptions that have rarely been tested in Australia. For the present area of operations Winter (1989) created a reserve design by employing land unit maps, his expert knowledge of endemism and richness based on prior surveying and consultation with minesite planning on operational opportunities and constraints. While the comprehensiveness, adequacy and representativeness of the Winter's design is yet to be independently assessed, it emerged that testing one particular assumption of surrogacy - the predictive capability of the economic value of the orebody underlying the landscape - was essential.

1.3 Anticipated fauna at Weipa

Biodiversity simply means the variety of life, and on a global scale Australia's is particularly significant, rich and unique (Office of the Chief Scientist 1992a).

The study area is located within the Embley River Basin of the Weipa Plateau subregion of the Cape York Peninsula biogeographic region. On a continental scale an assessment of terrestrial biodiversity (National Land & Water Resources Audit 2002) identified that the subregion is characterised by:

- The 3rd highest of 6 possible levels of landscape health stress,
- Near pristine wetlands,
- Riparian zones in good condition,
- Static condition trends in both wetlands and riparian zones,
- Threats associated with cattle grazing, exotic weeds, feral animals,
- Freedom from threats of pollution, salinity and hydrological changes,
- 41% of its ecosystems are threatened,
- Less than 25 threatened species,
- A high number of resident bird species,
- The most important bioregion for threatened bird taxa in northern Australia,
- A centre of endemism for birds, and
- A refuge for declining mammals.

The distribution and abundance of Australia's tropical savanna landscapes, and their climatological, floral and faunal attributes have been reviewed by Gillison (1983) in Bourliére (1983), and have more recently been broadly described by Dyne and Walton (1987). Australia's tropical savannas were also the subject of a joint symposium between the Ecological Society of Australia and the Australian Mammal Society in 1983 (Ridpath and Corbett 1985).

The biodiversity of Australia’s northern landscapes reflects the global pattern of high diversity in tropical latitudes. This is true at the generic level in the bats, terrestrial birds, varanid lizards, turtles, snakes and freshwater fish (Kikkawa and Pearse 1969; Ridpath 1985). The paradox in Australia’s northern biota is that at a family level the diversity of northern Australia’s birds and vascular plants is contained within its Eucalypt woodlands, and not its closed forests (Brereton and Kikkawa 1974; Kikkawa 1974; Taylor and Dunlop 1985).

Cape York Peninsula is one of the few areas of Australia for which an intensive and comprehensive regional study has been conducted. The Cape York Peninsula Land Use Strategy (CYPLUS) has compiled more than forty reports on a comprehensive variety of aspects of the region, including three that relate to the fauna of Weipa (Abrahams *et al.* 1995; Driscoll 1995; Winter and Lethbridge 1995). The natural history of Cape York Peninsula has also received popular treatment (Frith and Frith 1991; Frith *et al.* 1995).

Compared to northern Australia as a whole, the biodiversity of Cape York Peninsula is particularly high because of its size, its habitat mosaic and its proximity to landmasses to the north (Abrahams *et al.* 1995). There are 557 terrestrial vertebrates known from Cape York Peninsula, including seventy-two mammals, 321 birds, 133 reptiles and thirty-one frogs (Frith *et al.* 1995).

The terrestrial vertebrate fauna of the mine lease prior to this study stood at 327 species, and consisted of forty-one mammals, 202 birds (Winter and Atherton 1985), sixty-three reptiles and twenty-one frogs (Cameron and Cogger 1992). Winter and Atherton (1985) found a total of 197 terrestrial vertebrates in *E. tetrodonta* open forests, including thirty mammals, 121 birds, twenty-nine reptiles and seventeen frogs (Table 1).

Table 1 - Number of vertebrates recorded in selected major habitats at Weipa, based on Winter and Atherton (1985).

	Open Woodland	Gallery Forest (R2)	Paperbark Woodland (O5)	Grassland (G)
Mammals	30	15	12	11
Birds	121	87	54	30
Reptiles	29	10	8	2
Frogs	17	10	15	2
Total	197	122	89	45

A variety of field guides and other resources are available for the identification of the Weipa fauna:

- mammals (Covacevich and Easton 1974; Strahan 1983; Wharton 1988; Walton and Richardson 1989; Frith and Frith 1991; Strahan 1992; Strahan 1995; Webster Publishing c. 1996),

- birds (Slater *et al.* 1986; Frith and Frith 1991; Natural Learning Pty Ltd 1996; Griffin and Swaby c. 1990),

- reptiles (Cogger 1986; Frith and Frith 1991; Cameron and Cogger 1992; Horner 1992), and

- frogs (Cogger 1986; Frith and Frith 1991; Cameron and Cogger 1992; Hero 1995).

Winter (1989) reviewed prior fauna surveys of the Weipa region, and found that until the late 1970's, most biological surveying effort in Cape York had been directed toward the rainforests of the east coast. Since Winter's review the following field surveys have contributed information on the fauna of the region:

- herpetofauna survey undertaken by the Australian Museum (Cameron and Cogger 1992),
- freshwater fish of RAAF Base Scherger (Pearson and Tait unpub.),
- terrestrial vertebrate fauna of Andoom vine forest patches (Lethbridge and Macmillan 1996), and
- fauna of the regeneration habitats (Winter and Alford 1999).

These scientific surveys have comprehensively listed the fauna at Weipa, and some have made qualitative comparisons of the distribution and abundance of fauna between habitats, however it is only recently that work employing systematic sampling has enabled quantitative comparisons to be made of the distribution and abundance of fauna between habitats (Lethbridge and Macmillan 1996).

Although Cape York Peninsula is one of Australia’s key conservation areas, when compared to other Cape York regions the Weipa region itself is not particularly significant in terms of vertebrate fauna richness. Nonetheless, Weipa does support populations of the disjunctly distributed Black-footed Tree-rat *Mesembriomys gouldii*, Red-cheeked Dunnart *Sminthopsis virginiae* and Swamplands Lashtail *Lophognathus temporalis* (Abrahams *et al.* 1995). The Antilopine Wallaroo *Macropus antilinopus* (which is at the northern limit of its distribution) and the Squirrel Glider *Petaurus breviceps* are the only woodland and rainforest Cape York indicator mammals (Winter and Lethbridge

1995) that have been recorded in Weipa, and the Cape York Pad-tail Gecko *Rhacodactylus australis* is the only endemic Cape York reptile (Covacevich and Ingram 1980) that has been recorded at Weipa. Table 2 lists the thirteen endangered, vulnerable, rare or poorly known terrestrial vertebrates occurring on the Weipa mine lease, which consist of one mammal, eleven birds and one reptile (Blakers *et al.* 1984; Queensland Government 1989; Ingram and Raven 1991; Cameron and Cogger 1992; Commonwealth of Australia 1992; Garnett 1992; McFarland 1993; Garnett and Crowley 1995). Additional species of legislative interest would be those subject to the Environment Protection and Biodiversity Conservation Act (Environment Australia 2001).

Table 2 - Thirteen endangered, vulnerable, rare or poorly known vertebrates that are known or are likely to occur on the mine lease.

Status	Class	Scientific Name	Common Name
Endangered	Birds	*Erythrotriorchis radiatus*	Red Goshawk
		Erythrura gouldiae	Gouldian Finch
Vulnerable	Birds	*Sterna albifrons*	Little Tern
Rare	Mammals	*Saccolaimus mixtus*	Papuan Sheathtail Bat
	Birds	*Lophoictinia isura*	Square-tailed Kite
		Probosciger aterrimus	Palm Cockatoo
		Numenius madagascariensi	Eastern Curlew
		Ninox rufa	Rufous Owl
	Reptiles	*Simoselaps warro*	Robust Burrowing Snake
Poorly Known	Birds	*Esacus magnirostris*	Beach Stone Curlew
		Tadorna radjah	Radjah Shelduck
		Ephippiorhynchus asiaticus	Black-necked Stork
	Reptiles	*Varanus semiremex*	Rusty Monitor

1.4 The orebody at Weipa

Bauxite occurs in the form of spherical granules called pistolites. In its pisotolic form, the bauxite orebody occurs in undulating tertiary lateritic deposits between one and nine metres thick. The ore contains impurities in the form of sand (silica) and oxides of iron and titanium. While bauxite ores can be almost 100% aluminium oxide, at levels of 40-60% the bauxite ore is still considered to be of high quality and only becomes low quality at levels of 35-40% (Street and Alexander 1994).

The orebody is identified using data from a drilling program and then extracted by clearfelling the overlying forest, piling the organic matter into rows and incinerating them, stripping and stock-piling the topsoil, removing any overlying low-quality ore to the soil stockpile and shovelling the high-quality ore into trucks (McDonald and Mandla 1993).

The higher grade ore appears to occur where there is slightly higher ground, although the difference is often a matter of only a few metres in the generally flat relief of the region. On the basis of work conducted at Gove in the Northern Territory, P. Reddell (pers. comm.) suggested that higher grade ores are indicated by trees with larger girths. Because the area of vertical bark surfaces and the formation of arboreal hollows can be directly related to trunk girth (Lindenmayer *et al.* 1993), the bauxite ore value at Weipa may be a factor determining the abundance and distribution of fauna which require or prefer these microhabitat features.

At the margin of the economic orebody is a lower-quality bauxite ore that is accessed using a technique known as 'bench mining'. Bench mining removes the ore in stepped layers as compared to the deep and abrupt vertical face of open-cut mining. Bench mining may threaten the fauna of the region because it encroaches on the remnant woodland habitat buffering riparian habitats such as creeks and swamps.

1.5 The habitats of Weipa

Unlike the low open woodland on much of Cape York, the extensive low-lying coastal plain around Weipa consists of a tall open sclerophyll forest habitat. This forest habitat is interrupted by a network of riparian habitats associated with creeks and swamps, and by isolated patches of rainforest habitat. Along the coastal margins are grasslands and wooded dunefields with coastal swales. Low-lying areas close to the coast and estuaries are covered with mangrove or salt marsh vegetation. Grassy plains are rare, although these occur in woodlands following habitat clearance. In addition there are urban and industrial habitats, and extensive disturbed and regenerating habitats directly associated with the mining operation.

Godwin (1985) conducted a land unit classification of six of the land systems of the Weipa region, identifying thirty-seven land units - land units being integrated classification terms for describing Australian landscapes (Christian and Stewart 1953; Christian 1958; Speight 1990; Naveh and Lieberman 1994). Subsequent workers have refined and mapped the Weipa land units of the study area at a 1:24,000 scale (Gunness *et al.* 1987).

Woodland habitats

The habitat of most concern is the tall open *E. tetrodonta* forest (Winter 1989). This vegetation community is essentially Godwin's (1985) and Gunness, *et al.'s* (1987) land unit 2b and 5k, Tracey's (1982) vegetation Type 16k and 16l and Nelder and Clarkson's (1994) basic vegetation group number 16. This habitat covers 36.4% of Cape York Peninsula and occurs on two surfaces, deeply weathered plateaus and their remnants, or erosional surfaces and residual sands, covering an area of 2.59 million ha and 2.25 million ha respectively (Neldner and Clarkson 1994). The tall *E. tetrodonta* forest habitat occurs on the Cape in two formations, one as a chain of linked nodes along the west coast, and the other an isolated patch located in the Cape's north-east (See CYPLUS Infoback No. 9).

The tall woodland on aluminous laterite is characterised by Darwin Stringybark (*Eucalyptus tetrodonta*), Long-fruited Bloodwood (*Eucalyptus nesophila*), Cooktown Ironwood (*Eryhrophloeum chlorostachys*), Nonda Plum (*Parinari nonda*), Cocky Apple (*Planchonia careya*) and wattle (*Acacia rothii*). Of these species, Darwin Stringybark is predominant. This habitat includes Godwin's (1985) landunits 2b and 5k. In most areas Darwin Stringybark and Bloodwoods are host to arboreal termites, whereas Cooktown Ironwood is highly resistant. The ground layer is dominated by tropical tall grasses: Giant Spear grass (*Heteropogon triticeus*) and Plumed Sorghum (*Sorghum plumosum*). The dominant soil surface is a fine, hard-setting, cracking clay derived from weathered lateritic red soils, and has an abundance of smooth, small surface fragments.

Winter (1989) detailed fourteen vertebrate species which are considered to have a significant habitat preference for the Darwin Stringybark woodland (see Table 22). Some of the significant microhabitats within this habitat include an abundance of arboreal hollows, and smooth vertical surfaces provided by tree trunks. These species could be expected to be particularly threatened by the minesite operations.

Ecotones

Ecotones are "zones of transition between adjacent ecological systems, having a set of characteristics uniquely defined by space and time scales, and by the strength of the interactions between adjacent ecological systems." (Holland *et al.* 1992). Ecotones occur in situations of environmental discontinuity, point-source environmental damage, habitat patch dynamics and succession. They have differential effects on the biotic assemblage - to some species ecotones may be habitat barriers, whereas to others they may provide optimal conditions (Hansen and di Castri 1991). Traditional ecological dogma held that ecotones were richer than neighbouring habitats, and that some species were ecotone specialists (Leopold 1933). Contemporary workers now prefer to characterise ecotones by a change in the ratio of life forms, rather than possession of any particular species (Holland *et al.* 1992).

Intermediate habitats between the *E. tetrodonta* forests and riparian habitats include dunefield woodlands and other eucalypt woodlands (5e). These may be considered to be 'ecotone' habitats.

Grassy layered woodlands occur on seasonally waterlogged bleached yellow soils of the lower slopes and outer margins of drainage lines. Canopy trees include the Long-fruited Bloodwood (*E. polycarpa*), the Cape York Red Gum (*E. brassiana*) and the Nonda tree (*Parinari nonda*). The paperbarks Swamp Mahogany (*Lophostemon suaveolens*) and the Broad-leaved Paperbark (*Melaleuca viridiflora*) form a sub-canopy layer.

An open shrubby woodland with shallow yellowish-red soils and outcropping ironstone occurs on the eroding, gentle, lateritic slopes of the plateau. Canopy trees include Melville Island Bloodwood (*E. nesophila*) and Darwin Stringybark (*E. tetrodonta*). Land unit 5k is restricted to Andoom. On the slopes of the bauxite plateau conglomerates of pisotolic fragments form larger boulders known as ironstone; these persist as isolated emergents on the surface of wetland habitats (Parker and Schaap 1988).

Because the process of landscape change is increasing the relative abundance of 'ecotone' habitats, and there is a critical assumption that ecotone habitats are surrogate woodland habitats, characterising them has a direct relevance to minesite conservation practice.

In the context of the habitats of Weipa the notion of ecotones is complex. Because transitions between woodlands and riparian or rainforest habitats mostly occur over a few meters, rather than hundreds of meters, ecotones may not occur, are exceptionally truncated or, as A. Spain (pers. comm.) suggests, is a scale phenomena in which the dominant woodland matrix itself is an ‘ecotone’.

In the only survey of these ‘ecotone’ habitats Winter and Atherton (1985) recorded one hundred and twenty-five vertebrate species from dunefield woodlands (consisting of twenty-three mammals, eighty-two birds, fifteen reptiles and five frogs), and eighty-three vertebrate species from dunefield woodlands (including thirteen mammals, fifty birds, twelve reptiles and eight frogs).

Riparian habitats

Riparian habitats occur on land which adjoins, directly influences or is influenced by a body of water. Riparian habitats do not usually include vine forests, although these may be functionally equivalent because available water may be stored in tree hollows and canopy ferns. Wetlands are "...permanently or temporarily waterlogged, or covered by shallow water" (Sioli 1986), and include swamps, creeks and coastal dune systems.

Although the wetlands of the study area are not listed as significant at a continental or state scale (Blackman *et al.* 1995), nor are the riparian habitats of Weipa connected to any significant riparian Cape York Peninsula corridors (Abrahams *et al.* 1995), it is an accepted principal that wetlands and riparian habitats are important to the fauna at a local and regional level (Williams 1994; McIntyre *et al.* 2002). These principles include retaining and buffering riparian vegetation, excluding livestock during extreme wet or dry periods and controlling weeds.

Swamps are shallow depressions in the land surface. They experience a seasonal change in water levels, and thus an expansion and contraction of their margins. They are refuges for fauna (Braithwaite 1990), and in the nutrient-poor tropical Australian landscape nutrient input from faunal activity may be as significant as the accretion of nutrients from surrounding soils (Baxter and Fairweather 1995).

Land unit 7b (Gunness *et al.* 1986) consists of Melaleuca/swamp mahogany on the outer margins of the circular drainage depressions and sinkholes in flat plains. Land unit 7d, a paperbark (*M. viridiflora*) grassy woodland at Betteridge Landing riparian site, or land unit 3b, a Melaleuca swamp at the most consistent water level.

Creeks are linear elements which channel water runoff from springs, or which drain rainfall. They have an associated riparian vegetation which is characteristic of a closed forest habitat. The streams and swamps link the east and west coast, and drain the high country on the eastern border of Cape York. These gallery rainforests are corridors of moisture that range in width from 4 to 1000m, but are typically 20-50m wide. These habitats can experience dramatic change, with anoxic conditions arising from no water flow and an accumulation of nutrients from leaf fall in the dry, to a pulse of water, litter and nutrients followed by a sustained flow of water during the wet. Moisture from drainage is supplemented by aquifers in some regions of the Cape; this is a significant feature of the Weipa region.

For the purposes of this study the term riparian refers to creek, swamp and coastal marine woodland habitats, including gallery forest along semi-permanent watercourses (4a), mesophyll palm forest on freshwater surface aquifers (4b), paperbark grassy woodland (7d), Melaleuca/swamp mahogany low woodland (7b) woodland on low beach dunes (5c) and grassland on a marine terrace (12d).

In contrast to the dry, leached soils of the woodlands, the surface soils of riparian habitats consist of permanently saturated, black sandy-loams grading into sand and fine clays.

Other habitats

Although not part of this study, the Weipa region contains a number of other habitats, including isolated vine forest patches, regeneration and urban habitats.

Vine forests are not considered riparian habitats, although they could be considered functionally equivalent because available water may be stored in tree hollows and canopy ferns. While the closed forest habitats of Weipa are not directly connected to any significant riparian Cape York Peninsula corridors, they are of national conservation significance (Abrahams *et al.* 1995).

The terrestrial vertebrate fauna of vine forest habitats of Andoom have been surveyed in some detail (Winter and Atherton 1985; Lethbridge and Macmillan 1996), and in the only prior survey which quantitatively compared the fauna of Weipa habitats, Lethbridge and Macmillan (1996) found a variety of habitat preference patterns between vine and woodland forest habitats. These included twenty-one species they found only in vine forest and ecotone habitat, and forty-seven species only in woodland and ecotone habitat.

The fauna of the regeneration habitats of Weipa were surveyed by Reeders (1983), who observed 162 vertebrate species, including eighteen mammals, one hundred and three birds, twenty-seven reptiles and fourteen frogs. Compared to surrounding woodland habitat, regeneration habitats supported 55% of the species of mammals, 73% of birds, 86% of lizards, 64% of snakes and 94% of the frogs, however only the Canefield Rat and eight birds were known to be breeding in it (Reeders and Morton 1983).

The return of a relatively high proportion of fauna to regeneration has been reported for Alcoa's Western Australian bauxite mine in Jarrah forest (Ward *et al.* 1990). When surveyed in the mid-80's, the birds and arachnids recorded in regeneration at Alcoa's Western Australian bauxite mine were no different to the surrounding Jarrah forest (Nichols and Watkins 1984; Mawson 1986), and bird community patterns remained the same six years later (Ward *et al.* 1990).

1.6 The mine regions

The Comalco mining area at Weipa is divided into two operational regions, Andoom to the north, and Weipa to the south. The regions have different geological substrates, hydrological profiles, proportions of landscape elements, disturbance histories and habitat adjacencies. These factors may affect the regional composition of the fauna.

The geological layer beneath the bauxite orebody differs between the Weipa and Andoom regions. In the Weipa region the layer beneath the bauxite orebody is a sandy aquifer that grades into a clay - or kaolin and clay - layer along the coastal margin of the peninsula, whereas in the Andoom region it is a porous layer of ironstone that grades into clay at lower depths. The presence of a sandy aquifer in the Weipa region may mean there is a more abundant and continuous source of moisture in the dry season, and this in turn could have a biological effect.

In addition, the Weipa region has a higher density of linear creek elements, whereas the Andoom region has a higher density of elliptical swamp elements. If there are preferences by fauna species for particular types of riparian habitats, then a simple difference in the proportional abundance of these habitats between regions may have a biological effect.

At a larger scale the Weipa region is bound to the north by the Mission River and to the south by the Embley River, whereas the Andoom Region is bound only to the south by the Mission River. The implication of this is that the Andoom Region has a smaller proportion of marine riparian habitat, and a broader connection to an easterly expanse of woodland habitat, compared to the Weipa region.

One of the most distinct differences between the two regions is that urban habitat occurs almost exclusively in the Weipa region. Urbanisation has a differential effect on the fauna, with domestic pets preying upon some species, while suburban lawns and rockeries provide habitat for others (Low 2002).

The significance of detecting a regional difference in the fauna is that alternate conservation strategies and designs may be needed for each mining region.

1.7 Landscape effects

Change in landscape structure has been identified as the main effect of the mining on the fauna at Weipa, principally through a reduction in woodland habitat, fragmentation of woodland habitat and a ‘tonsure’ effect (Winter 1989).

Prior to mining, landscape change in the study area consisted primarily of the gradual change associated with altered soil-moisture gradients that led to the formation of swamps, creeks and marine habitats. Nutrient scarcity and fire - two of the distinguishing features that have shaped the Australian environment (Dyne and Walton 1987) - would also have played a role. Nutrients would have leached from the surrounding woodland and accumulated in low-lying riparian habitats, while fire would have created a mosaic of habitats.

The landscape change brought about by the mining is the sudden and abrupt effect associated with the deforestation wavefront that is the mineface. Unlike agricultural and pastoral use, both the tree and grass layers are entirely destroyed, and the extent and amount of destruction results in a fragmented landscape where about 35% of the landscape is retained. Retained habitat is essentially unmodified, although patches are occasionally used for managing livestock. Because the cleared habitat has no effective natural regeneration capacity, Comalco undertakes a dedicated restoration effort using seed stock from remnant vegetation.

Central to the issue of landscape change is determining the threshold point at which the landscape change will compromise the viability of a substantial proportion of the fauna (McIntyre *et al.* 2002). At Weipa, because no recorded vertebrate is endemic to either the study area or mine lease, it is arguable that any effect will mostly influence local populations (demes), rather than the entire species distribution (metapopulation). Any local extinction could be compensated for by recolonisation from the populations of the surrounding region, although under certain conditions metapopulations can become extinct through the loss of only a portion of their local populations (May 1991).

Within a metapopulation there is a spectrum of relationships that can exist between local populations (Bennett 1998). On the one hand there is the "mainland-island" relationship, in which a large population continually replenishes local populations (MacArthur and Wilson 1963; MacArthur 1967; Diamond 1975), and on the other a "source-sink" relationship, in which populations exist in a mosaic of patches of localised and ephemeral habitats that act as either a "source" of dispersing colonists, or as a "sink" of re-establishing colonists (Merriam 1991; Hansson *et al.* 1995).

The intuitive response in considering the Weipa landscape in this context is that the nutrient rich mesic habitats are principally population “sources”, and that the surrounding woodland matrix is a “sink”. Consider the case where a skink or frog is born in a creek, and then wanders out into the barrens of the woodlands to eventually perish. While this is probably the case for a number of species, the existing minesite conservation strategy of retaining riparian habitats mitigates the risk of local population extinction. In contrast, and not so intuitively conceived, is the potentially more worrisome case where a species breeds in the woodlands, and then preferentially moves into the riparian habitats (where it could be found in higher densities). In effect, the riparian habitat is a sink, even though survey incidence would suggest it is a source – a “pseudo-source” phenomenon. Loss of woodland habitats could cause local declines or extinction, and this may not be predictable from survey incidence data. This “pseudo-source” phenomenon may be a variant on Pulliam’s (1996) concept of “pseudo-sinks” - habitats in which deaths exceed births and immigration exceeds emigration, but which also maintain a population in the absence of immigration.

The “mainland-island” relationship would most likely apply to larger and more mobile species, such as the macropods and the Emu (*Dromaius novaehollandiae*). In the context of regional differences this landscape dynamic may operate in the Andoom region more than the Weipa region, because of the relatively larger outer operational boundary of shared habitats that Andoom has with the surrounding regional landscape. In contrast, an example of a species which exists as a metapopulation through a dynamic array of local “source-sink” populations is the Dingy Bush Brown butterfly (*Mycalesis perseus*) (Wharton 1988; Braby 1995), and an equivalent population dynamic may be operating on smaller vertebrates species such as the skinks. Differentiating between “mainland-island” and “source-sink” population persistence mechanisms may indicate which species are supported by retention of habitat fragments, rather than maintenance of connectivity with adjacent regions of habitat.

It is a principal of management and conservation that core conservation areas are required for species which are sensitive to habitat loss. The core areas should be at least 10% of the property, of suitable habitat, and the critical elements (such as mature trees, understorey vegetation and standing dead and fallen timber) should be retained and protected from grazing (McIntyre *et al.* 2002).

Fragmentation refers to the isolation of habitats, and its most telling effect is to change the surface area-to-volume relationship of the habitat. Landscape fragmentation exists as a spectrum, which McIntyre *et al.* (2002) have classified into four states, ranging from Intact (> 90% retained habitat) through to Relictual (< 10% retained). As a result of the mine operation, and factoring in the regeneration efforts optimistically, the Weipa landscape is being altered from an Intact to a Variegated one (ie. consisting of about 60-90% retained habitat), comprised of a small proportion of unmodified remnant habitat patches of about 2-22 ha (the largest being 58 ha) (Winter 1989) and a large proportion of mined land regenerated to a wide variety of native vegetation. The net effect of the regeneration is an increase in the floristic and structural diversity of the habitat in the landscape. Under this regime of landscape change, the main risks to the fauna include a decline in abundances, the unexpected re-assembly of the fauna (eg dominance by feral pests) or at worst extirpation (local extinction) (Hansen and di Castri 1991).

Habitat fragmentation has a size effect, whereby smaller fragments have less fauna than larger fragments, followed by an edge effect that degrades the quality of fragments at their peripheries. The size and edge effects act together in a 'sedge' effect (Soulé 1986b). A key question when appreciating an edge effect is estimating the depth to which it will penetrate from the periphery to the core of a habitat fragment (Laurance 1991). The relationship between habitat fragmentation and habitat preference is that species with a strong preference may require significant core areas of habitat, and core areas of habitat become exponentially scarce when a landscape is simply but consistently fragmented. Furthermore, as fragments become increasingly distant from each other, there is an isolation effect that operates on rates of colonisation, and if the fragment is particularly isolated it may exceed distance thresholds for migrants.

The conservation of the integrity of a landscape involves consideration of the connectivity of remnant habitats (Bridgewater 1987; Bennett 1990). As a general principal, a landscape connectivity threshold exists at between 30-70% habitat loss (McIntyre *et al.* 2002). The elements of a network of connected habitats includes nodes, of a particular size and shape, linked by a corridors, of a particular length and width. Where corridors are used there are a number of factors to consider (Hussey *et al.* 1989), including phenomena such as preference gradients inadvertently funnelling individuals into habitat 'cul-de-sacs', and species-specific responses (Ruefenacht and Knight 1995). In northern Australia's tropical savannas landscape nodes are typically wetland habitats such as swamps or rainforest patches, and corridors are riparian habitats along streams.

The principal tool for retaining connectivity is to link remnant habitat patches with corridors (Diamond 1975), and while their value is frequently promoted (Hussey *et al.* 1989), questions still remain about their effectiveness (Simberloff and Cox 1987; Hobbs 1992; Simberloff *et al.* 1992; Bonner 1994). For example, while some studies show that corridors are used for dispersal by some species (Bennett *et al.* 1994), others suggest they are primarily used as suboptimal habitat instead (Vermeulen 1994).

1.8 Seasonality

Seasonality refers to the change in a species' distribution, abundance or behaviour over the duration of an annual cycle.

Characterisation of the Weipa climate according to traditional ecological knowledge distinguishes five distinct seasons within the annual cycle (Figure 2), each being associated with specific phenological and faunal indicators (Birkin *et al.* 1988).

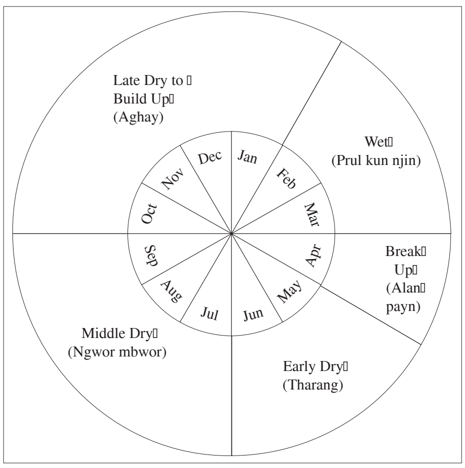


Figure 2 – Name, duration and timing of ecological seasons at Weipa.

The seasons recognised in Birkin *et al.* (1988) comprise:

- **Early Build-up and Build-up to the Wet (late Aghay)** - storms ignite the parched country to life, then quench the fires in the humid air of the afternoons. Magpie Geese (*Anseranas semipalmata*) congregate in the swamps and at night, in the forests, Flying Foxes (*Pteropus spp.*) can be seen feeding on fruits of the Lady Apple (*Syzygium suborbiculare*).

- **Wet Season (Prul kun njin)** - intense heat and humidity is broken by early morning and afternoon rains that can last for days. Waterfowl and crocodiles lay eggs, and Agile Wallabies are easier to approach.

- **Break-up of the Wet Season (Alan payn) -** sunny days become common and night-time temperatures drop. Waters begin to recede and dragonflies become abundant. The winds turn.

- **Early Dry Season (Tharang)** - the bush dries in the winds and rain becomes rare.

- **Middle Dry (Ngwor mbwor njan)** - surface pools dry up and temperatures become more intense.

- **Late dry (early Aghay) -** a hot dry period when daily temperatures and humidity intensify and any occasional rainfall does not replenish creeks and swamps. Storm clouds gather.

Characterising the climate of Weipa in a scientific manner has been variously undertaken by Ridpath (1985), Gillison (1983), Thackway and Cresswell (1994) and CYPLUS (1995). Bureau of

Meteorology (1992) data have been collected at Weipa (Site 27042) since 1913.

The climate of the Weipa region is tropical monsoonal, with distinct hot-wet summers and mild-dry winters. The key feature of the climate of Weipa - which is shared with other regions within the wet-dry tropics - is that its extremes of wet and dry weather vary in intensity and duration between years (Ridpath 1985).

During the dry season the bioclimatic envelope containing Weipa is restricted to the western coastal margin of Cape York, however in the wet season this envelope expands across the Cape to the south-east coast. This expansion of the bioclimatic envelope has ecological consequences, for example it carries with it a wave of butterflies that pupate on the Dutchman's Pipe vine (*Aristolochea spp*.).

The mean daily temperature at Weipa ranges from 25-30°C throughout the year, with the average monthly minimum and maximum daily temperatures ranging from 18°C to 30°C in July to 24°C to 33°C in December (Figure 3).

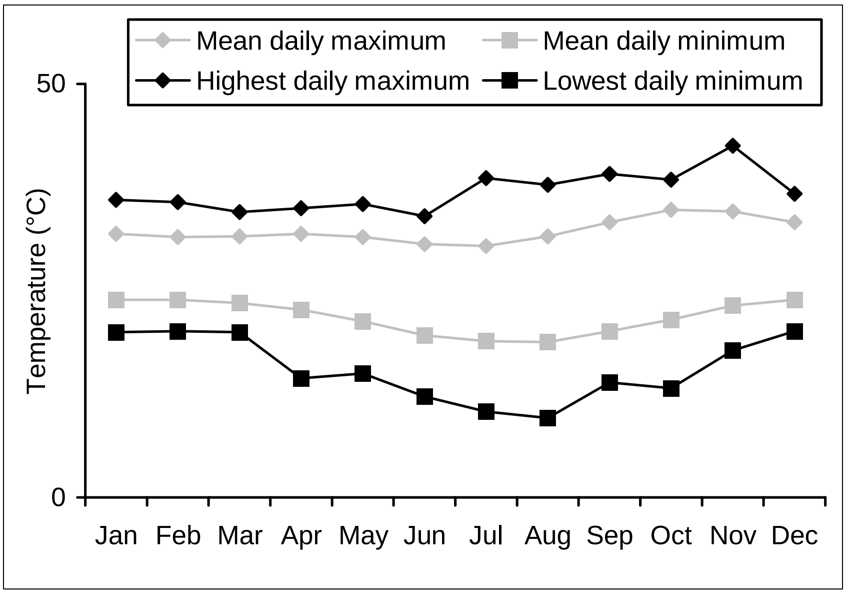


Figure 3 - Extreme and mean daily maximum and minimum temperatures in each month at Weipa based on 28 years of Bureau of Meteorology (1992) data.

Heavy rains occur in the period between January and March each year, and in some areas this has caused the water table to rise up to a metre above ground level. Following the first rains, floods occur within the streams and creeks of the region, and swamp margins expand. This has numerous consequences for the fauna, including an increase in primary productivity, flooding of nest sites, increased risks of pathologies arising through water-borne diseases and migration between riparian habitats across woodland habitat.

The median annual rainfall for the district is 1,459 mm, with a range of about 1079 - 1805 mm (1st and 9th deciles), and the average annual rainfall for Weipa is 2,051 mm, of which ninety-seven per cent falls between November and April (Figure 4). A comparison of total annual rainfall from 1975 to 1987 between the Andoom and Weipa regions (based on records for the Andoom Mine Office and the Weipa Regeneration Nursery) showed no significant difference in rainfall quantity or pattern.

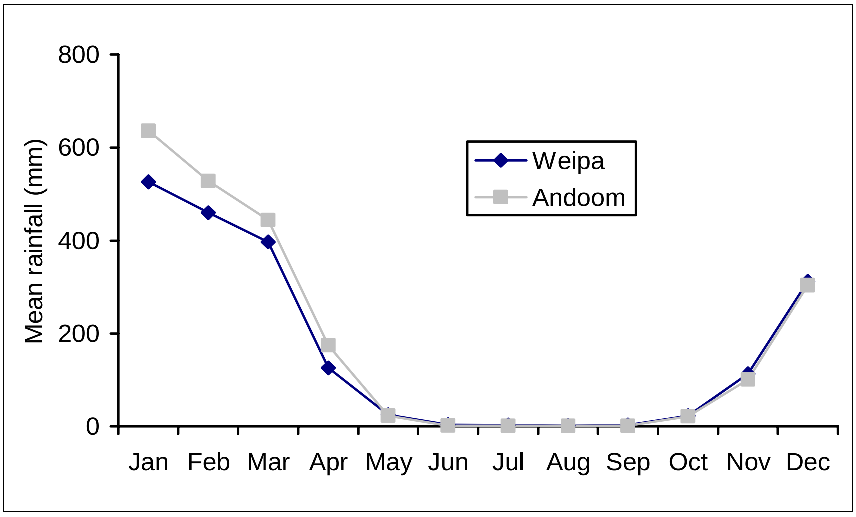


Figure 4 - Mean total monthly rainfall for the Andoom and Weipa regions based on 74 years of Bureau of Meteorology (1992) data.

The annual evaporation rate averages 1,820 mm per year, and peaks in the hot summer months. Relative humidity in the mornings is consistently about 75%, while evening humidity varies seasonally, being higher in summer months (Figure 5). High humidity has consequences for fauna. For example, the inefficiency of evaporative cooling causes fauna to choose cooler habitats, and to perform behaviours such as wallowing (Ridpath 1985).

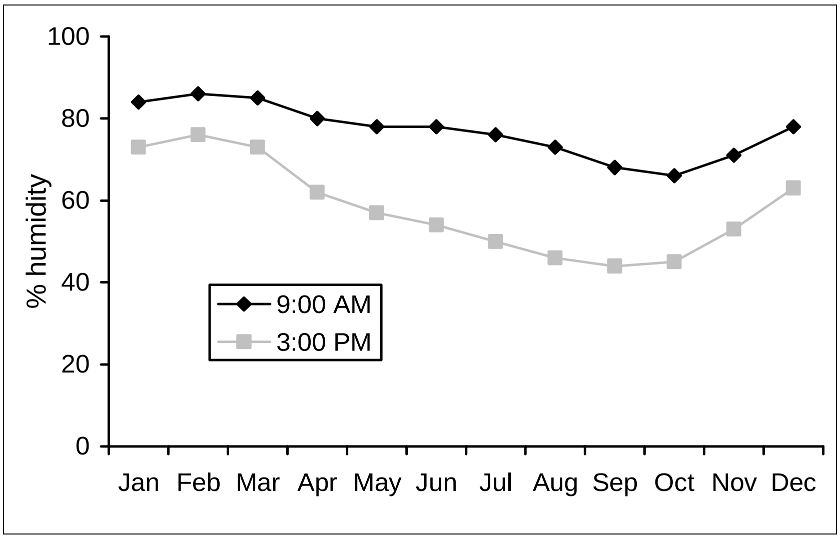


Figure 5 - Mean 9am and 3pm relative humidity recorded from Weipa based on 28 years of Bureau of Meteorology (1992) data.

Winds blow predominantly from the east and the south-east during the dry season, from the west and north during the wet season and are often strong. Although Weipa is within Australia's cyclonic belt - and during the course of the study experienced a major cyclone in January 1992 - it is not as prone to cyclones as is the east coast between Cooktown and Rockhampton. Cyclones and storms have faunal consequences because they create ground litter and knock down hollow wood.

The seasonal habitat preference of most vertebrate fauna in northern Australian landscapes becomes concentrated on riparian habitats in the dry season (Beeton 1985; Ridpath 1985), while during the wet there may be long distance dispersal and an increase in home range distance (Dickman *et al.* 1995). While some species seek refuge in riparian habitats during dry conditions, the opposite preference may also apply. For example, Friend *et al.* (1988) found that Canefield Rats (*Rattus colletti*) shifted from riparian habitats to woodland habitats during the wet season, because flooding of their ground burrows led to high rates of mortality. Because the driest habitat occurs in elevated areas of woodland - which are those areas particularly affected by the mining operation - species with this type of seasonal habitat preference would be particularly threatened by the habitat loss. This pattern of seasonal preference was also observed in the frogs of regeneration habitats (Reeders 1983).

Examples of seasonal breeding patterns in mammals which occur at Weipa include Agile Wallabies (*Macropus agilis*) (Bolton *et al.* 1985), the Bandicoot (*Isoodon macrourus*) (Friend 1990) and the Canefield Rat (*Rattus colletti*) (Friend *et al.* 1988). Breeding is generally associated with the onset of the wet, however Agile Wallabies (*Macropus agilis*) opportunistically breed during the dry (Bolton *et al.* 1985). A wide variety of seasonal breeding patterns also occur in tropical Australasian reptiles (Shine 1985; Clerke and Alford 1993), including wet-season breeders (eg. *Carlia spp.*) and dry-season breeders (eg. *Ctenotus spp., Sphenophryne gracilipes*). Shine (1985) observed that dry season breeding in reptiles is a characteristic attribute of arid zone species, whereas wet season breeding characterises riparian species. Clerke and Alford (1993) found breeding depression occurring in some tropical Australasian reptiles during the wet season and some species having more than one peak breeding period.

The significance of determining seasonality in relation to habitat preference is that unless sampling is distributed across seasonal extremes, species which require, say, the resources of one habitat to breed, yet use another to disperse or forage in, may have their preferences misdiagnosed or simply not detected. For example, Price (2004) found indirect evidence that six frugivorous birds all previously recorded from the study area track fluctuating fruit resources among rainforest patches in the Northern territory.

To date, the effects of climate change (Office of the Chief Scientist 1992b) have not been appreciated for the west coast of Cape York

Peninsula. Climate change has consequences for the conservation strategy because:

- its fixed design may not cater to rapid expansion of plant communities

- the disturbed community's response may be unlike that of the comparatively intact remnant habitats

- it may particularly affect marginal homeotherms for which evaporative cooling is important

Changes with respect to plant communities can be extremely rapid, for example since alterations to the fire regime in the mid-40's about 70% of the Eucalypt woodland forests on the western margin of the Wet Tropics rainforest area have converted to rainforest (Harrington and Sanderson 1994). The implication of this is that remnant woodland habitat strips alongside riparian habitats may disappear within a matter of decades if riparian plant communities expand, particularly under a greenhouse scenario.

1.9 Aims, objectives and hypotheses

In conclusion, prior terrestrial vertebrate fauna surveys of northern Australia's tropical woodland savanna have generated results which have led different authors to different conclusions about habitat preferences. Because some terrestrial vertebrate fauna may prefer the habitat being mined, conservation of viable populations of these species will depend to some extent on their preferences for remnant habitats. Thus, the aim of the study was to demonstrate the extent to which planned remnant habitats contained the fauna of habitat being mined.

Objectives

The study objectives were:

- To document vertebrate fauna use of native forests growing on bauxite ore bodies - habitat partitioning, total or partial use of bauxite habitats

- To document seasonal changes in the vertebrate fauna's use of habitats.

- To determine whether it is necessary to conserve *Eucalyptus tetrodonta* forests growing on economic bauxite deposits in addition to those growing on uneconomic deposits, to provide for the sustainability of the native fauna.

- To recommend future studies required to conserve and manage faunal communities in native forests on the bauxite ore body.

- To recommend designs for future studies to assess the suitability of revegetated areas for the re-establishment of the pre-mining faunal community.

- To provide a detailed inventory of terrestrial vertebrate fauna present in the areas under study.

- To recommend management options arising from the study.

Hypotheses

In the context of the material presented in the literature review, four factors emerged as manageable candidates for tests of significant effects on the composition and abundance of terrestrial fauna.

These factors were:

- effects of the value (concentration of silica) of the underlying orebody,
- effects of proximity to a riparian habitat,
- effects of type of riparian habitat, and
- regional differences between Andoom and Weipa.

These factors were expressed as four principal unifying hypotheses, with secondary specific hypotheses where the factor had more than two levels. These hypotheses are:

1: There were no significant differences between the vertebrate faunas of woodland habitats above economic and un-economic ore.

2: There were no significant differences between the vertebrate faunas of riparian, ecotone and woodland habitats.

(a): There were no significant differences between the vertebrate faunas of riparian and ecotone habitats.

(b): There were no significant differences between the vertebrate faunas of riparian and woodland habitats.

(c): There were no significant differences between the vertebrate faunas of ecotone and woodland habitats.

3: There were no significant differences between the vertebrate faunas of creek, swamp and marine riparian habitats.

(a): There were no significant differences between the vertebrate faunas of swamp and marine riparian habitats.

(b): There were no significant differences between the vertebrate faunas of creek and swamp riparian habitats.

(c): There were no significant differences between the vertebrate faunas of creek and marine riparian habitats.

4: There were no significant differences between the vertebrate faunas of the Andoom and Weipa regions.

(a): There were no significant differences between the vertebrate faunas of the ecotone and woodland habitats of the Andoom and Weipa regions.

(b): There were no significant differences between the vertebrate faunas of riparian, ecotone and woodland habitats of the Andoom and Weipa regions.

2 Methods

2.1 Study area

The study area (Figure 6) was particularly well mapped, as it encompassed Comalco's current area of operation.

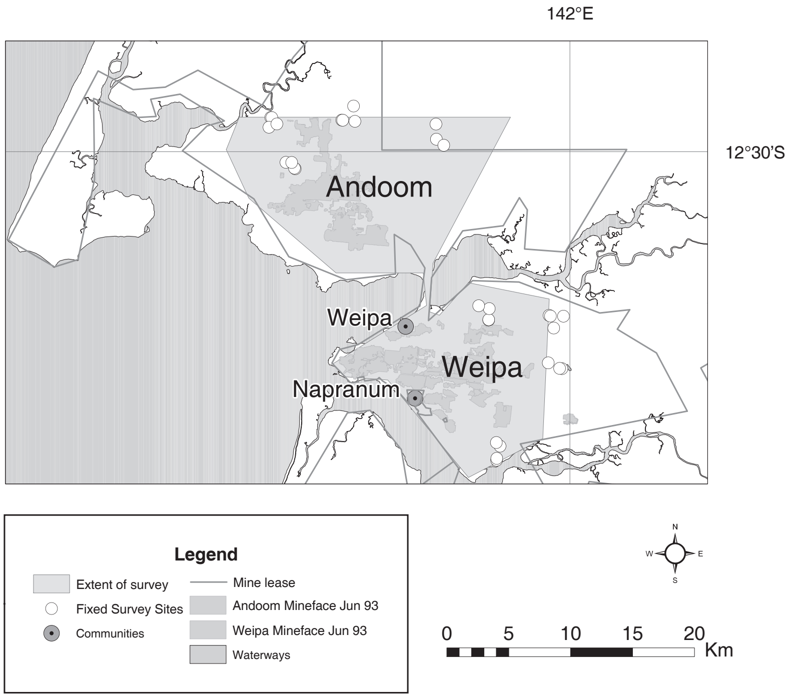


Figure 6 - Location of study sites and approximate area of operations of the Weipa bauxite mine as at 1993, the year of the study.

Spanning a latitudinal range of about twenty minutes (30km), a longitudinal range of seventeen minutes (40km) and an altitudinal range of 20m, it is covered topographically at a 1:100,000 scale by maps SH 50-15 and SH 50-16, and has an aerial photo history of at least twenty years.

The company’s area of operation contains two distinct regions separated by the Mission River - Andoom to the north-west and Weipa to the south-east.

The site selection process made specific use of two maps, a 1:25,000 scale map of the study area's landunits (Gunness *et al.* 1987), and a 1:23,000 geological map showing the percentage silica of the bauxite ore body (Bryce 1991).

2.2 Survey design

The project proposal contained two broad competing objectives: to quantitatively assess the extent to which fauna on habitats above economic bauxite orebody reserves were equivalent to the fauna on habitats above uneconomic bauxite orebody reserves, and to make broad-scale descriptive observations on the vertebrate fauna.

The quantitative part of the survey examined four factors, and was implemented using a fixed, four-factor sampling design detailed below, and summarised in Table 3:

- To identify whether the economic value of the orebody was having an effect, a comparison would be made using sites in woodland habitat above economic and uneconomic ore. Woodland sites were located in pairs, and were situated about 800m from each other, and from any nearby riparian habitats.

  The results of the orebody value test were used to determine whether the fauna from all woodland sites, or only those woodland sites above uneconomic ore, would be used in the test for a habitat type effect.

- To identify a landscape position effect, comparisons were made at three points along a gradient. A gradient's origin was located in woodland, passed through an ecotone and ended in a riparian habitat.

Each gradient had two woodland sites as part of the design to test for an orebody effect. If the prior test indicated no significant difference between the fauna of woodland habitat sites above economic and uneconomic ore then the data for these two sites could be pooled, giving the analysis more power.

- To identify whether the type of riparian habitat on a gradient had an effect, comparisons were made between the three which conspicuously occurred within the region - swamp, creek and coastal marine habitats.

  The results of the riparian habitat type test were used to determine whether all sites, or only woodland, would be used in the test for regional effects.

- To identify a regional effect comparisons were made between Andoom and Weipa by pooling the observations from each region's sites.

  The prior test results determined which habitat sites from could be used in the comparison, and these were only the woodland sites.

Table 3 - Summary of the survey design factors, levels of each factor and number of replicates at each level.

Factor	**Levels**	**Number of sites**
Ore value of Woodland habitat (nested)	Economic	8
	Uneconomic	6
Proximity to riparian habitat	Woodland	14
	Ecotone	8
	Riparian	8
Type of Riparian habitat (nested)	Creek	3
	Swamp	3
	Marine	2
Regional woodland	Andoom	7
	Weipa	7

Although fire was considered a major factor determining the fauna of Weipa the design essentially ignored any fire effect. It was identified that fire would confound the design only if particular combinations of certain sites were to burn, and it was estimated that the odds of this occurring were low.

2.3 Survey sites

Thirty sites were systematically sampled at eight specific localities, four at Andoom (Figure 7) and four at Weipa (Figure 8). Six of the eight localities allowed placement of one site in or near a riparian habitat, one site in ecotone habitat and two sites in woodland habitat that were perpendicular and equidistant from the riparian habitat site, one above economic bauxite ore and the other above uneconomic bauxite ore. A further two localities allowed placement of one site in or near a riparian habitat, one site in ecotone habitat and one site in woodland habitat, all perpendicular to the riparian habitat site.

The rules for site selection included a requirement for uninterrupted forest between the riparian and woodland sites, and a location as far as possible from the mine face, clearings and haul roads. Candidate sites were located using a map of the landunits of the region (Adamson 1991), and a map of the company's ore model (Bryce 1991). The assumption that sites allocated to economic and un-economic levels of the survey had significantly different percentage silica ore compositions was confirmed ($t=-7.553$, $df = 10$, $p=0.0001$).

Each site was located in the field, marked using a wooden stake, fluorescent paint and survey tape, and a precise geographic reference was obtained using a 20-minute averaging procedure with a Garmin GPS 100 Survey global positioning system (see Appendix A).

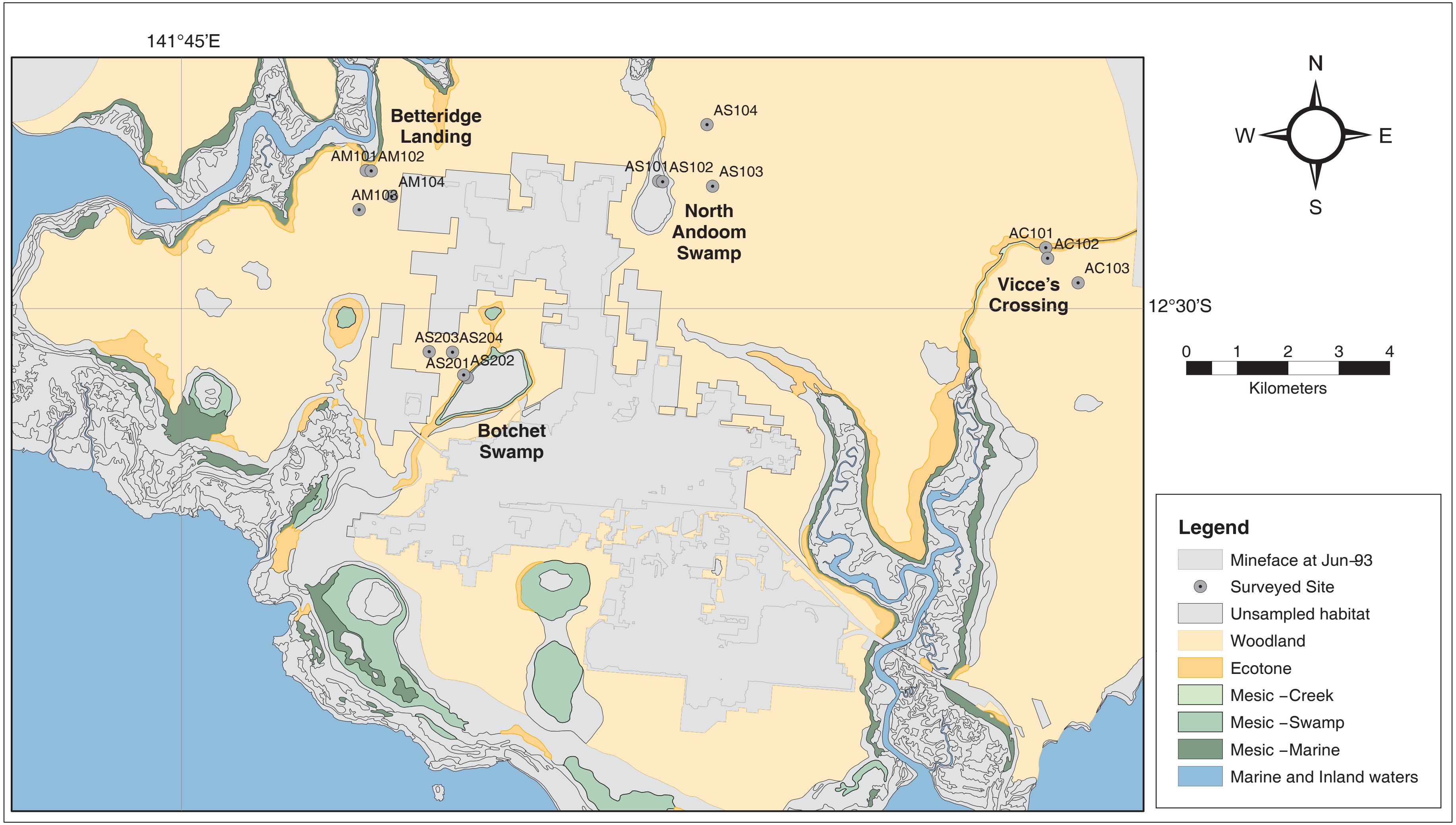


Figure 7 - Map of Andoom region showing survey sites, sampled habitats, the mineface (1993) and the edge of the economic orebody.

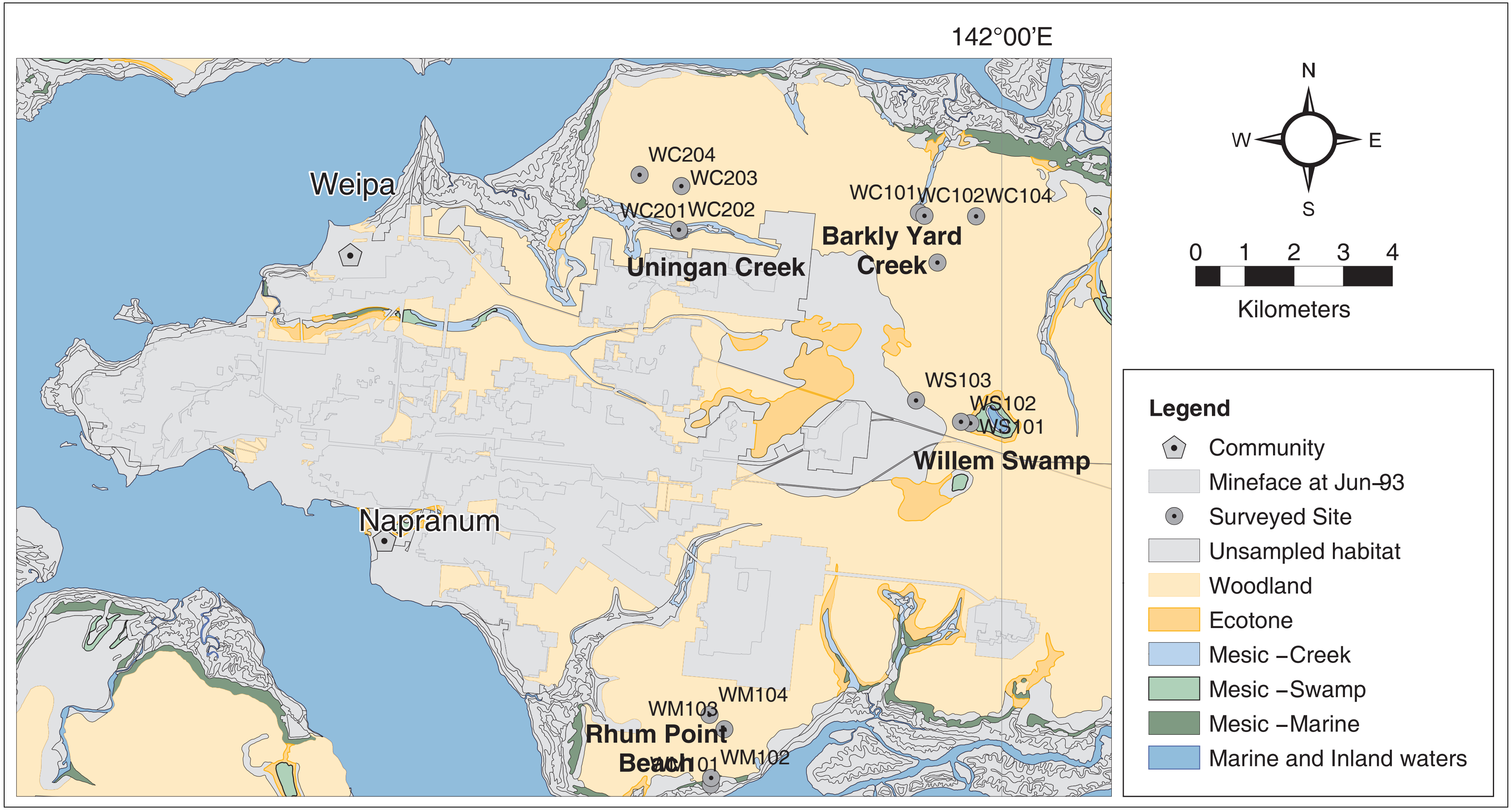


Figure 8 - Map of Weipa region showing urban communities, survey sites, the sampled habitats, the mineface (1993) and the edge of the economic orebody.

The geographical co-ordinates for all sites are given in Appendix A, and bracketed codes refer to landunits as detailed in Appendix B (Godwin 1985; Gunness *et al.* 1987).

All fourteen woodland sites were located in tall eucalypt woodland (2b). Of the eight ecotone sites three were located in tall eucalypt woodlands (2b) and the remainder were in grassy layered woodlands (5e). Riparian sites were located once in gallery forest along semi-permanent watercourses (4a), twice in mesophyll palm forest on freshwater surface aquifers (4b), once in paperbark grassy woodland (7d), twice in Melaleuca/swamp mahogany low woodland (7b), and once in woodland on low beach dunes (5c).

The woodland sites were all located on level ground. Ecotone sites were all located on gently inclining simple slopes between the elevated plateau of the low relief woodland habitat, and the low depressions in which riparian habitats were situated. Most riparian sites had an extremely low relief, except for the marine site in the Weipa region where it was situated on the ridge of low dune.

There were some sites that experienced fires and flooding during the course of the study, which were the two main factors that could not be feasibly accommodated in the survey design. The fire factor was a particular risk, however on calculation of the odds of fires at site combinations that would affect the sampling design, it was judged low enough to simply be taken.

Botchet Swamp (Andoom)

The Botchet Swamp locality (Figure 7) consisted of two tall Darwin Stringybark (*Eucalyptus tetrodonta*) forest (2b) woodland sites, an ecotone site in a grassy woodland (5e) and a riparian site in a paperbark woodland (7b) on the fringe of a swamp.

North Andoom Swamp (Andoom)

This swamp locality (Figure 7) consisted of two tall Darwin Stringybark (*E. tetrodonta*) forest (2b) woodland sites, an ecotone site in grassy woodland (5e) and a riparian site in a paperbark woodland (7b) on the fringe of a swamp.

Betteridge Landing (Andoom)

The Betteridge Landing locality (Figure 7) consisted of two tall Darwin Stringybark (*E. tetrodonta*) forest (5k) woodland sites, an ecotone site in grassy woodland (5e) and a riparian site in a grassy woodland habitat (7d) adjacent to mangroves.

Vicce’s Crossing (Andoom)

The Vicce’s Crossing locality (Figure 7) consisted of one tall Darwin Stringybark (*Eucalyptus tetrodonta*) forest (2b) woodland site, an ecotone site in grassy woodland (5e) and a riparian site in gallery forest (4a) along a creek.

Uningan Creek (Weipa)

The Uningan Creek locality (Figure 8) consisted of tall Darwin Stringybark (*Eucalyptus tetrodonta*) forest (2b) woodland and ecotone sites, and a riparian site in a mesophyll palm forest on a moist soil (4b) adjacent to the closed scrub zone of a spring-fed swamp (8b).

Barkly Yard Creek (Weipa)

The Barkly Yard Creek locality (Figure 8) consisted of tall Darwin Stringybark (*Eucalyptus tetrodonta*) forest (2b) woodland and ecotone sites, and a riparian site in gallery forest (4b) adjacent to a swampy sclerophyll fern forest (4c).

<u>Willem Swamp (Weipa)</u>

The Willem Swamp locality (Figure 8) consisted of a tall Darwin Stringybark (*Eucalyptus tetrodonta*) forest (2b) woodland site, an ecotone site in grassy woodland (5e) and a riparian site in Melaleuca/Swamp Mahogany low woodland (7b) on a swamp margin.

<u>Rhum Point Beach (Weipa)</u>

The Rhum Point Beach locality (Figure 8) consisted of two tall Darwin Stringybark (*Eucalyptus tetrodonta*) forest (2b) woodland sites, an ecotone site in a Darwin Stringybark (*Eucalyptus tetrodonta*) forest (2b) woodland and a riparian site in woodland on low beach dunes (5c) adjacent to a mosaic of mangroves, paperbark woodland and closed forest.

2.4 Field schedules

One hundred and eighty days of field sampling were carried out from a total of three hundred and twenty-five days spent at Weipa, over a period of two years and in six visits (Table 4).

Table 4 - Schedule of survey visits with dates of arrival and departure, and duration of each visit.

Visit	Arrival	Departure	Days sampling	Duration (days)
1	9 Oct 1991	1 Nov 1991	20	23
2	17 Jan 1992	6 Mar 1992	32	49
3	18 May 1992	6 Jul 1992	32	49
4	5 Aug 1992	3 Oct 1992	32	50
5	26 Nov 1992	16 Jan 1993	32	51
6	19 Mar 1993	30 Jun 1993	32	103
			180	325

The first of the six visits was a short duration pilot survey, with subsequent visits lasting about fifty days except for the sixth, which was extended due to flooding of the sites. Survey visits were dispersed throughout all stages of the annual seasonal cycle - as illustrated in Figure 9.

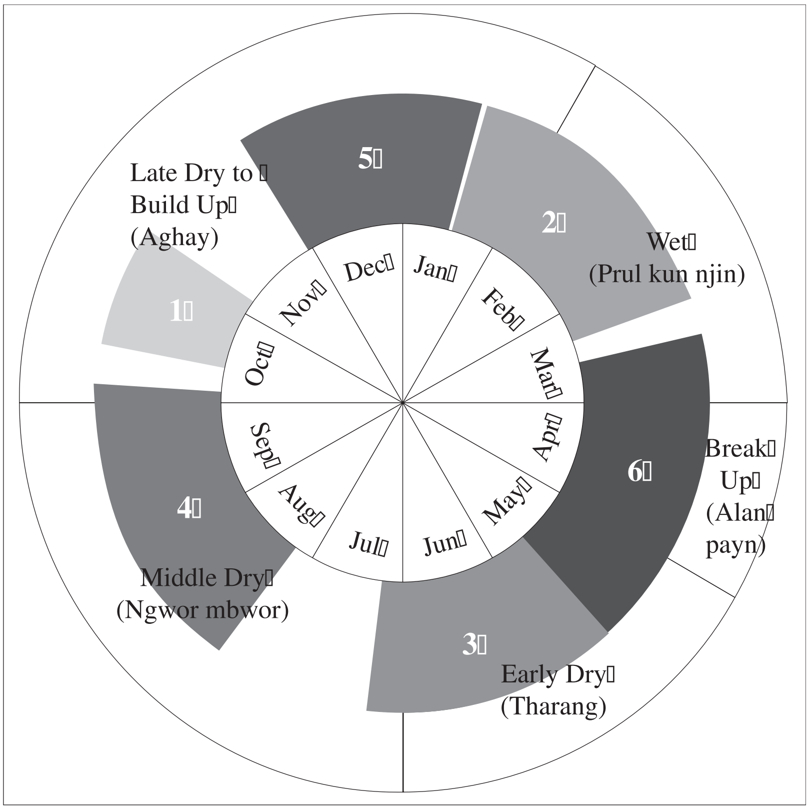


Figure 9 - Timing of survey visits, compared to ecological seasons.

The order of surveying of localities during each visit (Table 5) was selected by a random draw. Visits 2, 4, and 6 involved sampling of two extra localities to balance the survey design.

Table 5 - Sequence of sites surveyed for each visit.

Visit	1st	2nd	3rd	4th	5th	6th	7th	8th
1	WS1	AS1	WC2	AC1	AS2	-	-	-
2	AS1	WC1	AC1	AM1	WC2	WS1	AS2	WM1
3	WM1	WC2	AM1	AS2	WC1	AS1	-	-
4	AM1	AS2	WS1	WC1	AS1	AC1	WM1	WC2
5	WC1	AM1	AS1	WC2	AS2	WM1	-	-
6	AS1	AM1	AC1	WC1	AS2	WS1	WM1	WC2

Abbrev.: A = Andoom, W = Weipa, S = Swamp, C = Creek, M = Mangrove, 1=1st replicate, 2 = 2nd replicate.

Daily schedule

Following a day of site preparations, one of the four sites within a locality would be sampled according to a daily schedule (Table 6). The timing and sequence of survey activities was designed to minimise the time animals spent in traps during the mornings, as this factor (along with trap flooding) was a primary determinant of trap mortality rates.

Table 6 - Daily site sampling schedule.

Time	Activity
0630 to 0730	- Bird census
0800 to 1000	- Check traps
	- Weather notes
	- Handling trap specimens
	- Opportunistic observations
1000 to 1100	- Ground search for reptiles
1130 to 1200	- Diggings transect
1200 to 1300	- Site characteristics
	- Vegetation transect
1400 to 1700	- Administration, data checking/input, resting, dinner
1730 to 1830	- Check traps
1900 to 1905	- Bat census
1900 to 2000	- Arboreal census
2005 to 2100	- Ground search - reptiles, frogs, spiders

2.5 Field methods

At each site descriptive lists of observed species were made using both systematic surveying methods and incidental observations.

Early Morning Bird Census

Bird abundances were recorded for Observed and Heard birds, either Inside, Outside, Above or Far from each site, using a one-hour point census between 0700 and 0800 at each site on each survey visit. Nocturnal birds were also observed in night arboreal searches with spotlights.

A second independent observer (M. Andrews) conducted replicate bird censuses during one visit.

The dataset includes observations based on a minimum of 114 hours censusing from thirty sites for the second, third, fourth, fifth and sixth visits. Search effort was balanced across all levels of the survey design.

Cage Trapping

Six wire cage large mammal (and bird) traps were alternately placed 5m to the side of, and at 10 m intervals along, a 50m transect at each site, and set for four nights per visit per site. An oat-sausage bait was used for all visits except the sixth, when it was changed to an oat-vanilla mix. The oat mix consisted of oats, peanut butter and honey mixed to a firm paste and rolled into a ball of about a centimetre diameter. The sausage was a two centimetre segment of thick sausage.

The dataset includes observations based on 1680 trap nights from twenty-four sites for the second, third and fourth visits, with trap effort balanced across all levels of the survey design.

Elliott Trapping

Six pairs of Elliott traps for small mammals, herpetofauna and centipedes were placed at 10 m intervals along a 50m transect and left open for four nights per visit. An oat-sausage bait was used for all visits except the last, when it was changed to an oat-vanilla mix.

The dataset includes observations based on 3360 trap nights from twenty-four sites for the second, third and fourth visits, with trap effort balanced across all levels of the survey design.

Pitfence Trapping

Two 'L' shaped small mammal, herpetofauna and invertebrate pit-and-fence traps - each with a boundary length of 15m, a fence height of 25-cm and with two 60cm deep buckets placed at the ends of each arm of the fence - were installed at each site, and set for a 96-h period, per visit.

The layout of each pitfence is illustrated in Figure 10.

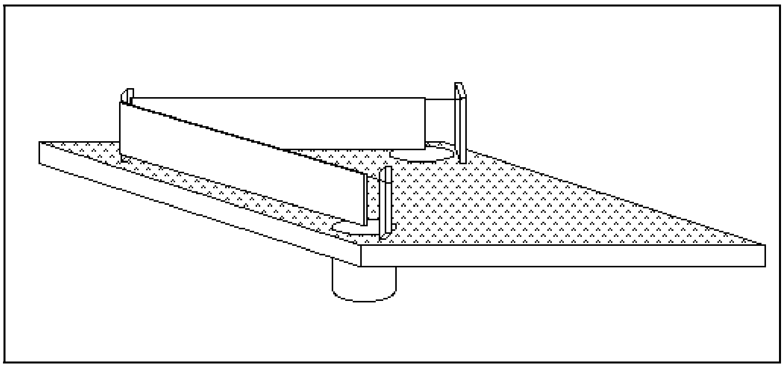


Figure 10 - Layout of pitfence traps.

The two 'L' traps at each site were oriented so as to catch proportionally more individuals travelling through the site, as compared to configurations with fences running in only one orientation, without the bias of a directional trend in catchability or movement patterns.

The dataset includes observations based on 680 trap nights from twenty-four sites for the second, third, fourth, fifth and sixth visits. Trap effort was balanced across all levels of the survey design when all visits were clumped, but was unbalanced for the fifth and sixth visits. Traps that were burnt were replaced, and fencing loosened by wind or fauna was restored. During the sixth survey visit the fencing was removed and replaced with a shallow trench. A small hole plugged with a twig in the base of the bucket was used as a drain following rain.

Day Ground Search

Day ground searches consisted of counts of occurrence of mostly herpetofauna within a fixed-pattern, 350 metre long, five metre wide transect, conducted at around 9 am at each site, during each visit.

The dataset includes observations based on having searched 145km^2 of ground from thirty sites for the second, third, fourth, fifth and sixth visits. Search effort was balanced across all levels of the survey design.

Night Ground Search

Night ground searches consisted of counts of occurrence of mostly herpetofauna within a fixed-pattern, 200 metre long, five metre wide transect, conducted at around 8 pm at each site during each visit.

The dataset includes observations based on having searched 71km^2 of ground from thirty sites for the second, third, fourth, fifth and sixth visits. Search effort was balanced across all levels of the survey design.

Night Arboreal Search

Night arboreal searches, which located mostly herpetofauna, consisted of a minimum forty-minute systematic search of the tree trunks and canopies using a 30-watt, 12-volt spotlight, conducted at around 9 pm, at each site during each visit. A fixed path along the boundary of the site was followed.

The dataset includes observations based on having spent a minimum of fifty-five hours spotlighting from thirty sites for the second, third, fourth, fifth and sixth visits. Search effort was balanced across all levels of the survey design.

Incidental Observations

Incidental observations were made on species observed outside the systematic survey activities. Aside from direct observations of species, signs of fauna such as carcasses, bones, scratchings, diggings, nests, hollows, faeces, and casts - were recorded.

Site Structural Attributes

Site attributes were measured at three scales, at a larger landscape scale using many of the landform and land surface attributes recommended in McDonald, et al. (1990), at a mid-range 25m scale using Gillison's (1988) plant functional attribute sampling, and at a smaller ground scale using nine quantitative attributes of 1 x 1m quadrats.

Attribute		**Description**
Ground Cover - Bare	%	Proportion of quadrat with exposed soil
Ground Cover - Live	%	Proportion of quadrat with green or live vegetation
Ground Cover - Litter	%	Proportion of quadrat with dry litter
Ground Cover - Ash	%	Proportion of quadrat with charcoal
Hollow Logs	Count	Incidence of logs on ground with hollows
Stumps > 30mm	Count	Incidence of tree stumps with a diameter at base > 30 mm
Termite Mounds – Blunt	Count	Incidence of termite mounds with a basal diameter > 50% of height
Termite Mounds – Conical	Count	Incidence of termite mounds with a basal diameter < 50% of height
Termite Mounds – Tree Stocking	Count	Incidence of trees with significant termite stocking

Table 7 – Structural habitat attributes sampled from all sites.

The proportion of four types of ground cover were visually assessed for five 1-meter quadrats spaced at ten meter intervals on a 50m transect at each site. Absolute counts of hollow logs, stumps and three types of visible termite structures were made within each 50-meter by 50-meter site quadrat.

2.6 Data analysis

Field data were recorded using the following media:

- custom forms
- field notebooks
- diaries
- compact cassette audio tapes
- memocorder audio tapes
- 35mm slides.

Observations were digitised, validated and maintained in a relational database.

Species Identification

Species names follow Strahan (1985) for mammals, Christidis and Boles (1994) for birds and Cogger (1986) for reptiles and frogs.

The following reptile synonyms have been incorporated:

- *Demansia atra* now *D. vestigiata* (G. Torr. pers. comm.)
- *Liasis maculosa* now *Antaresia maculosa* (G. Torr. pers. comm.)
- *Pseudothecaudactylus australis* now *Rhacodactylus australis*

In the early stages of the survey in particular, difficulty was experienced in discriminating between the following taxa:

- Flying foxes Pteropus spp.
- Graceful Honeyeater vs Yellow-spotted Honeyeater
- Frigatebirds
- Orioles

- Friarbirds
- Butcherbirds
- *Carlia* species (other than *C. storri*)
- *Gehyra dubia* vs juvenile *Rhacodactylus australis*
- Desiccated frogs
- Varanids

Observations for which the identifications were unreliable at the species level were grouped into complexes and considered a single "operational taxonomic unit" (Sokal and Sneath 1963; Oliver and Beattie 1993; Beattie and Oliver 1994).

Reporting Procedures

Survey sites were categorized based on the level they represented for each of the four factors in the sampling design. The site listing (Appendix A) gives the precise location of each of the thirty systematically sampled survey sites, and their habitat categorizations.

The observed species listing (Appendix C) gives a list of all systematically and incidentally recorded terrestrial vertebrates, including waterbirds and seabirds.

Species distribution maps of selected mammal, bird, frog and reptile species for this survey (Appendix D) were rasterised to a 5' grid over the mine lease, and overlaid on earlier workers observations (Winter and Atherton 1985).

Subsets of site data, based on the factor being analysed, were drawn from the pool of all observations, with criteria that limited the observations to:

- terrestrial vertebrates, and

- verified surveying records.

An ordered and summarised cross-tabulation was generated for each of the four survey factors (Appendices E to H), giving for each level of the factor the:

- count of incidental observations,
- count of observations from systematic sampling,
- Goodness of fit chi-square statistics for the null hypothesis that any differences between categories were due solely to differences in sampling effort (null hypotheses specified in footnotes),
- Probability of chi-square result based on resampling,
- Indication of degree of significance of observed differences,

for each species, for all sites, within each habitat level.

Bird abundances were the only data that presented analysis issues, as these values had been recorded in the field as categories. For this class the sum of systematically sampled observations was used as a quantitative surrogate for their abundances.

Diversity Analyses

Basic alpha, beta and gamma diversity statistics (Whittaker 1972; Clarke and Gorley 2001) were reported for each of the data subsets used in the survey. Here, alpha diversity was the average species richness per factor level, beta diversity was calculated as the ratio of the total number of species to the average number of species (gamma over alpha), and gamma diversity was the total number of species per factor level.

Summary data were tabulated within the lists, and additional exploratory data analysis was conducted using JMP 3.1.6 (SAS Institute 1997) statistical visualisation software.

To assess sampling adequacy species-area curves of the cumulative number of species observed (with site order averaged over 999 permutations) were plotted using PRIMER (Clarke and Gorley 2001) and interpreted using Thompson and Whithers (2003) guidelines.

Summary data were visualised using histograms to compare species richness between and among habitats, and line plot overlays to compare species abundance.

The proportional composition of the fauna for each habitat level was visualised using a mosaic plot (Hartigan and Kleiner 1981) in which the area of each rectangle of the mosaic is proportional to the frequency count of interest – as illustrated in Figure 11.

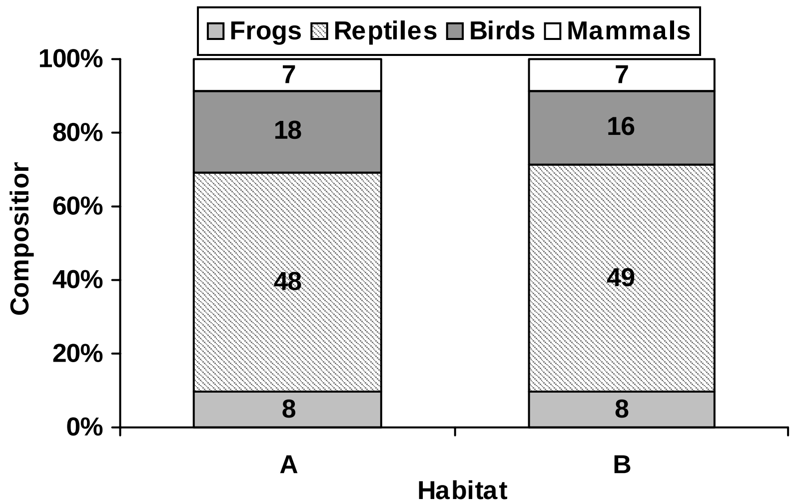


Figure 11 - Example of a mosaic plot showing the proportional composition of the fauna of two habitats.

Figure 11 is an illustration of a mosaic plot as a side-by-side divided bar chart, displaying in this example differences in the proportional richness by class of three habitats through rectangular areas (SAS Institute 1997). Differences in the species richness of all taxa between and among habitats were tested using G-tests. Depending on whether the frequency table had one, two or three contingencies, a chi-square test was used to test for independence.

The distributions of species richness and abundance at sites between and among habitats were visualised and compared using box plots, showing the means with a solid black box, the outliers with hollow boxes and 90% quantile as whiskers, and mean diamonds. The variance of the species richness and abundance of sites between and among habitats were compared; using an O'Brien's test where there were two habitats and a Bartlett's test when there were three habitats (Sokal and Rohlf 1995; SAS Institute 1997). The equality of the mean species richness and abundance of sites between habitats was tested using a non-parametric t-test where there were two habitats (also known as a Wilcoxin 2-sample test), and a one-way ANOVA when there were three habitats (also known as a Kruskal-Wallis n-sample test) (SAS Institute 1997).

The degree of uniqueness and commonality of species between the levels of each factor were presented using Venn diagrams. A greyscale gradient was used to illustrate the proportional composition of each subset, where a darker shade of grey indicates a higher proportion of the overall fauna with an observed pattern of habitat occurrence.

Compositional Analyses

To assess the degree of site similarity for each level of habitat factor, a matrix of site-site similarity measures were calculated using the Bray-Curtis distance measure and transformation of the data to species presence/absence. Differences between habitats were visualised using multidimensional scaling (MDS) with ten restarts, using PRIMER (Clarke and Gorley 2001).

To test for the significance of differences amongst the fauna assemblages of the habitats a multi-response permutation procedure (MRPP) was employed. A MRPP estimates the probability of a test's outcome, in this case the test being the degree of similarity by way of a distance measure between observation groups (Lewontin and Felsenstein 1965; Diaconis and Efron 1983; Pollack *et al.* 1994; Simon and Bruce 1995; Sokal and Rohlf 1995).

The distance measure employed in these analyses was the sum of the squared Euclidean distances (SSED) between the original observations and their own group centroids. One would expect that if species really do occur in habitat-specific groups, this sum would be small.

Group identities were repeatedly shuffled among observations a very large number of times, keeping the number of observations in each group constant. With each step the SSED was calculated and added to a distribution. If the original groups were real (i.e. small and clustered), this new sum would most likely be larger than the original sum.

Finally, the SSED of the original, real configuration is compared to the distribution of SSED's obtained from shuffling. If it is in the tail of the distribution it is unlikely to have arisen due to a random configuration of data and the null hypothesis that there is no pattern in the data can therefore be rejected. This procedure was implemented using a custom application (Alford 1995) based on routines found in Manly (1991), and is equivalent to the ANOSIM analysis available in PRIMER.

The MRPP procedure was run on each matrix of systematically observed species and sites using a presence/absence transformation, an intermediate abundance transformation (using Ln(N+1)) and the raw untransformed abundance. This provided analytical precision weighted for composition, intermediate abundances and actual abundance.

Species-specific analyses

Species-specific differences in abundance between each level of each factor were tested using the chi-square. The significance of the chi-square was evaluated traditionally for large enough sample sizes, and through randomised resampling for smaller sample sizes.

To explain, where enough individuals were seen to expect at least five individuals in each habitat, the test of significant difference employed a traditional Yates-corrected, chi-square function (Zar 1984). However, it was possible to extend the analysis to estimate the probability of significance for as few as six or four individuals across two or three habitats respectively, by using a randomisation test to exhaustively compare the observed chi-square value with every permutation of all possible values. A computer program to implement this was custom written by Alford (1995), and was verified for accuracy and precision against SAS GLM MANOVA and Blossom (Cade and Richards 1999).

Environmental covariate analyses

The multivariate pattern in the site attribute data was compared to the species data to identify any correlations.

The analysis process involved:

- log transforming the recorded percentage and absolute site attribute values,
- substituting average values for missing data,
- using a Draftsman plot to visually identify the degree of correlation between attributes,
- principal component analysis plotting and
- measurement of agreement between the sites-by-species and sites-by-attributes similarity matrices

The process was implemented within PRIMER using the BIO-ENV procedure with the Spearman rank correlation coefficient.

Numerical statistical probabilities were qualitatively explained using a consistent terminology (Moss and Schneider 1997; Schneider 1997), as given in Table 8 below.

Table 8 - Terminology used to explain numerical statistical probabilities

Numerical	**Odds**	**Plain english**
0.99	99/100	Virtually certain
0.90	9/10ths sure	Confident
0.67	2/3 chance	Probable
0.33	3:1 against	Questionable
0.10	10:1 against	Unlikely
0.01	100:1 against	Very unlikely

3 Results

3.1 Ore value

A total of ninety-nine (N=99) terrestrial vertebrates were observed in woodland habitat sites above either economic or uneconomic ore, most of which were birds (N=58), followed in turn by reptiles (N=21), frogs (N=9) and mammals (N=11). The number of incidental and systematic observations of each of these species for all woodland habitat sites above economic and uneconomic ore are tabulated and summarised in Appendix E.

Diversity

Basic species diversity measures show virtually no difference between the fauna of woodland habitats above economic and uneconomic ore (Table 9).

Table 9 – Species diversity of woodland habitats above economic and uneconomic ore.

		Diversity measure		
	Sites	alpha	beta	gamma
Economic	8	31.4	2.6	81
Uneconomic	6	37.2	2.2	80

The low shoulder in the species-area plot of the cumulative number of species observed indicates that while a substantial and adequate proportion of the total fauna for the habitat was sampled for comparative purposes, the complete diversity of these habitats was not recorded (Figure 12).

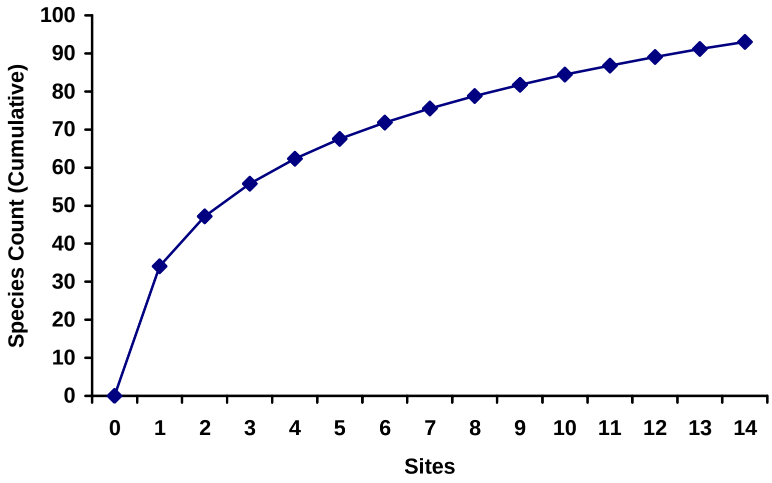


Figure 12 - Cumulative number of species observed from all woodland sites, showing that a substantial proportion of the terrestrial vertebrate fauna was sampled.

Whether incidentally or systematically sampled, virtually the same number of species and individuals were observed in *E. tetrodonta* woodland habitat above either economic or uneconomic ore (Figure 13).

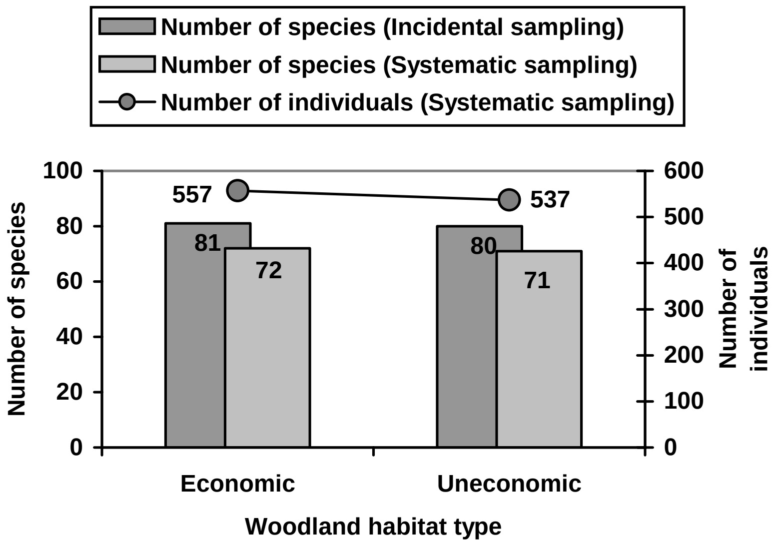


Figure 13- The species richness and total abundance of the observed terrestrial vertebrate fauna of woodland habitat above economic and uneconomic ore, showing no significant differences.

A comparison of the terrestrial vertebrate richness of sites in woodland habitats above economic and uneconomic ore (Figure 14) found no significant difference in either their variance (O'Brien's homogeneity of variance test; F = 3.175, *P* = 0.1001), nor their mean (t-test for difference between means; t = -1.782, df = 12, *P* = 0.1001).

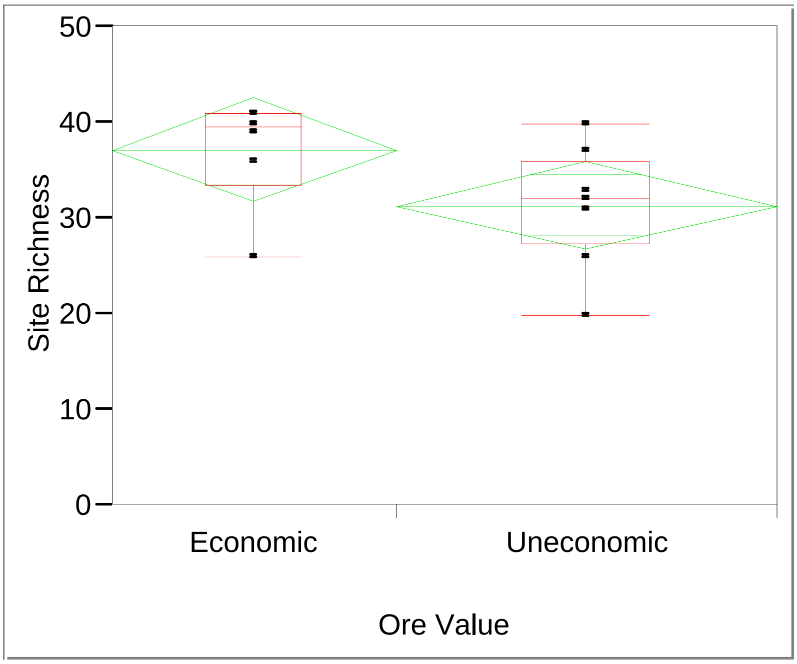


Figure 14 – Average species richness of the terrestrial vertebrates of woodland habitat sites above economic and uneconomic bauxite ore showed no significant differences.

The relative proportion of unique and shared terrestrial vertebrate species between woodland habitat above economic and uneconomic ore showed that almost two-thirds (63%) were common to both habitats, and that the remainder of the species were balanced (19% in economic and 18% in uneconomic) across the two habitats (Figure 15A).

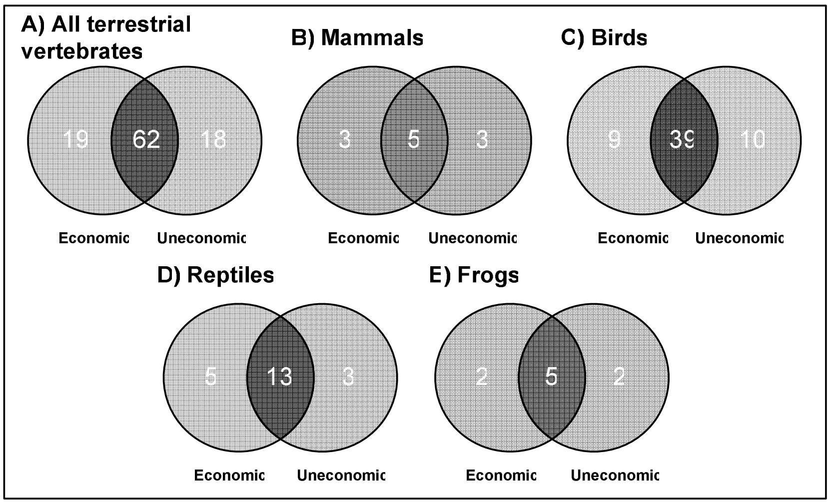


Figure 15 – Absolute count and proportion (indicated by intensity of grey shading) of unique and shared terrestrial vertebrate species across woodland habitat above economic and uneconomic ore.

Similarity

As a whole the composition of the terrestrial vertebrate fauna of sites from woodland habitat sites above economic ore could not be distinguished from those above uneconomic ore, as evidenced by the complete overlap of the minimum convex polygons in the ordination plot of sites projected against observed species presence/absence (Figure 16).

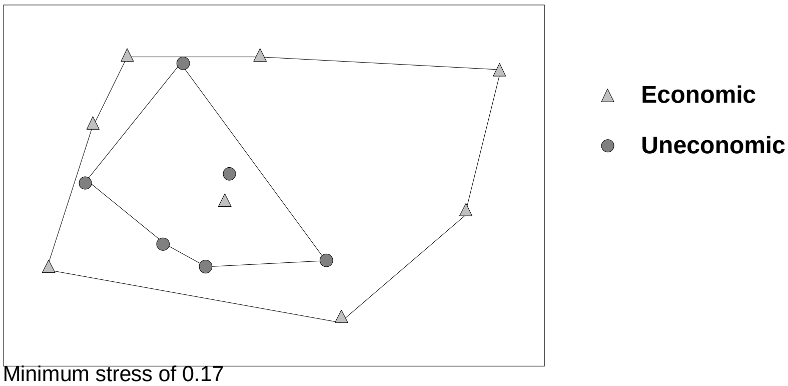


Figure 16 - Ordination (NMS) and minimum convex polygons of woodland habitat sites above economic and uneconomic ore against species presence/absence composition shows no distinguishable pattern of difference.

No significant difference in the composition or abundance of the terrestrial vertebrate fauna, either as a whole or by class was suggested by the results of resampling the Sum of squared Euclidean Distance (SSED) statistic for species presence/absence, ln(N + 1) and raw abundance data for all economic and uneconomic woodland habitat sites (Table 10).

Taxa	**Probability of significant SSED statistic**		
	Presence/ Absence	**Ln(N+1) Abundance**	**Raw Abundance**
All	0.413^{ns}	0.496^{ns}	0.544^{ns}
Mammals	0.814^{ns}	0.705^{ns}	0.623^{ns}
Birds	0.477^{ns}	0.562^{ns}	0.575^{ns}
Reptiles	0.224^{ns}	0.216^{ns}	0.269^{ns}
Frogs	0.676^{ns}	0.666^{ns}	0.663^{ns}

*** P<0.001, ** P <0.01, * P<0.05 and ^{ns} P>0.05

Table 10 – Results of resampling procedure for comparisons of composition of observed terrestrial vertebrates in woodland habitats above economic and uneconomic ore showed no significant differences at any level of analysis.

Differences in the proportional richness of terrestrial vertebrates by class between economic and uneconomic woodland habitat, as illustrated in a mosaic plot (Figure 17), were not significant (Likelihood Ratio: $\chi^2 = 0.257$, $P = 0.968$).

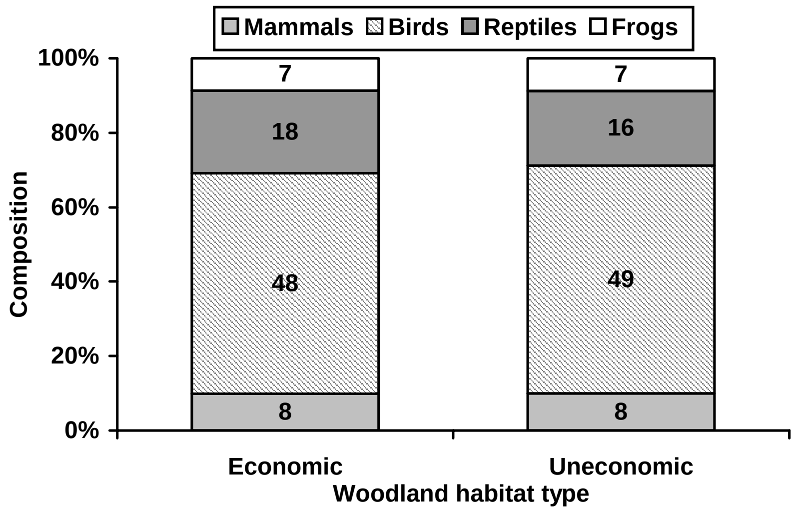


Figure 17 – No significant difference was observed in the absolute (N) or proportional composition in species richness, by class, of the terrestrial vertebrates of woodland habitats above economic and uneconomic ore.

A strong and direct correlation ($R^2 = 0.923$) between the abundances of each observed species for all woodland sites above economic bauxite and uneconomic ore was observed, supporting the hypothesis that the value of the bauxite has no significant influence on the abundance of terrestrial vertebrates in woodland habitats (Figure 18).

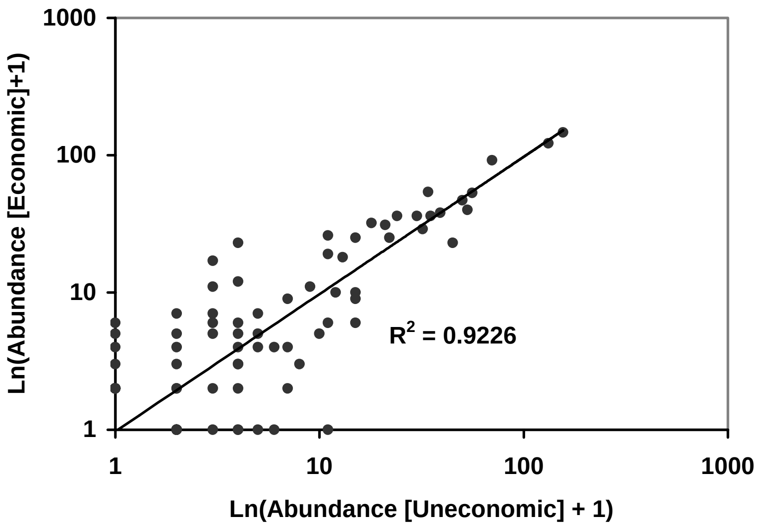


Figure 18 - Scatter plot of the abundance (Ln(N+1))of each observed terrestrial vertebrate from the combined woodland habitat sites above economic ore and uneconomic bauxite ore.

A box plot (Figure 19) and comparative tests of the summed abundance of the systematically sampled terrestrial vertebrates of sites in woodland habitats above economic and uneconomic ore suggested that observed differences in the mean (t-test ; t = 1.912, df = 12, P = 0.081) and variance (O'Brien's test; F = 0.013, P = 0.909) of site abundance were also not significant.

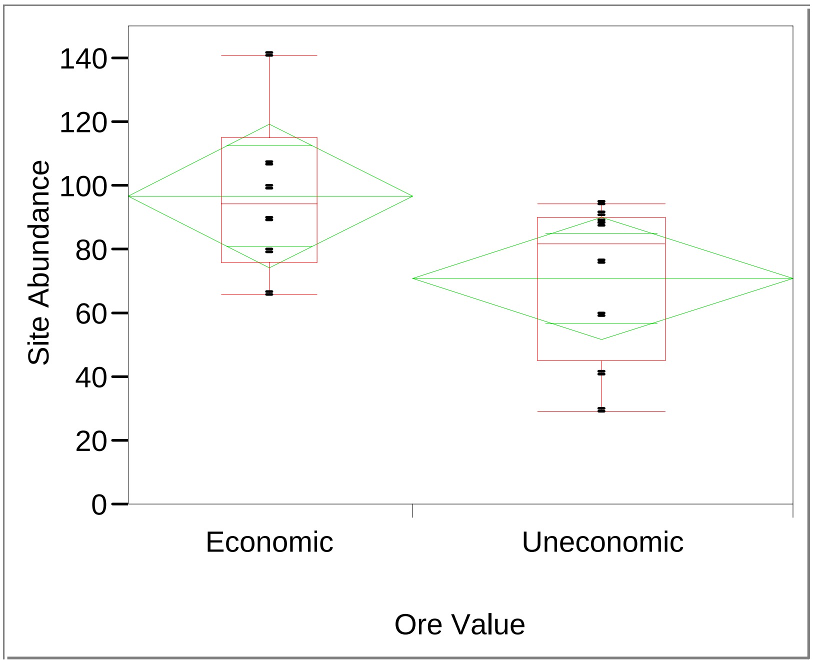


Figure 19 - Average abundances of systematically sampled terrestrial vertebrates from woodland habitat sites above economic and uneconomic bauxite ore show no significant difference.

The five vertebrates which most characterised woodland habitat above economic ore were:

Species	**% Contribution**	**Cumulative %**
White-throated Honeyeater *Melithreptus albogularis*	9.60	9.60
Little Friarbird *Philemon citreogularis*	9.52	19.13
Rainbow Lorikeet *Trichoglossus haematodus*	9.22	28.35
Pelagic Gecko *Nactus pelagicus*	7.75	36.09
White-bellied Cuckoo-shrike *Coracina papuensis*	5.85	41.94

Table 11 - The top five terrestrial vertebrates which based on both species richness and abundance most characterised woodland habitat above economic ore.

The five vertebrates which most characterised woodland habitat above uneconomic ore were:

Species	**% Contribution**	**Cumulative %**
Rainbow Lorikeet *Trichoglossus haematodus*	8.08	8.08
Pelagic Gecko *Nactus pelagicus*	7.98	16.06
White-throated Honeyeater *Melithreptus albogularis*	7.30	23.36
Little Friarbird *Philemon citreogularis*	6.42	29.79
White-bellied Cuckoo-shrike *Coracina papuensis*	5.95	35.74

Table 12 - The top five terrestrial vertebrates which based on both species richness and abundance most characterised woodland habitat above uneconomic ore.

The five vertebrates which most characterised the difference between woodland habitats above economic and uneconomic ore were:

Species	% Contribution	
	Individual	Cumulative
Pelagic Gecko *Nactus pelagicus*	8.52	8.52
Carlia longipes *Carlia longipes*	8.29	16.81
Carlia complex A *Carlia complex A*	8.28	25.09
Two-lined Dragon *Diporiphora bilineata*	4.73	29.82
Oedura rhombifer *Oedura rhombifer*	2.51	32.33

Table 13 - The top five terrestrial vertebrates which based on both species richness and abundance most characterised the difference in woodland habitats above economic and uneconomic ore.

Eighty-four (85%) of the observed terrestrial vertebrates were systematically surveyed, of which two (both reptiles) had a significant difference in incidence between woodland habitat above economic and uneconomic ore for (Table 14).

Table 14 - Number of terrestrial vertebrates systematically and incidentally observed in woodland habitat sites economic and uneconomic, and the number of these with a significant difference in incidence.

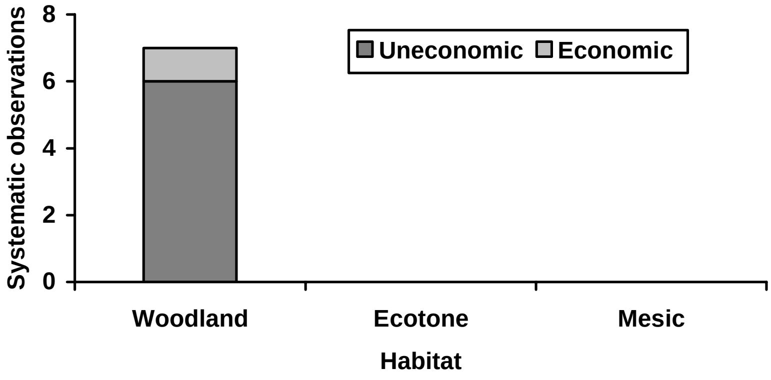
Observation Type	Mammals	Birds	Reptiles	Frogs	**Total**
All	11	58	21	9	**99**
Systematic methods only	5	53	20	6	**84**
Significant difference in incidence	-	-	2	-	**2**

Of the ninety-nine terrestrial vertebrates recorded from all woodland habitat sites, sixty-two (63%) were observed in woodland above both economic and uneconomic ore, while the remaining thirty-seven (37%) were observed exclusively in habitat above either economic or uneconomic ore (Appendix E and Figure 15).

Species-specific observations

Significant differences in observed incidence were confidently observed for an uncommon gecko (*Heteronotia binoei*) found exclusively in open forest habitat ($\chi^2 = 5.3$, $P = 0.047$), and the common Two-lined dragon (*Diporiphora bilineata*) found in all surveyed habitats ($\chi^2 = 6.7$, $P = 0.011$). Both of these species were more abundantly recorded in woodland habitat above economic ore.

The gecko *Heteronotia binoei*



The dragon *Diporiphora bilineata*

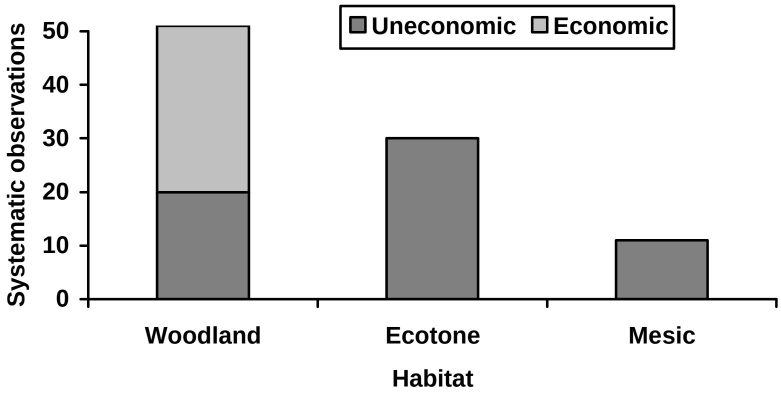


Figure 20 - Systematic observations of the gecko *Heteronotia binoei* and a common dragon *Diporiphora bilineata*.

The gecko *Heteronotia binoei* was observed six times exclusively in woodland habitats above economic ore and once above uneconomic ore when systematically sampled, and once more above economic ore incidentally. The odds of it being observed like this if it actually had no habitat preference between economic or uneconomic are about 1:20 (P = 0.0471). This makes it virtually certain that this species has a specific preference for woodland habitat above economic ore.

Summary

In summary, at all levels of summary analysis there was strong evidence of no significant difference in the species richness, abundance or composition of the vertebrate fauna of economic and uneconomic woodland habitat sites. At a species specific level two systematically observed terrestrial vertebrate species – a locally uncommon gekko (*Heteronotia binoei*) and a very abundant dragon (*Diporiphora bilineata*) - were significantly more frequently observed in woodland habitat above economic ore. Otherwise, none of the remaining observed terrestrial vertebrates showed a significant difference in abundance between woodland habitat sites above economic and uneconomic ore.

On the basis of observed incidence alone, for the overwhelming proportion of the native terrestrial vertebrate fauna surveyed and in a variegated landscape, the open forest habitat above uneconomic ore is most probably, if not certainly, an effective substitute for open forest habitat above economic ore.

3.2 Landscape position

A total of one hundred and fifty-two terrestrial vertebrate species were observed in woodland, ecotone and riparian habitats, mostly birds (N=94), followed by reptiles (N=28), frogs (N=17) and mammals (N=13). The number of observations of each of the observed species for all woodland, ecotone and riparian habitat sites are tabulated and summarised in Appendix F.

Diversity

Basic species diversity measures show virtually no difference between the fauna of woodland, ecotone and riparian habitats (Table 17).

Table 15 – Species diversity of woodland, ecotone and riparian habitats.

		Diversity measure		
	Sites	alpha	beta	gamma
Woodland	12	33.9	2.92	99
Ecotone	8	39.3	2.57	101
Riparian	8	41.5	2.77	115

The low shoulder in the species-richness plot suggests that an adequate proportion of the total fauna for these three habitats was sampled for the purposes of comparison, but that the complete diversity for the three habitats had not been sampled (Figure 21).

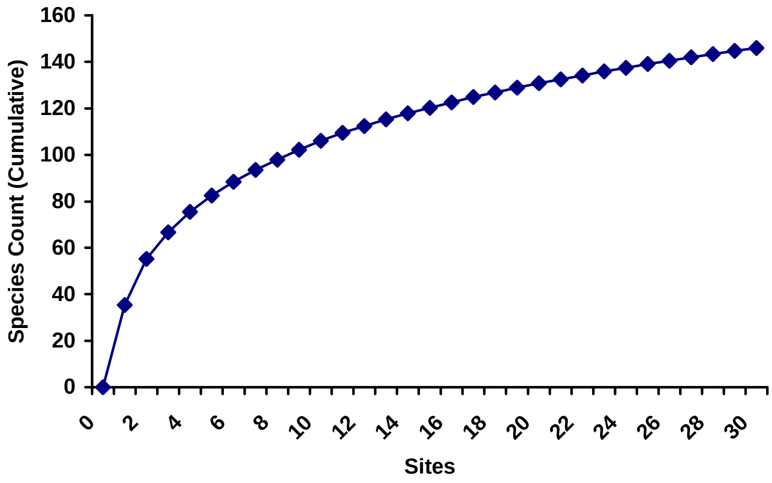


Figure 21 - Cumulative species-richness curve for all terrestrial vertebrate species observed from all woodland, ecotone and riparian sites, indicating that for comparative purposes an adequate proportion of the fauna was sampled.

Overall, riparian habitat was the most speciose, with 115 observed species for all riparian sites combined. However, while riparian habitats had fourteen and sixteen species more than either ecotone or woodland habitats respectively (Figure 22), the differences in numbers of species amongst these habitats were not statistically significant (Pearson test: $\chi^2 = 3.604$, $P = 0.165$). Likewise, the differences in the numbers of systematically sampled species between woodland, ecotone and riparian habitats were also not significant.

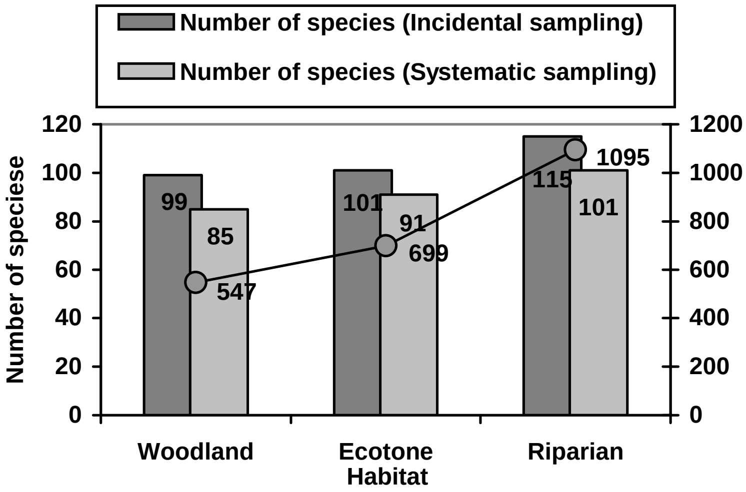


Figure 22 – Comparison of the terrestrial vertebrate richness and abundance (corrected for sampling effort) of woodland, ecotone and riparian habitats.

When the abundances of all the systematic observations are summed, and after adjusting for having sampled woodland habitats twice as much as either ecotone or riparian habitats, it was found that significantly more individuals were observed in riparian habitats (N=1095) compared to either woodland (N=547) or ecotone (N=699) habitats .

The most speciose site (with 67 species) was located in ecotone habitat, however there was no significant difference in the means (Student's t; t = 2.052) or variance (O'Brien's test; F = 1.466, *P* = 0.289) of site richness among woodland, ecotone and riparian habitats (Figure 23).

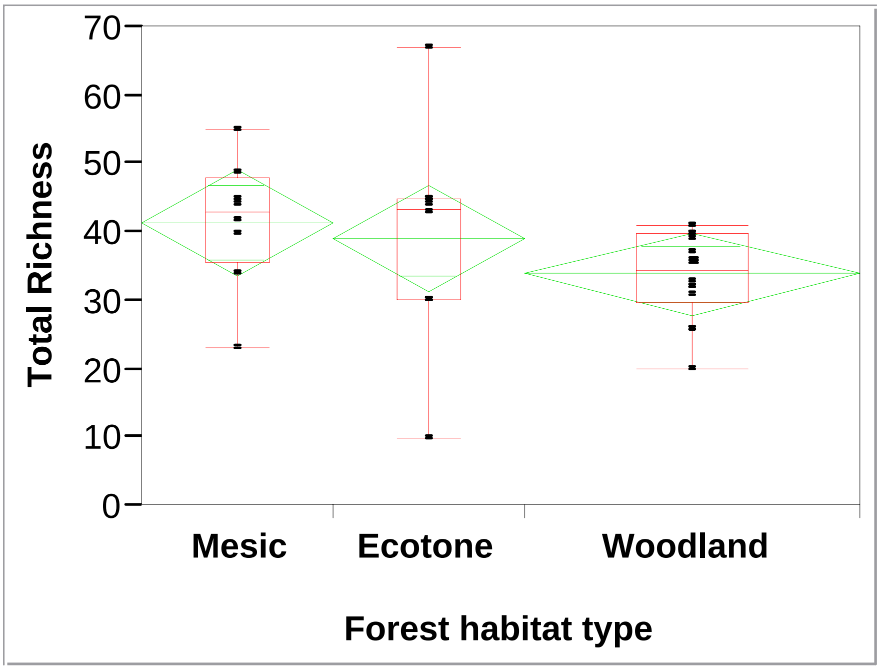


Figure 23 - Comparison of the mean terrestrial vertebrate richness of sites from woodland, ecotone and riparian habitats indicates no significant difference.

The strongest pattern of occurrence for woodland, ecotone and riparian habitat amongst the terrestrial vertebrates was that of ubiquity; 40% of species were observed in all three habitats. This is indicated in Figure 24 by the comparatively darker shade of grey for the central segment of all the diagrams, and although less so for the birds was a pattern consistent for each vertebrate class.

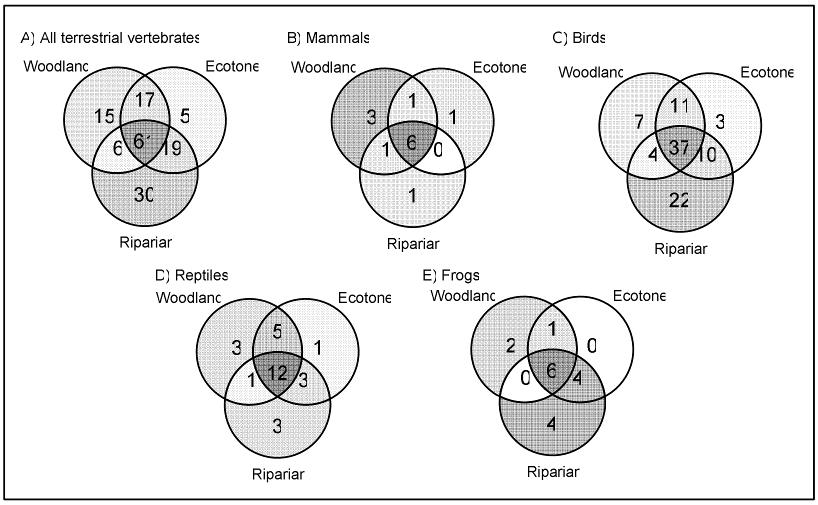
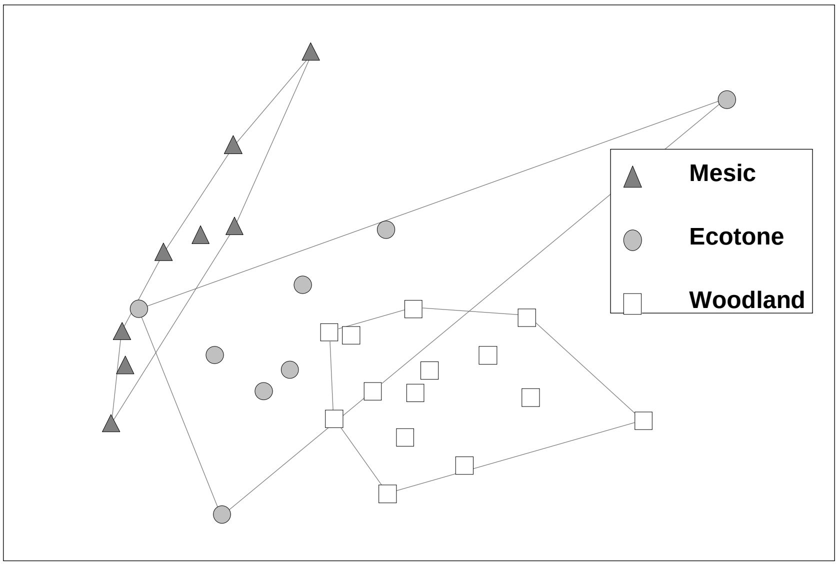


Figure 24 – Absolute count and proportion (indicated by intensity of grey shading) of unique and shared terrestrial vertebrates across woodland, ecotone and riparian habitats, showing that most species occur in all three habitats, with only birds and frogs having a preponderance of species restricted to mesic habitats.

Similarity

As a whole the composition of the terrestrial vertebrates of woodland, ecotone and riparian habitats were distinguishable from each other along a gradient, as evidenced by the arrangement and degree of separation of the minimum convex polygons in the ordination plot of sites projected against observed species presence/absence (Figure 25).



Minimum stress of 0.19

Figure 25 – Non-metric multidimensional scaling plot for the standardised transformed abundance of species abundance of woodland, ecotone and riparian habitat sites shows a distinguishable difference and a gradient in their fauna composition.

Figure 25 clearly show a gradient running from left to right, with woodland and riparian habitats the furthest apart, and with ecotone in the middle.

When the compositional similarities of the site faunas are plotted by landunit it shows two features of note. Firstly, it illustrates the similarity of landunit 5k to 2b. Secondly, it illustrates that while the landunit considered as ecotone (5e) has some similarity to woodland habitats (landunits 2b and 5k), this similarity is driven almost exclusively by the fauna of two sites (AM12 and WM12), but that it is otherwise clearly distinct (Figure 26). The overlap in fauna similarity between ecotone and woodland habitat appears sensitive to the landunit diagnosis of 2b for the WM12 site, and 5e for the WM12 site.

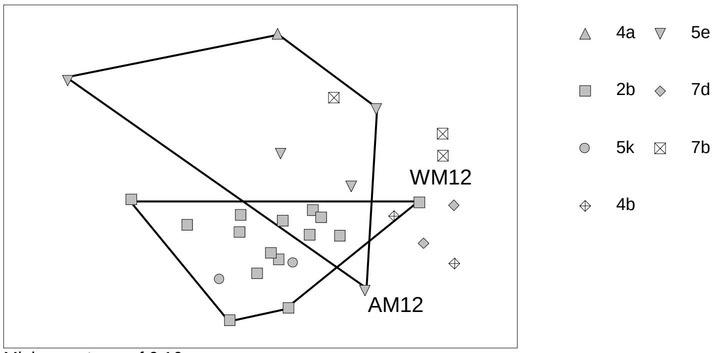


Figure 26 - Non-metric multidimensional scaling plot for the Log(X+1) transformed abundance of species of sites from those landunits sampled in the study, shows that while there is some overlap with woodland landunits (2b, 5k) the ecotone landunit (5e) is also clearly different in its terrestrial vertebrate fauna composition.

Using three measures of abundance, resampling the distance measure very strongly indicated that the difference between the faunas of riparian, ecotone and woodland habitats was significant (E = 1921.677, P = 0.0001). Furthermore, pairwise comparisons strongly suggested a very significant difference in composition between the fauna of woodland habitat compared to either riparian or ecotone habitat, and strongly suggested that when compared to woodland and riparian habitats, ecotone habitats were much more similar to riparian habitats. These results provide strong quantitative support to the differences between the habitats that are seen in Figure 25.

Taxa	**Test of Difference**		
	Presence/ Absence	**Ln(N+1) Abundance**	**Raw Abundance**
All observed vertebrates			
Riparian vs Ecotone vs Woodland	0.001***	0.001***	0.001***
Riparian vs Ecotone	0.101 ns	0.150 ns	0.219 ns
Riparian vs Woodland	0.001***	0.001***	0.001***
Ecotone vs Woodland	0.001***	0.003**	0.010**

Mammals			
Riparian vs Ecotone vs Woodland	0.049*	0.025*	0.054 ^{ns}
Riparian vs Ecotone	0.733 ^{ns}	0.072 ^{ns}	0.120 ^{ns}
Riparian vs Woodland	0.001***	0.003**	0.004**
Ecotone vs Woodland	0.462 ^{ns}	0.696 ^{ns}	0.752 ^{ns}
Birds			
Riparian vs Ecotone vs Woodland	0.001***	0.001***	0.001***
Riparian vs Ecotone	0.803 ^{ns}	0.624 ^{ns}	0.573 ^{ns}
Riparian vs Woodland	0.001***	0.001***	0.001***
Ecotone vs Woodland	0.001***	0.001***	0.001***
Reptiles			
Riparian vs Ecotone vs Woodland	0.002**	0.002**	0.007**
Riparian vs Ecotone	0.001***	0.001***	0.002**
Riparian vs Woodland	0.003**	0.011*	0.056 ^{ns}
Ecotone vs Woodland	0.453 ^{ns}	0.583 ^{ns}	0.635 ^{ns}
Frogs			
Riparian vs Ecotone vs Woodland	0.002**	0.008**	0.011*
Riparian vs Ecotone	0.370 ^{ns}	0.244 ^{ns}	0.204 ^{ns}
Riparian vs Woodland	0.002**	0.002**	0.001***
Ecotone vs Woodland	0.040*	0.015*	0.009**

*** P<0.001, ** P <0.01, * P<0.05 and ^{ns} P>0.05

Table 16 – Results of resampling procedure for comparisons of composition of observed terrestrial vertebrates in woodland, ecotone and riparian habitats.

This pattern of abundance was present most strongly in birds and frogs, whereas reptiles had a contrasting pattern, with ecotone fauna most similar to woodland habitat fauna.

Comparison of the number of species in each class by habitat found that the proportional richness by vertebrate class between woodland, ecotone and riparian habitats (Figure 27) was not significantly different (Likelihood Ratio: χ^2 = 2.73, P = 0.842).

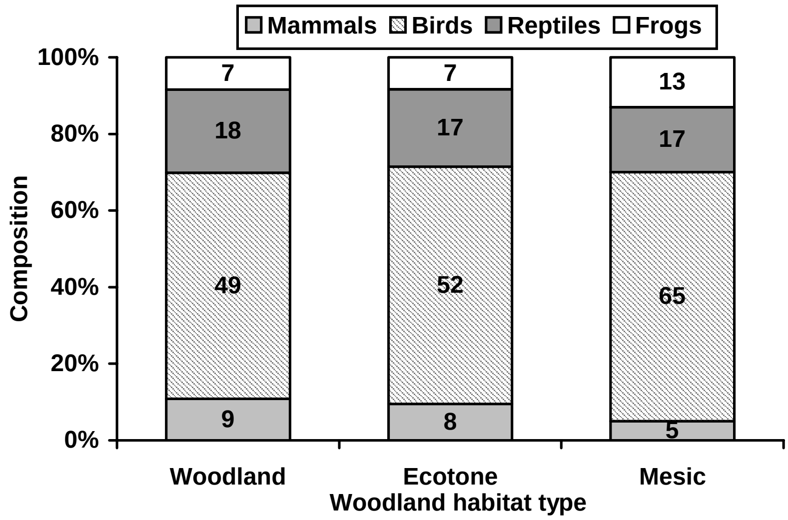


Figure 27 – No significant difference was observed in the absolute (N) or proportional composition in species richness, by class, of the terrestrial vertebrate richness of woodland, ecotone and riparian habitats.

Direct comparisons of the log of species abundances between woodland and ecotone habitats, and riparian and ecotone habitats, were more highly correlated than between woodland and riparian habitats (r = 0.32, 0.45 and -0.08 respectively), as illustrated in the Figure 28.

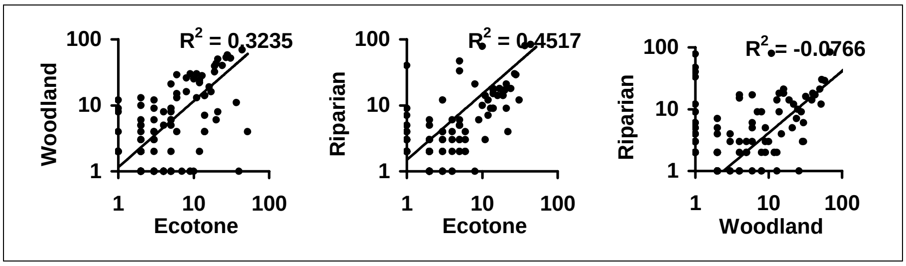


Figure 28 - Scatterplots of the log of abundance (sum of individuals) of each observed terrestrial vertebrate from each two-way permutation of woodland, ecotone and riparian habitat sites.

A box plot (Figure 29) and comparative tests of sites using the abundance of the systematically sampled terrestrial vertebrates among woodland, ecotone and riparian habitats suggested that there was a significant difference in the means of woodland and riparian habitat sites (O’Brien’s test; F=1.335, P = 0.287), and that there was a significant difference in the variance of abundance between sites (ANOVA: F = 3.667, P = 0.039).

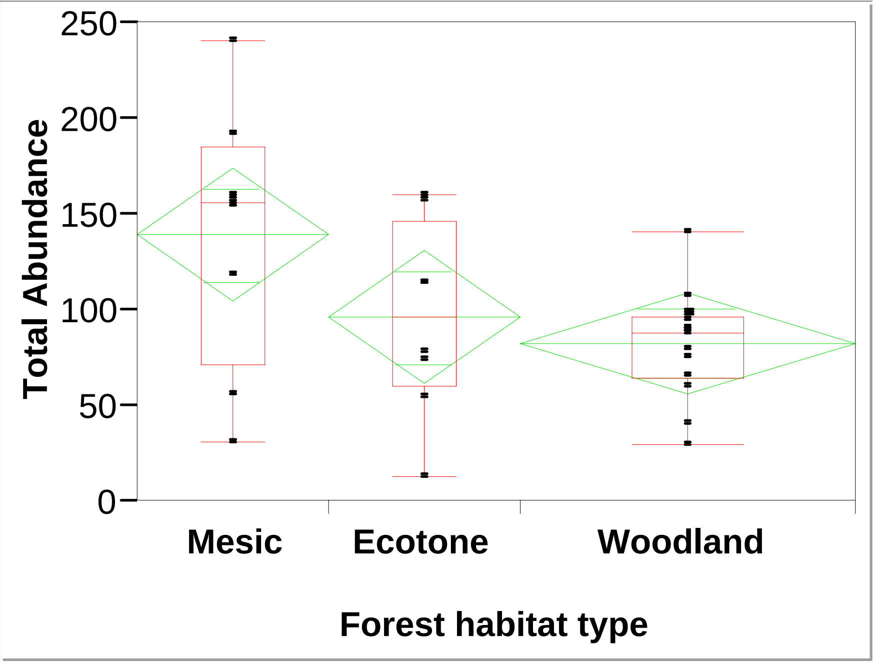


Figure 29 - Comparison of the average sum of abundances of systematically observed terrestrial vertebrates from woodland, ecotone and riparian habitat sites.

Species-specific observations

Based on systematic and incidental records sixty-one (40%) taxa were found in all three habitats, forty-one (27%) taxa were shared between two habitats (all except six being adjacent habitats) and fifty (33%) taxa were observed exclusively in a single habitat (Appendix F).

Systematic surveying enabled analysis of species specific differences in incidence between woodland, ecotone and riparian habitats for one hundred and thirty-three (88%) of all the observed terrestrial vertebrates. Of these, thirty-nine (29%) differed significantly in occurrence across woodland, ecotone and riparian habitats, as summarised in Table 17.

Table 17 - Number of species used in comparison of woodland, ecotone and riparian habitat sites, and the number of these with a significant observed difference in incidence.

Observation Type	Mammals	Birds	Reptiles	Frogs	**Total**
All	13	94	28	17	**152**
Systematic methods only	8	86	25	14	**133**
Significant incidence	2	14	13	10	**39**

Seven taxa were observed exclusively and significantly within a single habitat (Table 18), although where there were 3 or 4 observations it would be fair to say that the strength of the evidence for significance is weak.

Table 18 - Taxa observed exclusively and significantly in one habitat type

Species	**Observations**	**Habitat**
Sugar Glider *Petaurus breviceps*	3	Ecotone
Fairy Gerygone *Gerygone palpebrosa*	3	Riparian
Tawny-breasted Honeyeater *Xanthotis chrysotis*	3	Riparian
Little Shrike-thrush *Colluricincla megarhyncha*	4	Riparian
Bynoe's Gecko *Heteronotia binoei*	7	Woodland
Tawny Rocketfrog *Litoria nigrofrenata*	8	Riparian
Naked Treefrog *Litoria rubella*	8	Riparian

Of the seventeen species seen in both woodland and ecotone habitats only the Zigzag Gecko *Oedura rhombifer* was observed frequently enough to identify a significant difference. This Gecko was observed twenty-five times in woodland and seven times in ecotone, and whilst not recorded even once in riparian habitats in this study it has been in an earlier study (Cameron and Cogger 1992).

Eight species seen in both riparian and ecotone habitats were observed frequently enough to identify a significant difference:

- the Orange-footed Scrubfowl *Megapodius reinwardt* – observed once in ecotone and five times in riparian habitats,

- the Yellow-billed Kingfisher *Syma torotoro* – observed four times in ecotone and twice in riparian habitat,

- the Weebill *Smicroronis brevirostris* – observed eleven times in woodland and once in riparian habitat,

- the Great Bowerbird *Chlamydera nuchalis* – observed three times in ecotone and five times in riparian habitat,

- the skink *Glaphyromorphus nigricaudis* - observed four times in ecotone and forty-six times in riparian habitats,

- the Dragon *Lophognathus temporalis* – observed once incidentally in ecotone and three times systematically in riparian habitats,

- the skink *Carlia storri* - observed once incidentally in ecotone and thirty-nine times systematically from riparian habitats,

- the White-lipped Treefrog *Litoria infrafrenata* - observed twice from ecotone habitats and eleven times from riparian habitats,

- the Striped Rocketfrog *Litoria nasuta* - observed nine times from ecotone habitats and seventy-seven times from riparian habitats.

If the species which were exclusive to a habitat are clumped with species which are shared between ecotone and the same habitat, then there are thirteen species associated with riparian habitats, two associated with woodland habitats and one with ecotone habitats.

Of the sixty-one species observed in all three habitats, twenty-two had a statistically significant difference in incidence between habitats. Significant differences were observed for:

• woodland and/or ecotone habitat by six species:

- Laughing Kookaburra *Dacelo novaeguineae*
- Noisy Friarbird *Philemon corniculatus*,
- Black-backed Butcherbird *Cracticus mentalis*,
- Pelagic Gecko *Nactus pelagicus*,
- Northern Velvet Gecko *Oedura castelnaui*, and
- Two-lined Dragon *Diporiphora bilineata*,

• ecotone habitat by two species:

- Peaceful Dove *Geopelia striata*,
- The skink *Ctenotus spaldingi*,

• riparian and/or ecotone habitat by fourteen species:

- Grassland Melomys *Melomys burtonis*,
- Bar-shouldered Dove *Geopelia humeralis*,
- Yellow Honeyeater *Lichenstomus flavus*,
- Dusky Honeyeater *Myzomela obscura*,
- the skink *Carlia longipes*,
- Fence Skink *Cryptoblephartus virgatus*,
- Major Skink *Egernia frerei*,
- the Snake *Demansia atra*,
- Ornate Burrowing Frog *Limnodynastes ornatus*,
- Torres Gungan *Uperolia mimula*,

- Torrid Froglet *Crinia remota*,
- Northern Sedgefrog *Litoria bicolor*,
- Shrill Chirper *Sphenophryne gracilipes*, and
- Cane Toad *Bufo marinus*.

If the species which were observed exclusively within a habitat are clumped with species which are shared between the one or both other habitats, as well as species which are ubiquitous but which were significantly more frequently observed for the habitat, then there are twenty-seven species associated with riparian habitats, four associated with ecotone habitats and ten species associated with woodland habitats.

This shows that compared to woodland habitats the riparian habitats are more than twice as rich with habitat specialists (mostly birds), and that there are two habitat generalists that prefer woodland habitat for each generalist that prefers riparian habitat.

The indication to use reptiles instead of birds as common faunal habitat indicators to discriminate between the riparian, ecotone and woodland habitats at Weipa is illustrated by the result that, of those species which primarily provide the first 30% of the species richness and abundance information, half are the three same birds – the White-throated Honeyeater, Rainbow Lorikeet and Little Friarbird (Tables 19-21).

Table 19 – Six species accounted for the first 30% of the dissimilarity of riparian habitat.

Species	% Contribution	
	Individual	Cumulative
Carlia complex A *Carlia complex A*	8.04	8.04
White-throated Honeyeater *Melithreptus albogularis*	6.21	14.25
Rainbow Lorikeet *Trichoglossus haematodus*	6.12	20.37
Little Friarbird	4.43	24.80

Philemon citreogularis		
Laughing Kookaburra		
Dacelo leachii	3.78	28.58
Honeyeater complex A		
Meliphagia complex A	3.63	32.21

Table 20 – Five species accounted for the first 30% of the dissimilarity of ecotone habitat.

Species	% Contribution	
	Individual	Cumulative
Rainbow Lorikeet		
Trichoglossus haematodus	7.06	7.06
White-throated Honeyeater		
Melithreptus albogularis	7.04	14.1
Little Friarbird		
Philemon citreogularis	6.28	20.38
Lemon-bellied Flycatcher		
Microeca flavigaster	6.1	26.48
Sulphur-crested Cockatoo		
Cacatua galerita	5.43	31.91

Table 21 – Seven species accounted for the first 30% of the dissimilarity of woodland habitat.

Species	% Contribution	
	Individual	Cumulative
Rainbow Lorikeet		
Trichoglossus haematodus	7.19	7.19
White-throated Honeyeater		
Melithreptus albogularis	7.16	14.35
Little Friarbird		
Philemon citreogularis	6.97	21.32
Pelagic Cecko		
Nactus pelagicus	5.78	27.11
White-bellied Cuckoo-shrike		
Coracina papuensis	5.58	32.69

Across all combinations of habitat preference the proportion by class of fauna among riparian, ecotone and woodland habitat was not significantly different (Likelihood Ratio: χ^2=17.532, P = 0.4869).

The skink *Carlia munda* remains to be found in any swamp, creek, dune or vine thicket habitat (Cameron and Cogger 1992), and was not recorded in this survey.

Five of the thirteen species which Winter (1989) reported as being locally rare and restricted to woodland were observed in this survey (Table 22).

Table 22 - Species considered by Winter (1989) to be locally rare and restricted to woodland habitat, and the number of observations of these made in this survey.

Species	Habitat Observations
Eastern Snapping-Frog *Cyclorana maculosa*	One in woodland
Excitable Delma *Delma tincta*	Two, one each in woodland and ecotone
Claw-snouted Blind Snake *Ramphotyphlops ungirostris*	not observed
Orange-naped Snake *Furina ornata*	not observed
Prickly Knob-tailed Gecko *Nephrus asper*	not observed
Frilled Lizard *Chlamydosaurus kingii*	not observed
Black-headed Python *Aspidites melanocephalus*	not observed
Northern Death Adder *Acanthophis praelongus*	not observed
White-throated Gerygone *Gerygone levigaster*	not observed
Cicadabird *Coracina tenuirostris*	Six, one each in riparian and woodland and four in ecotone
Red-browed Pardalote *Pardalotus rubricatus*	not observed
Yellow-eyed Cuckoo-Shrike *Coracina lineata*	not observed
Pale Field-rat *Rattus tunneyi*	not observed

Summary

The results of the comparison of the terrestrial vertebrates of woodland, ecotone and riparian habitats was the finding that the common Bynoe’s Gecko *Heteronotia binoei* was the only terrestrial vertebrate observed exclusively and in significant abundance within woodland habitats, while a further nine were observed significantly frequently in it. At least four species were observed exclusively in riparian habitats, with a further fourteen species observed significantly frequently in it.

Although significantly less abundant, the terrestrial fauna of woodland habitat was as equally diverse and unique in its composition as that of riparian habitats. About one-third of the terrestrial vertebrate fauna was observed to have a significant difference in abundance between habitats. Ecotone habitats were intermediate in many respects.

3.3 Creek, Swamp and Marine habitats

A total of one hundred and fifteen terrestrial vertebrates were observed in creek, swamp and marine riparian habitats, and of these the most commonly observed species were birds (N=74), followed in turn by the reptiles (N=19), frogs (N=14) and mammals (N=8). The number of observations of each of these species in creek, swamp and marine riparian habitats is tabulated and summarised in Appendix G.

Diversity

Basic species diversity measures of the fauna of creek, swamp and marine riparian habitats show some differences, including a lower alpha diversity measure for creeks (Table 23).

Table 23 – Species diversity of creek, swamp and marine riparian habitats.

		Diversity measure		
	Sites	alpha	beta	gamma
Creek	12	33.9	2.92	99
Swamp	8	39.3	2.57	101
Marine	8	41.5	2.77	115

A species-area plot of the cumulative number of species observed with each new site appears not to have reached a plateau, which suggests that not all of the fauna of riparian habitats has been sampled (Figure 30).

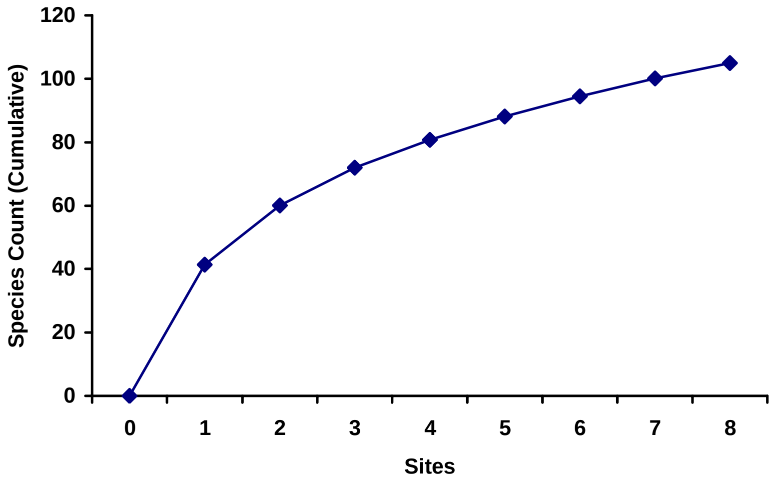


Figure 30 - Cumulative species-richness curve for all terrestrial vertebrate species observed from all creek, swamp and marine riparian sites, indicating that for comparative purposes an adequate proportion of the fauna was sampled.

Swamp habitats were the most speciose (N=74 for all swamp sites), with five more species than marine habitats and eight more species than creek habitats (Figure 31), although these differences were not significant (Pearson test: $\chi^2 = 2.0$, $P = 0.368$).

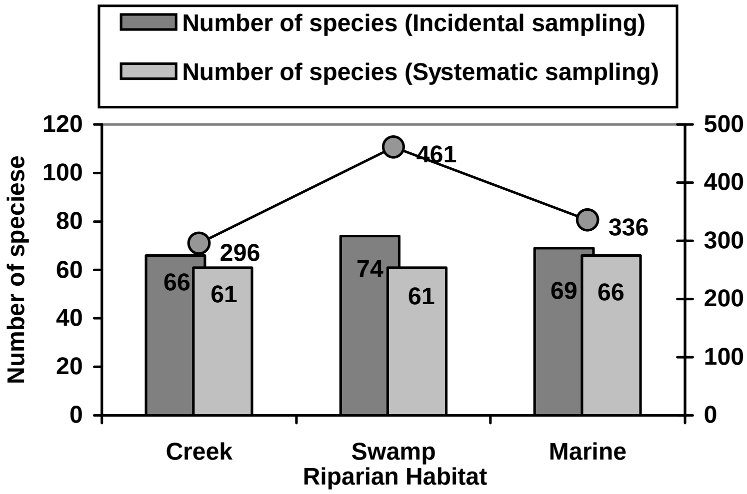


Figure 31 - Comparison of the richness and abundance (corrected for sampling effort) of the terrestrial vertebrate fauna of creek, swamp and marine riparian habitats.

After factoring for differences in the sampling effort (3:3:2 creek:swamp:marine) significantly more individuals were observed in swamps compared to either creek or marine habitats.

The two most speciose sites (with 56 species) were located in marine habitat (Figure 32) but there was no significant difference in the means (ANOVA: F = 2.077, P = 0.220) or variance (O'Brien's test: F=1.959, P = 0.141) of site richness among creek, swamp or marine riparian sites. These results are qualified with the caution that there were too few replicates to give the comparison much power.

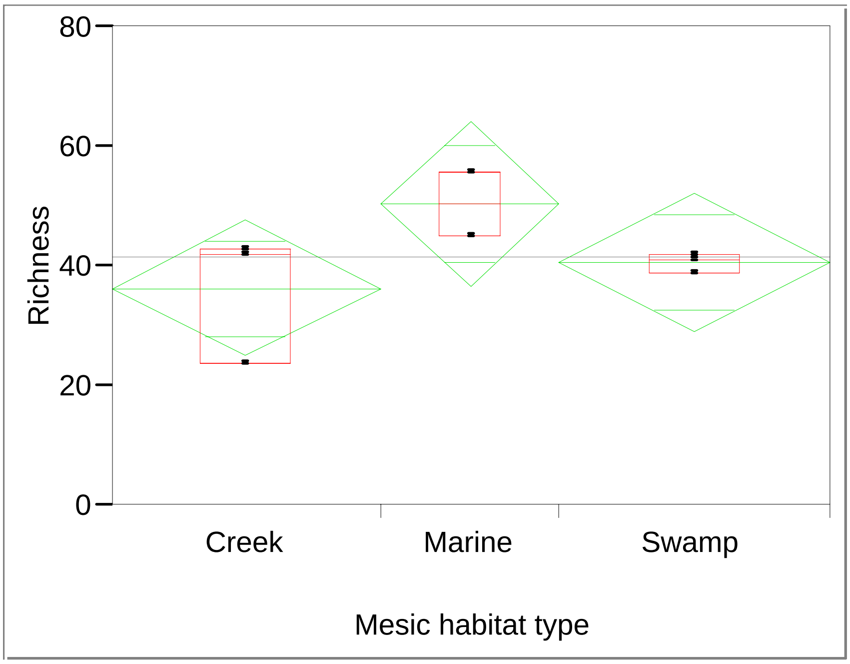


Figure 32 - Comparison of the richness of terrestrial vertebrates of sites from creek, swamp and marine riparian habitats.

While most frog species were observed within all three types of riparian habitat, there were a significant number of bird species that were observed exclusively within swamp habitats (Figure 33).

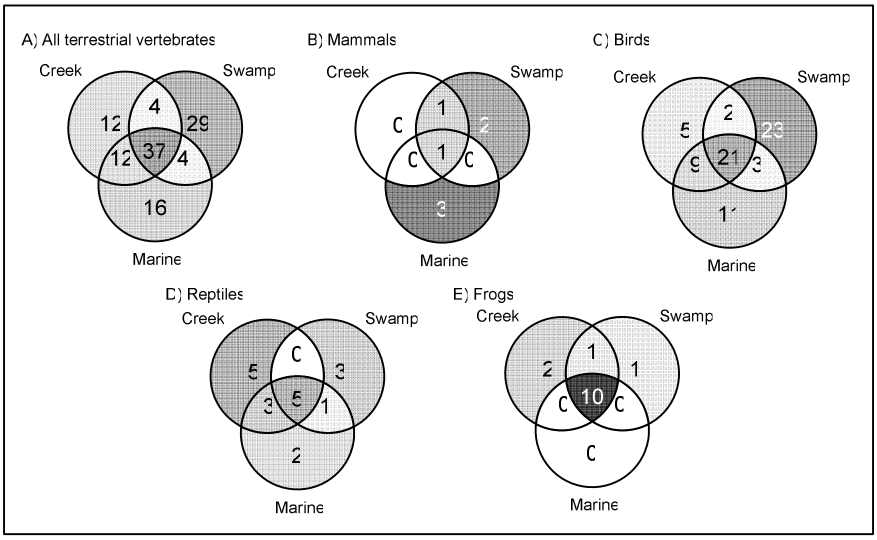
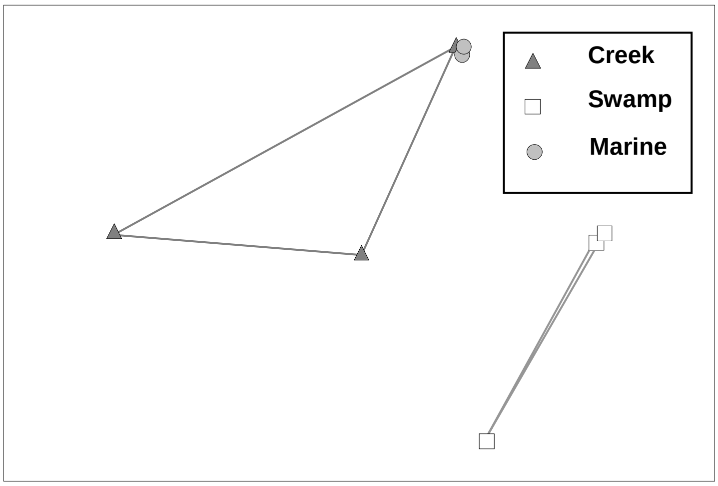


Figure 33 - Absolute count and proportion (indicated by intensity of grey shading) of unique and shared terrestrial vertebrates across creek, swamp and marine riparian habitats, showing that each class has a distinct pattern of beta diversity.

Similarity

The fauna of swamp habitats was clearly distinguishable from either creek or marine habitats, however the survey design did not allow for a third marine site to inform the analysis (Figure 34).



Minimum stress of 0.01

Figure 34 - Ordination (NMS) of creek, swamp and marine riparian habitat sites shows a distinguishable difference in the fauna composition of swamps, and

suggests some similarity in the fauna composition of creek and marine riparian habitats.

The resampling procedure on presence/absence, log(N+1) and raw abundance data indicated that there was a significant overall difference in the composition of the faunas of creek, swamp and marine riparian habitats. This significant overall difference was most apparent in the birds and reptiles and although weak it was driven mostly by the difference of swamps to either creek or marine habitats.

Taxa	Test of Difference		
	Presence/ Absence	**Ln(N+1) Abundance**	**Raw Abundance**
All observed vertebrates			
Creek vs Swamp vs Marine	0.021*	0.045*	0.016**
Creek vs Marine	0.310	0.483	0.297
Creek vs Swamp	0.088	0.096	0.102
Swamp vs Marine	0.094	0.105	0.100
Mammals			
Creek vs Swamp vs Marine	1	0.141	0.138
Creek vs Marine	1	0.302	0.336
Creek vs Swamp	1	0.315	0.339
Swamp vs Marine	1	0.666	0.663
Birds			
Creek vs Swamp vs Marine	0.005**	0.044*	0.055
Creek vs Marine	0.124	0.303	0.324
Creek vs Swamp	0.103	0.084	0.099
Swamp vs Marine	0.090	0.081	0.103
Reptiles			
Creek vs Swamp vs Marine	0.081	0.045*	0.024*
Creek vs Marine	1	0.898	0.598
Creek vs Swamp	0.09	0.097	0.097
Swamp vs Marine	0.105	0.100	0.078
Frogs			
Creek vs Swamp vs Marine	0.414	0.352	0.348
Creek vs Marine	0.194	0.399	0.598
Creek vs Swamp	0.492	0.317	0.287
Swamp vs Marine	0.900	0.497	0.700

*** P<0.001, ** P <0.01, * P<0.05 and ^{ns} P>0.05

Table 24 – Results of resampling procedure for comparisons of composition of observed terrestrial vertebrates in creek, swamp and marine riparian habitats.

Figure 35 shows that the proportional richness of the fauna by vertebrate class among creek, swamp or marine riparian habitats was not significantly different (Likelihood Ratio: χ^2=2.767, P = 0.838).

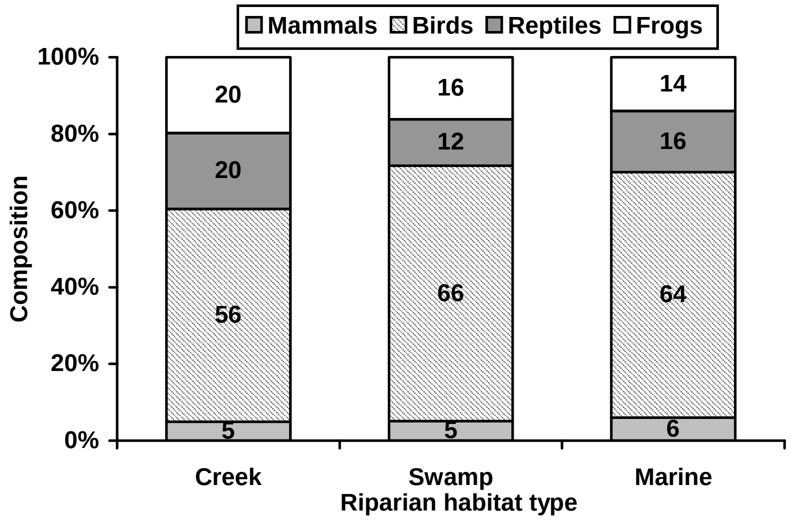


Figure 35 – Differences in the proportional composition by class of terrestrial vertebrate species richness of creek, swamp and marine riparian habitats were not significant.

Pairwise comparisons of species abundances between the riparian habitats showed that these were poorly correlated (r = 0.459, r = 0.606, r = 0.456; Figure 36).

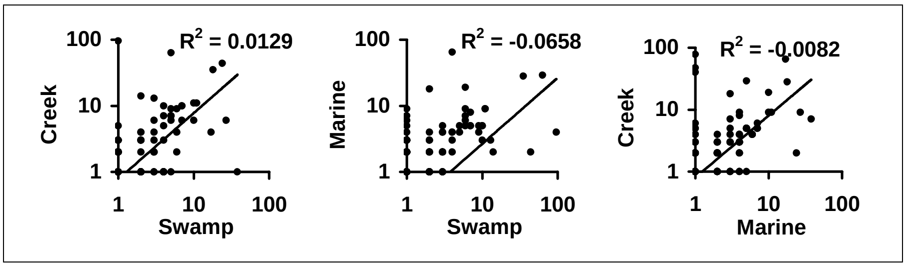


Figure 36 - Scatterplot matrix of the sum of individuals of each observed terrestrial vertebrate, from creek, swamp and marine riparian habitat sites.

The site with the greatest number of individuals was in swamp habitat, however the difference in mean number of individuals at sites among creek, swamp and marine riparian habitats was not significant, although this conclusion should be qualified with the caution that there were too few replicates to give the comparison much power (Figure 37; ANOVA F = 0.3977, P = 0.6914). The variance in site abundance among creek, swamp and marine riparian habitats was also not significant (O'Brien's test; F = 0.477, P = 0.528)

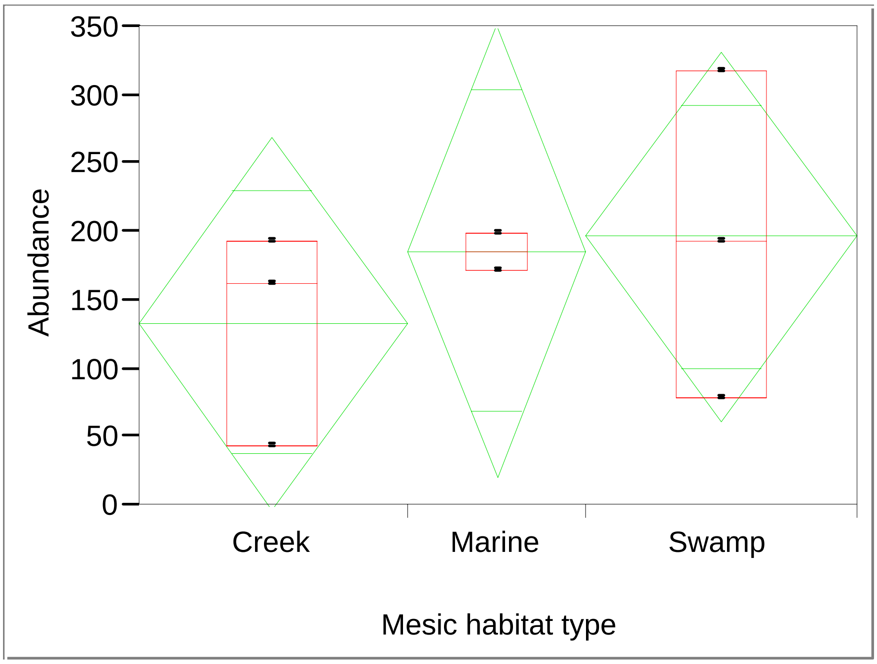


Figure 37 - Comparison of the sums of abundances of terrestrial vertebrate species from creek, swamp and marine riparian habitat sites.

The relative proportion by class of the sum of number of individuals among creek, swamp and marine riparian habitats was not significantly different (Likelihood Ratio; χ^2 = 1.961, P = 0.923).

Species-specific

Using systematic methods enabled analysis of the species specific differences in incidence for ninety-nine (86%) of all observed terrestrial vertebrates in creek, swamp and marine riparian habitats. Of these, and after factoring for unequal sampling, seventeen (17%) (mostly reptiles and frogs) were found to have a significant preference for one of the three riparian habitat types surveyed (Table 25).

Table 25 - Number of species used in comparison of creek, swamp and marine riparian habitat sites and with a significant habitat preference.

Observation Type	Mammals	Birds	Reptiles	Frogs	**Total**
Systematic and incidental	8	74	19	14	**115**
Systematic only	4	66	16	13	**99**
Significant habitat preference	1	2	7	7	**17**

Almost half of all observed species in riparian habitats were exclusive to a single type of riparian habitat, most of which were birds, while eighteen species were shared between two habitats and thirty-seven species were found in all three of the riparian habitats (Table 26; Appendix G).

Table 26 - Number of species by class which were observed (significantly) for each permutation of habitat preference among creek, swamp and marine habitat sites.

Habitat Preference	Class				Total
	Mammals	Birds	Reptiles	Frogs	
Shared - All riparian habitats	1	21(6)	5(4)	10(7)	37(17)
Exclusive - Creek	-	6	6	2	14
Exclusive - Swamp	1	17(1)	3	2	23(1)
Exclusive - Marine	3	12(1)	2	-	17(1)
Shared - Creek-Marine	-	8(3)	3(2)	-	11(5)
Shared - Swamp-Creek	1	2	-	-	3
Shared - Swamp-Marine	-	3	1	-	4
Grand Total	6	69(11)	20(6)	14(7)	109(24)

From the results of the comparison among woodland, ecotone and riparian habitats, only eighteen (17%) of the fifty-four species observed exclusively within one of the riparian habitat types were not otherwise observed in ecotone or woodland habitats. Of the eighteen species which were totally exclusively observed from one type of riparian habitat, only the Tawny-breasted Honeyeater *Xanthotis chrysotis* was observed frequently enough (four times) to determine that it had a significant and exclusive preference for marine riparian habitats.

Using the results of the comparison among woodland, ecotone and riparian habitats again, of the fifteen species which had a significant preference for riparian habitats all except the skink *Glaphyromorphus nigricaudis* occurred in all three types of riparian habitats.

The skink *Glaphyromorphus nigricaudis* was observed fifty-five times in riparian habitats, four times in ecotone habitats and yet not once in woodland habitat. Of the riparian habitat observations forty-nine were in creek habitat, seven in marine habitat and yet there was not one in a swamp habitat. This pattern of observations could have suggested that the skink *Glaphyromorphus nigricaudis* was specifically reliant on the continuity of creekline remnants for the viability of its population, except that Cameron and Cogger (1992) had already observed it in woodland and swamp habitats.

The results of this survey were unable to demonstrate the presence of the Jewel Skink *Carlia jarnoldae* and the Zigzag Gecko *Oedura rhombifer* in swamp habitats, strengthening Cameron and Cogger's (1992) earlier findings.

Of the species which significantly preferred riparian habitats and occurred in all three types of riparian habitat, significant habitat preferences were detected for:

• marine habitat in two species.

the skink *Carlia longipes* and
the Ornate Burrowing Frog *Limnodynastes ornatus*,

• creek habitat in one species,

the skink *Carlia storri*, and

• swamp habitat in five species (all frogs),

the Torres Gungan frog *Uperoleia mimula*,
the Torrid Froglet *Crinia remota*,
the Northern Sedgefrog *Litoria bicolor*,
the Striped Rocketfrog *Litoria nasuta*,
the Shrill Chirper *Sphenophryne gracilipes* and
the Cane Toad *Bufo marinus*.

If the species which were exclusive to a habitat are clumped with species which are shared between it and another, and species which are ubiquitous but which have a significant preference for the habitat, then there are two species significantly associated with creek habitats, two species significantly associated with marine habitats and six species associated with swamp habitats.

The indication to use reptiles instead of birds as common faunal habitat indicators to discriminate between creek, swamp and marine riparian habitats at Weipa is illustrated by the result that, of those species which primarily provide the first 30% of the species richness and abundance information, most are reptiles (Tables 27-29).

Table 27 – Five species accounted for the first 30% of the dissimilarity of riparian creek habitat.

Species	% Contribution	
	Individual	Cumulative
Glaphyomorphus nigricaudus *Glaphyomorphus nigricaudus*	7.77	7.77
Carlia complex A *Carlia complex A*	7.53	15.30
White-throated Honeyeater *Melithreptus albogularis*	7.19	22.48
Carlia longipes *Carlia longipes*	7.13	29.61
Rainbow Lorikeet *Trichoglossus haematodus*	6.48	36.09

Table 28 – Five species accounted for the first 30% of the dissimilarity of riparian swamp habitat.

Species	% Contribution	
	Individual	Cumulative
Carlia complex A		
Carlia complex A	8.59	8.59
Cane Toad		
Bufo marinus	7.67	16.26
Northern Sedgefrog		
Litoria bicolor	6.33	22.59
Torrid froglet		
Crinia remota	5.31	27.90
Rainbow Lorikeet		
Trichoglossus haematodus	5.09	32.99

Table 29 – Five species accounted for the first 30% of the dissimilarity of riparian marine habitat.

Species	% Contribution	
	Individual	Cumulative
Carlia longipes		
Carlia longipes	10.14	10.14
Grassland Melomys		
Melomys burtonis	6.60	16.73
Carlia complex A		
Carlia complex A	6.44	23.18
Cane Toad		
Bufo marinus	5.95	29.12
Two-lined Dragon		
Diporiphora bilineata	4.48	33.60

The finding in this survey that the skink *Carlia storri* so strongly preferred the gallery forests of the creeks during this survey is notable, given that a prior survey had found it in most other habitats except gallery forests (Cameron and Cogger 1992).

Summary

The principle result of this aspect of the study is that while the observed terrestrial vertebrate fauna of creek, swamp and marine habitats within the study area were not significantly different in species richness, they were significantly different in their abundance and composition.

In summary, it was found that differences in species richness among creek, swamp and marine riparian habitats were not significant; however swamps had significantly more individuals than creek or marine habitats. On the basis of this survey one species (the Ornate Burrowing Frog *Limnodynastes ornatus*) was found to have an exclusive preference for marine riparian habitat, while a further nine species had a significant preference for one of creek, swamp or marine riparian habitats.

3.4 Andoom and Weipa regions

Comparisons and tests in this chapter were done without riparian sites because of an imbalance in the design (see the section '2.2 Survey design' on page 51 for more details).

Diversity

A total of one-hundred and forty-nine species were systematically observed in the Andoom and Weipa regions, of which eight had a significant regional preference (Appendix H, Table 30).

Basic species diversity measures show virtually no difference between the fauna of woodland habitats above economic and uneconomic ore (Table 30).

Table 30 - Species diversity of the woodland habitats of the Andoom and Weipa regions.

		Diversity measure		
	Sites	alpha	beta	gamma
Andoom	8	31.4	2.6	81
Weipa	6	37.2	2.2	80

A species-area plot of the cumulative number of species observed indicates that a substantial and adequate proportion of the total fauna for the habitat was sampled (Figure 38).

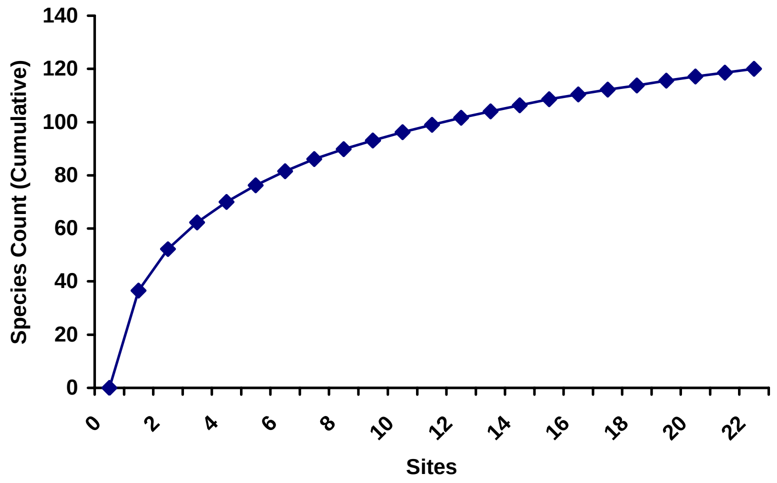


Figure 38 - Cumulative species-richness curve for all terrestrial vertebrate species observed from non-riparian sites, indicating that for comparative purposes an adequate proportion of the fauna was sampled.

Whether incidentally or systematically sampled, virtually the same number of species and individuals were observed in *E. tetrodonta* woodland habitat of the Andoom and Weipa regions (Figure 39).

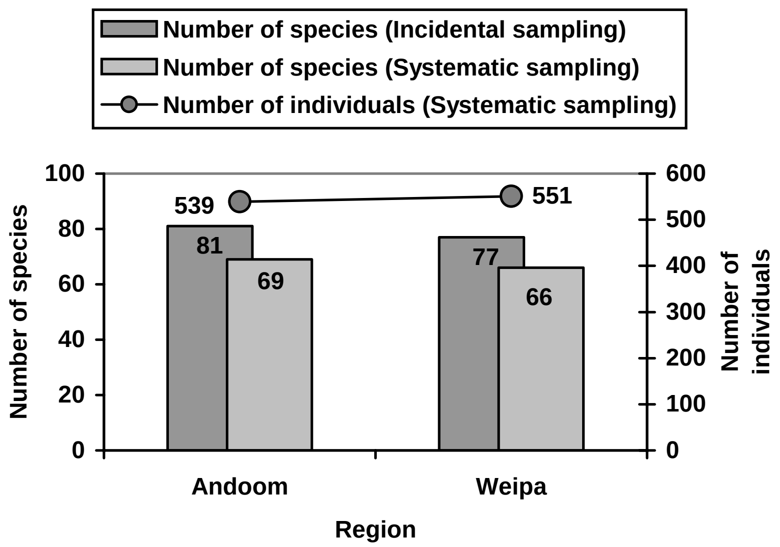


Figure 39 – The species richness and abundance of the terrestrial vertebrate fauna of combined ecotone and woodland habitat sites of the Andoom and Weipa regions.

Similarity

No significant difference in the composition or abundance of the terrestrial vertebrate fauna, either as a whole or by class was suggested by the results of resampling the Sum of squared Euclidean Distance (SSED) statistic for species presence/absence, ln(N + 1) and raw abundance data for woodland habitat sites in Andoom and Weipa (Table 31).

Taxa	**Probability of significant SSED statistic**		
	Presence/ Absence	**Ln(N+1) Abundance**	**Raw Abundance**
All	0.418	0.499	0.549
Mammals	0.807	0.691	0.596
Birds	0.482	0.534	0.593
Reptiles	0.208	0.225	0.258
Frogs	0.705	0.656	0.647

*** P<0.001, ** P <0.01, * P<0.05 and ^{ns} P>0.05

Table 31 – Results of resampling procedure for comparisons of composition of observed terrestrial vertebrates in woodland habitats from Andoom and Weipa regions show no significant differences at any level of analysis.

The similarity between regions can also be seen in the degree of overlap between the Andoom and Weipa groups of sites in an MDS plot (Figure 40).

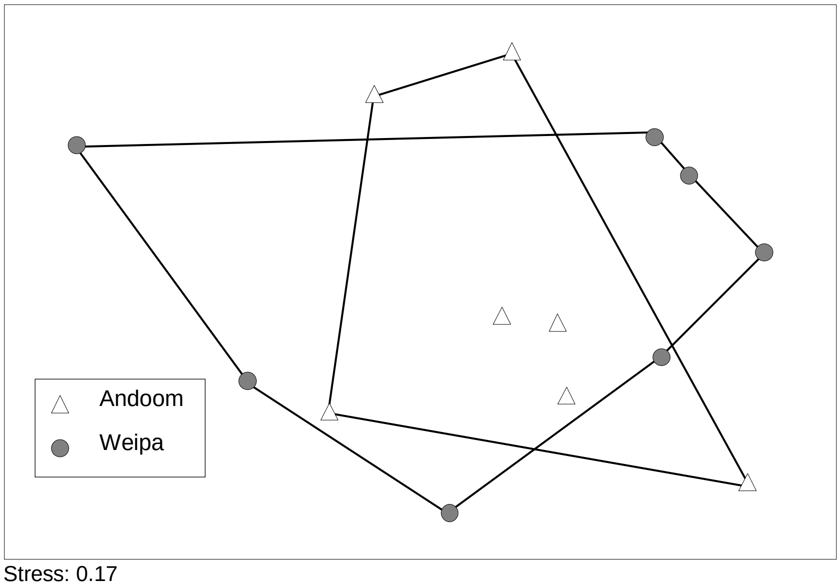


Figure 40 – Ordination (NMS) of woodland habitat sites of the Andoom and Weipa regions show no distinguishable difference in their fauna composition.

The richest site was located at Betteridge Landing in Andoom (AM102; Figure 41).

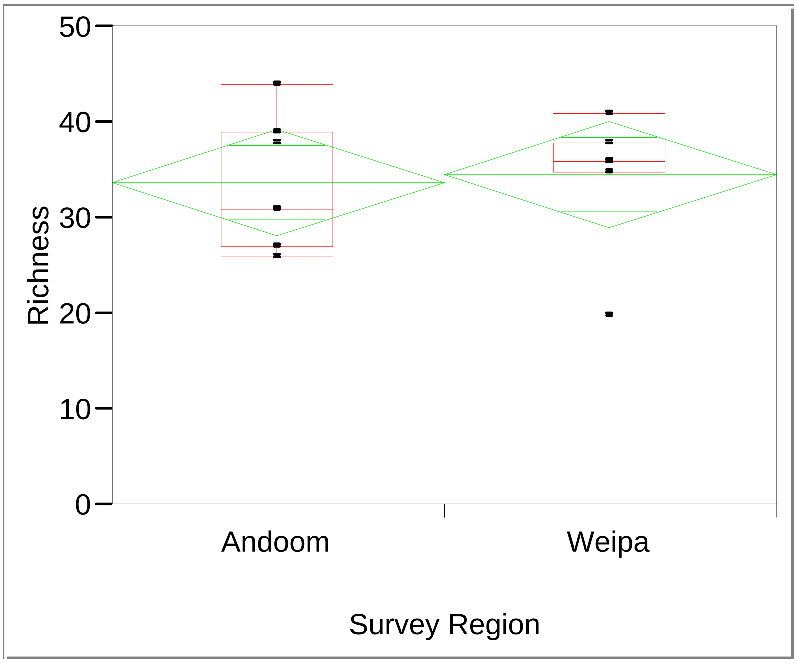


Figure 41 - Species richness of Andoom and Weipa woodland habitat sites.

There was no significant difference in the mean species richness of sites between the regions for woodland and ecotone sites only (t-test; t = 0.391, df = 20, P = 0.705), or for all sites (t-test; t = -0.515, df = 28, P = 0.611), site richness in the Andoom region was significantly more variable than Weipa (O'Brien's test; F=1.724, P = 0.204).

Differences in the proportional richness by class of the fauna of the Andoom and Weipa regions were not significant, whether riparian sites were included (Likelihood Ratio: χ^2=1.407, P = 0.704) or not (Likelihood Ratio: χ^2=0.661, P = 0.882).

Using species abundance counts, the resampling procedure indicated that while there was a significant difference in species compositions between regions when all habitat sites are used (E = 2547.173; P = 0.045), the difference was not significant if all except riparian habitat sites were used (E = 1614.255; P = 0.088).

Figure 42 shows the correlation in species abundance between regions for ecotone and woodland habitat sites (r = 0.909).

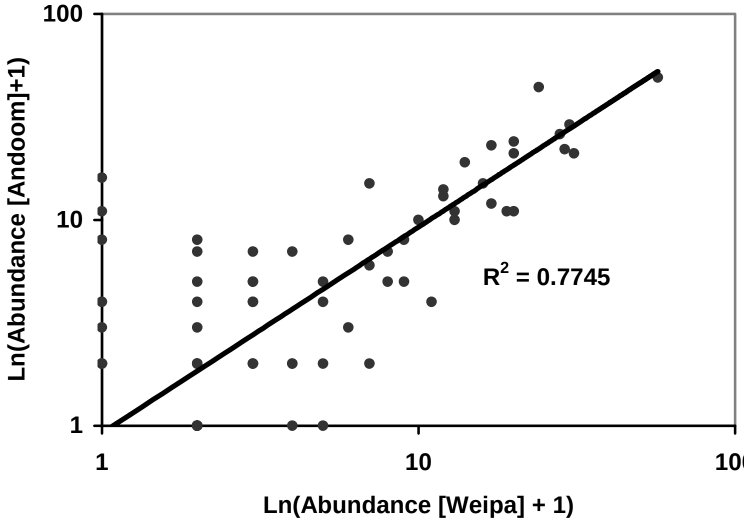


Figure 42 - Scatterplots of the sum of individuals of each species, from the combined woodland habitat sites of the Andoom and Weipa regions.

The largest number of individuals recorded using only systematic sampling techniques was in the Andoom region in an ecotone habitat site (AM102) located at Betteridge Landing (Figure 43).

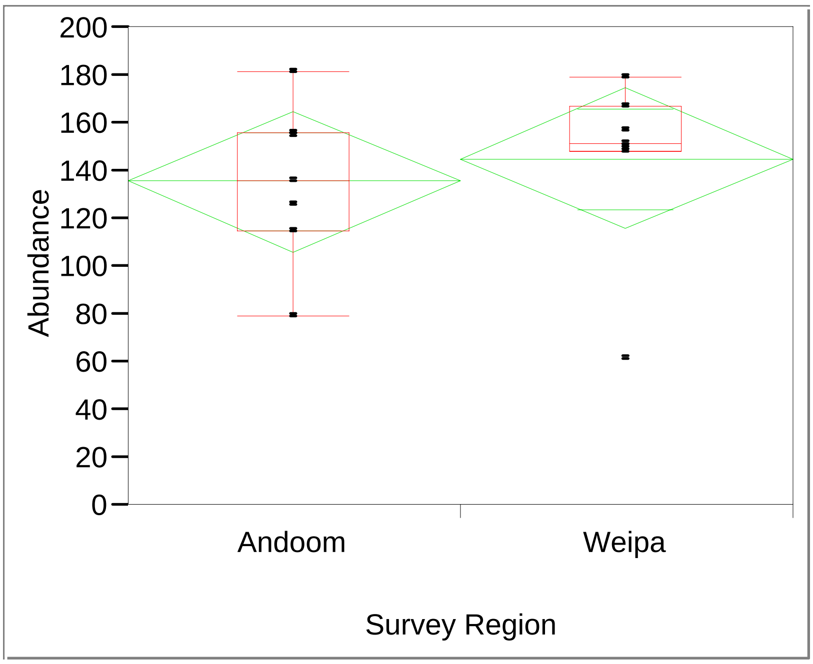


Figure 43 - Species abundances of Andoom and Weipa woodland habitat sites.

Neither the variance (O'Brien's test; F=2.421, P = 0.131) nor the means (t-test; t = -0.126, df = 20, P = 0.901) of the sum of individuals were significantly different between the Andoom and Weipa regions when riparian habitat sites were included, nor was there any significant difference in the variance (O'Brien's test; F=1.275, P = 0.272) or means of the sum of individuals (t-test; t = 0.237, df = 28, P = 0.816) when riparian habitat sites were excluded.

Differences in the proportional richness by class of the fauna of the sum of number of individuals between Andoom and Weipa regions were not significant, whether riparian sites were included (Likelihood Ratio: χ^2=0.596, P = 0.897) or not (Likelihood Ratio: χ^2=0.948, P = 0.814).

A comparison of the total annual rainfall between the Andoom mine office and the regeneration nursery at Weipa from 1975 to 1987, strongly suggests that the rainfall between these regions was different (Kendall's coefficient of rank correlation: τ = 0.515, P = 0.020), with Andoom receiving more rain each year than Weipa.

Species-specific observations

Of the one hundred and forty-seven taxa systematically observed in either the Andoom and Weipa regions, ninety-three occurred in both regions, fifty-four were exclusive to either Andoom or Weipa, but only eight species sufficiently frequently observed to compare their preferences (Appendix H, Table 32).

Table 32 - Number of species observed (significantly) between the Andoom and Weipa regions.

Habitat Preference	Class				Total
	Mammals	Birds	Reptiles	Frogs	
Shared - Both regions	5	56(2)	20(2)	12(4)	93(8)
Exclusive - Andoom	4	26	7	1	38
Exclusive - Weipa	1	7	4	4	16

Grand Total	10	89(2)	31(2)	17(4)	147(8)

While none of the species which were observed in only one region were sufficiently frequently observed to diagnose a statistically significant difference in occurrence, of the eight species with a regional preference two preferred the Andoom region and six preferred the Weipa region (Table 33).

Table 33 - Species which had a significant difference in the number of individuals between the Andoom and Weipa regions.

Species	Count of individuals	
	Andoom	Weipa
Torrid Froglet *Crinia remota*	102	8
Cane Toad *Bufo marinus*	117	14
Peaceful Dove *Geopilia striata*	11	66
Varied Triller *Lalage leucomela*	5	33
Carlia longipes	46	122
Glaphyromorphus nigricaudis	2	45
Limnodynastes ornatus	3	39
Uperoleia mimula	40	84

Six of the eight species with a significant difference in the number of individuals between regions also had a significant preference for the particular type of riparian habitat that was most abundant in the region. The two species with a significantly higher abundance in the Andoom region also had a significant preference for swamp habitats, yet of the six species with a significantly higher abundance in the Weipa region the only species with a preference for creeks was the skink *Glaphyromorphus nigricaudis*.

In summary, there were no significant differences in the species richness, diversity or composition between the Andoom and Weipa regions.

3.5 Seasonal habitat observations

Two aspects of seasonal habitat observations were explored; differences among visits (subsequently treated as differences among seasons), and differences among riparian, ecotone and woodland habitats among seasons.

Based on systematic observations only, thirty (one mammal, thirteen birds, nine reptiles and seven frogs) of the one hundred and forty-six observed species had a significant seasonal difference in the number of times they were observed (Appendix I).

There was no significant difference in the relative richness of all observed vertebrate taxa between survey visits (Likelihood Ratio: χ^2=3.229, P = 0.994), neither were there any significant differences in species richness by class between survey visits (Appendix I: Figure 44).

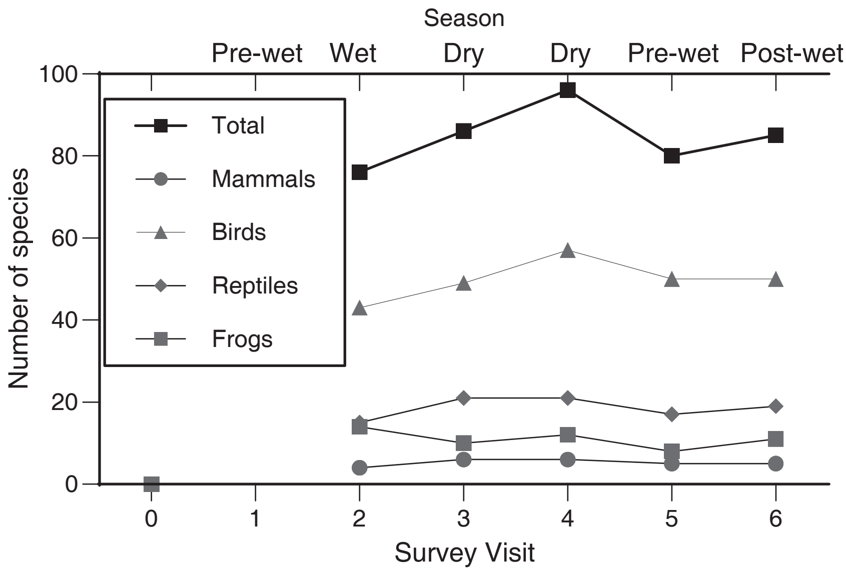


Figure 44 - The species richness of the observed fauna for each survey visit (with season).

Over the life of the survey there is a suggestion in the data (Figure 38) of a peak in abundance during the dry season visits, driven mostly by an increase in the observable diversity of birds.

Possible patterns of seasonality among the thirty species with a significant difference in systematically observed abundance include;

• a single wet-season peak

- The Grassland Melomys *Melomys burtoni* (this particular result was confounded with the effect of having changed the trap bait)
- Shrill Chirper *Sphenophryne gracilipes*

• a single dry-season peak

- The Peaceful Dove *Geopelia striata*
- Blue-winged Kookaburra *Dacelo leachii*
- Leaden Flycatcher *Myiagra rubecula*
- Torresian Crow *Corvus orru*
- Pelagic Gecko *Nactus pelagicus*
- Zigzag Gecko *Oedura rhombifer*
- A skink *Carlia longipes* (after a post-wet low)
- Jewel Skink *Carlia jarnoldae* (although indeterminate due to absence of records in middle dry)
- A skink *Glaphyromorphus nigricaudis*
- Striped Rocketfrog *Litoria nasuta*

• a pre-wet dip (or post-wet to dry peak)

- The Bar-shouldered Dove *Geopelia humeralis*
- Sulpher-creasted Cockatoo *Cacatua galerita*

- Red-winged Parrot *Aprosmictus erythropterus*
- Rainbow Bee-eater *Merops ornatus*
- Little Friarbird *Philemon citreogularis*
- Noisy Friarbird *Philemon corniculatus*
- White-throated Honeyeater *Melithreptus albogularis*
- Lemon-bellied Flycatcher *Microeca flavigaster*
- Grey Shrike-thrush *Colluricincla harmonica*
- Torrid Froglet *Crinia remota*
- Northern Sedgefrog *Litoria bicolor*

• a post-wet dip (or dry to pre-wet peak)

- Fence Skink *Cryptoblepharus virgatus*

• a bimodal (wet and dry) peak

- Tommy Roundhead *Diporiphora sp. A*
- A skink *Carlia storri*
- A skink *Ctenotus spaldingi*
- Ornate Burrowing frog *Limnodynastes ornatus*
- Torress Gungan frog *Uperoleia mimula*

• a post-wet peak

- Cane Toad *Bufo marinus*

• no difference

- Rainbow Lorikeet *Trichoglossus haematodus*
- Pheasant Coucal *Centropus phasianinus*
- Laughing Kookaburra *Dacelo novaeguineae*
- Forest Kingfisher *Todirhamphus macleayii*
- Yellow Honeyeater *Lichenostomus flavus*

- White-bellied Cuckoo-shrike *Coracina papuensis*
- Black-backed Butcherbird *Cracticus mentalis*

Species for which there was good evidence that they disperse as a pulse from their preferred riparian habitats out into the woodlands during the wet season include the Peaceful Dove *Geopelia striata*, the skink *Glaphyromorphus nigricaudis*, the Torrid Froglet *Crinia remota*, and the Striped Rocketfrog *Litoria nasuta.* The evidence for the seasonal dispersion of the Striped Rocketfrog *Litoria nasuta* from riparian habitat into woodland habitat was based on incidental observations of these species trapped by uncapped boreholes. In contrast, some species appeared to expand into the woodland from their preferred riparian habitats during the dry, such as the Bar-shouldered Dove *Geopelia humeralis,* the Palm Cockatoo *Probosciger aterrimus* and the Ornate Burrowing Frog *Litoria ornatus*.

Species which appeared to expand their woodland preference into riparian habitats during the dry include the Red-winged Parrot *Aprosmictus erythropterus*, the Brown Treecreeper *Climacteris picumnus* and the Zigzag Gecko *Oedura rhombifer*.

3.6 Microhabitat factors

Exploratory data analysis of the eleven microhabitat factors recorded from the sites suggested that none were strongly correlated with the pattern of distribution and abundance of observed terrestrial vertebrates.

3.7 Species-specific accounts

The survey recorded a total of one-hundred and ninety-five terrestrial vertebrates, which consisted of fourteen mammals, one hundred and thirty-two birds, thirty-two reptiles and seventeen frogs (Appendix C).

One mammal was incidentally and newly collected from the region - Australia’s largest rodent, the Black-footed Tree Rat *Mesembriomys gouldii*.

Species distribution maps of selected mammal, bird, frog and reptile species have been overlaid on the observations of Winter and Atherton (1985) and mapped on a 5’ grid over the mine lease (Appendix D).

Mammals

Fourteen of the forty-one known mammals from the study area were recorded, including the introduced cow, horse and cat. An incidental record based on a roadkill specimen confirmed the presence of the Black-footed Tree Rat *Mesembriomys gouldii*. (Field No 55, Appendix J), which was not previously recorded from the Weipa region. Systematic surveys observed seven mammals, of which only one was sufficiently frequently observed to estimate differences in abundance (Appendix C).

No endangered, vulnerable or rare mammal as listed under either Commonwealth or Queensland state legislation was recorded during this survey (Commonwealth of Australia 1992; Queensland Government 1992; Queensland Government 1994).

Some expected marsupials were not observed. For example, despite being recorded fifteen times and considered highly detectable and common by Winter and Atherton (1985), the Northern Quoll *Dasyurus hallacatus* was not recorded during this survey - a decline which may be linked to the demonstrable invasion and spread of the Cane Toad *Bufo marinus* (Burnett 1997).

Twenty-two sites had between one and four mammals recorded at them, however the only mammal that was observed frequently enough to reliably test for a habitat preference was the Grassland Melomys *Melomys burtoni* which was frequently trapped in the last visit (following seasonally heavy rains). The next most abundantly recorded mammal was the ubiquitous Northern Brown Bandicoot *Isoodon macrourus*.

Using any precision of abundance, the resampling procedure indicated that differences in mammal fauna composition were significant between woodland, ecotone and riparian habitats, but not between economic and uneconomic woodland, between creek, swamp and marine riparian habitats, or between the Andoom and Weipa regions.

Five mammal specimens were lodged with the Queensland Museum (Appendix J).

Birds

This survey incidentally and systematically recorded one hundred and thirty-two species of birds from Weipa, with most of the unobserved but previously recorded species either waterbirds or vagrants (Appendix C).

Significant observations include records of the rare Square-tailed Kite *Lophoictinia isura,* Star Finch *Neochimia ruficauda* and Palm Cockatoo *Probosciger aterrimus* (Commonwealth of Australia 1992; Queensland Government 1992; Queensland Government 1994). Other birds which were observed and are of special concern include the Radjah Shelduck *Tadorna radjah* and the Black-breasted Buzzard *Hamirostra melanosternon* (Garnett 1992).

Between nine and forty-one bird species were observed for all sites, with most having fifteen to thirty (Figure 45).

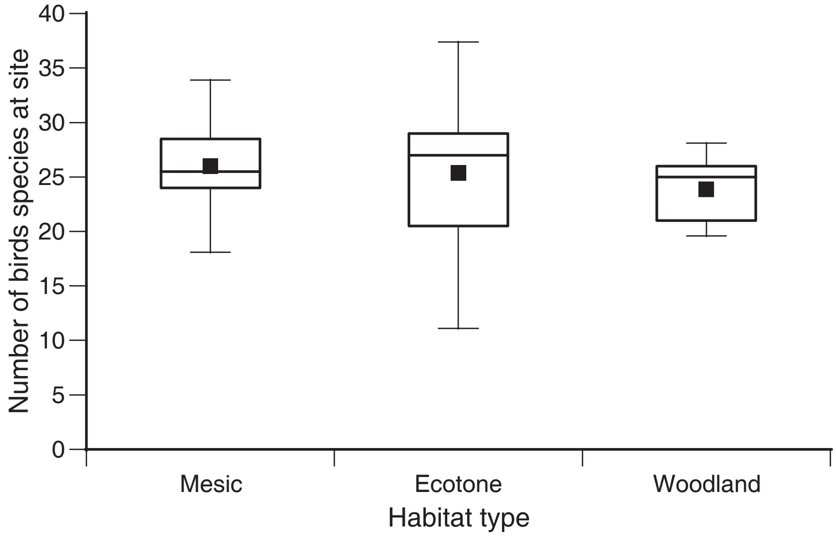


Figure 45 - The distribution and dispersion of the number of bird species at all survey sites.

Bird richness in ecotone habitat sites was no more variable (O'Brien's test; F = 1.455, *P* = 0.256) than in either riparian or woodland habitat sites, and there was no significant difference (ANOVA; F = 0.065, *P* = 0.937) in the mean number of bird species among woodland, ecotone and riparian habitat sites (Figure 39).

Using presence/absence species data for birds alone, the resampling procedure indicated that differences in avifauna composition were significant among woodland, ecotone and riparian habitats (E = 1170.464, *P* = 0.012) and creek, swamp and marine riparian habitats (E = 360.825; *P* = 0.013), but not between economic and economic woodland (E = 517.279, *P* = 0.714) or between the Andoom and Weipa regions (E = 1382.896, *P* = 0.467).

Using species abundance data for birds alone, the resampling procedure indicated that differences in bird fauna species compositions were significant between woodland, ecotone and riparian habitats (E = 746.440, *P* = 0.004), but not between economic and economic woodland (E = 448.481, *P* = 0.891), creek, swamp and marine riparian habitats (E = 233.148; *P* =

0.488), or between the Andoom and Weipa regions (E = 1478.048, *P* = 0.206).

No bird specimens were lodged with the Queensland Museum (Appendix J).

Reptiles

Thirty-two reptiles, none of which were new, were incidentally and systematically recorded in this survey - twenty-one through systematic surveying alone (Appendix C). This was about half of the sixty-three reptiles (excluding crocodiles, marine turtles and marine snakes) which are known to occur at Weipa (Cameron and Cogger 1992).

No endangered, vulnerable or rare reptile as listed under either Commonwealth or Queensland state legislation was recorded during this survey (Commonwealth of Australia 1992; Queensland Government 1992; Queensland Government 1994).

Significant observations include specimens supporting Cameron and Cogger’s (1992) predictions of the occurrence of *Varanus tristis* in the region. Cameron and Cogger (1992) diagnosed their specimens of the common woodland varanid as *V. timorensis*. However, based on the density and size of the supra-ocular scales (Cogger 1986) specimens and observations from this survey were diagnosed as *V. tristis* subsp. *orientalis* (Appendix J: Specimen No's 28 and 56).

One particular specimen was the shell of a turtle at Botchet Swamp. Turtles are scarce and were the subject of a traditional story told by Joyce Hall. The essence of the story is about how a young boy becomes a turtle after failing to heed the warnings of his parents about eating the poisonous red seeds of the Gidgee-Gidgee.

Reptiles still missing, or predicted but not confirmed as occurring on the mine lease, include the rare Knob-tailed Gecko *Nephrus asper* and the cryptic Frill-necked Lizard *Chlamydosaurus kingii*. (Cameron and Cogger 1992).

Between two and seventeen reptile species were observed in all sites, while most sites had seven reptiles (Figure 46).

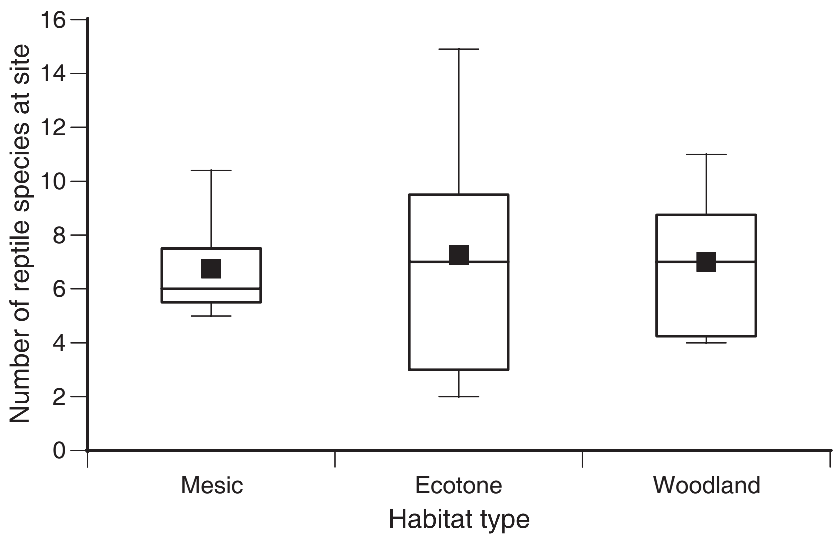


Figure 46 - The distribution and dispersion of the number of reptile species at all survey sites.

There was no significant difference in the variance (O'Brien's test; F = 1.455, P = 0.256) or mean number of observed reptile species (ANOVA; F = 0.065, P = 0.937) among woodland, ecotone or riparian habitat sites.

Using presence/absence species data for reptiles alone, the resampling procedure indicated that differences in reptile fauna composition were significant between woodland, ecotone and riparian habitats (E = 394.88, P = 0.003) and possibly significant among creek, swamp and marine riparian habitats (E = 103.587; P = 0.054), but not significant between economic and economic woodland (E = 250.143, P = 0.403), or between the Andoom and Weipa regions (E = 579.791, P = 0.155).

Using species abundance data for reptiles alone, the resampling procedure indicated that differences in reptile fauna species compositions were significant between woodland, ecotone and riparian habitats (E = 309.215, P = 0.002), and between creek, swamp and marine riparian habitats (E = 70.142; P = 0.007), but were not significant between economic and economic woodland (E = 188.124, P = 0.658), or between the Andoom and Weipa regions (E = 579.548, P = 0.127).

Species-specific differences were significant for Bynoe's Gekko *Heteronotia binoei* and the Two-lined Dragon *Diporiphora bilineata*.

H. binoei was observed exclusively within woodland habitat, six times in woodland above economic ore and once above uneconomic ore. The observed distribution was not exclusively correlated to the value of the orebody underlying the woodland habitat, and the preference can only be described as being weakly significant (p=0.047) due to its infrequent occurrence.

H. binoei is virtually identical in appearance and size to *Nactus pelagicus*, and the two species have previously been found co-occurring under the same rock (Cameron and Cogger 1992). Whilst uncommon *H. binoei* occurs throughout the Australian continent, and is sympatric with *N. pelagicus*. In contrast, *Nactus pelagicus* is common within its more restricted range, which is principally the east coast of Cape York Peninsula, down to Townsville (Ingram and Raven 1991). Neither *H. binoei* or *N. pelagicus* have been recorded as using tree hollows (Gibbons and Lindenmayer 2002), and both have been recorded in regeneration habitats (Reeders and Morton 1983; Cameron and Cogger 1992). In a survey of forty offshore Arnhem Land islands *H. binoei* occurred on thirty-four, and showed no significant variation in abundance across the eight vegetation types that were sampled (Woinarski 1999).

Detailed treatments of *H. binoei* and *N. pelagicus* are given in Greer (1989). Neither species are specialist feeders on termites, although *H. binoei* has been observed licking man-made sugary liquids, and may consume sap or nectar. *H. binoei* reproduces parthenogenetically (ie without requiring males), which enables individual animals to colonize and rapidly repopulate disturbed habitats. Its presence on most small offshore Arnhem Land islands is good indicative evidence of its recolonizing capacity (Woinarski *et al.* 1999). Gekkos remain active in very high temperatures, and so are not specifically expected to be deleteriously affected by the direct effects of forecast climate change. *H. binoei* shelter by day in ground burrows, made mostly by other animals. Both *H. binoei* and *N. pelagicus* have less developed toe pads, and are generally considered terrestrial. This suggests that attributes of the topmost layers of the soil profile may be worth further investigation as a determining factor in the recolonization of regeneration habitats.

The results have provided reptile information that supplements Cameron and Cogger (1992), specifically:

- *Lophognathus temporalis* was seen frequently in urban habitat.
- *Egernia freri* was trapped in creek and woodland habitat.
- *Delma tincta* was recorded for the survey region
- *Lialis burtonis* was recorded in riparian, ecotone and woodland habitat.
- *Diporiphora spp.* occur in creek habitat
- *Carlia storri* does occur in creek habitat
- *Morethia taeniopleura* occurs in gallery forest habitats, and that some individuals may have a rich red chin.

- *Rhamphytyphlops spp.* occurs in woodland habitat
- *Rhinoplocephalus nigrostriatus* occurs in woodland habitat

One hundred and nine reptile specimens were lodged with the Queensland Museum (Appendix J), which found that juvenile *Carlia longipes* had been mis-identified as *Carlia jarnoldae*. My recollection is that for most of these individuals my diagnosis would have been based on the presence of dorso-lateral white flecks between the armpit and leg.

Frogs

Seventeen of the twenty frogs known from Weipa (Cameron and Cogger 1992) were incidentally and systematically observed, while twelve species were observed through systematic surveying alone (Appendix C). The introduced Cane Toad *Bufo marinus*. was the most frequently observed vertebrate during the survey.

No endangered, vulnerable or rare frog as listed under either Commonwealth or Queensland state legislation was recorded during this survey (Commonwealth of Australia 1992; Queensland Government 1992; Queensland Government 1994).

Between one and ten frogs were recorded from twenty-two sites, and the mean number of frog species at riparian sites was found to be significantly higher than either ecotone or woodland habitat sites (Figure 47; ANOVA: F = 12.024, P = 0.0004).

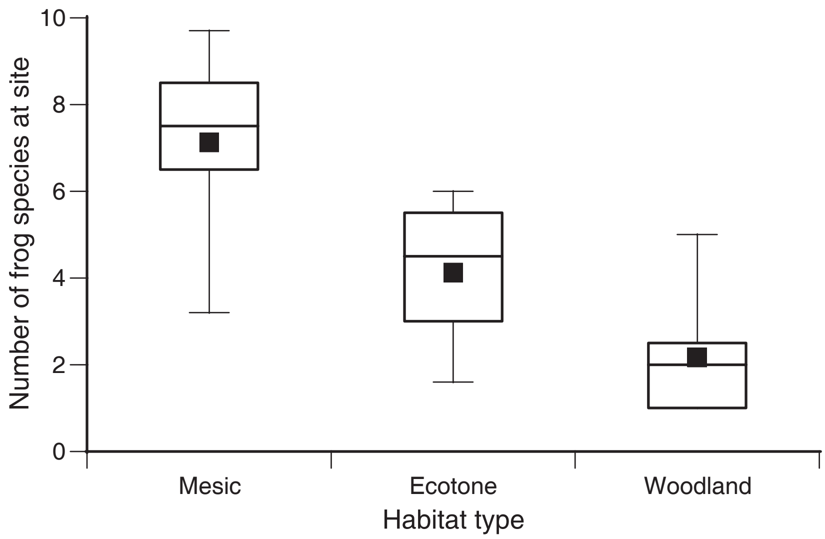


Figure 47 - Number of species of frogs at sites among riparian, ecotone and woodland habitat sites

Using presence/absence species data for frogs alone, the resampling procedure indicated that differences in frog fauna composition were significant between woodland, ecotone and riparian habitats (E = 221.711, *P* = 0.0005), and possibly between the Andoom and Weipa regions (E = 265.378, *P* = 0.056), but not between economic and economic woodland (E = 98.984, *P* = 0.550), or between creek, swamp and marine riparian habitats (E = 76.006; *P* = 0.272).

Using species abundance data for frogs alone, the resampling procedure indicated that differences in frog fauna species compositions were significant between woodland, ecotone and riparian habitats (E = 172.558, *P* = 0.009), but not between economic and economic woodland (E = 67.24, *P* = 0.689), creek, swamp and marine riparian habitats (E = 60.214; *P* = 0.310), or between the Andoom and Weipa regions (E = 267.243, *P* = 0.074).

Many unidentifiable desiccated frogs were recorded from pitfence traps. Of those identifiable, all but a few were of the smaller species *U. mimula* and *C. remota*.

The results have provided information on the amphibia that supplements Cameron and Cogger (1992), specifically:

- *Crinia remota* also occurs in dunefield woodlands
- *Limnodynastes convexiusculus* also occurs in dunefield woodland habitat
- *Uperoleia mimula* also occurs in Eucalypt woodland, dunefield woodland and grassland habitat
- *Cyclorana novaehollandiae* also occurs in Eucalypt woodland habitat
- *Litoria infrafrenata* also occurs in Eucalypt woodland, dunefield woodland and grassland habitat
- *Litoria nasuta* occurred in woodland habitat
- *Sphenophryne gracilipes* also occurs in dunefield woodland and grassland habitat
- the Cane Toad *Bufo marinus* also occurs in Eucalypt woodland, dunefield woodland and grassland habitat

In contrast to Cameron and Cogger's (1992) earlier findings on the frogs of Weipa, neither *Cyclorana novaehollandiae* or *Rana daemeli* were observed in swamp habitats, nor was *Litoria caerulea* recorded as commonly or in as diverse a number of habitats as earlier.

One hundred and fourteen frog specimens were lodged with the Queensland Museum (Appendix J).

3.8 Species sampling

The species accumulation curve for this survey shows that two-thirds of the observed terrestrial vertebrates were detected by the third visit, and that most of the diversity of the sampled habitats had been recorded by the fourth visit (see Figure 48).

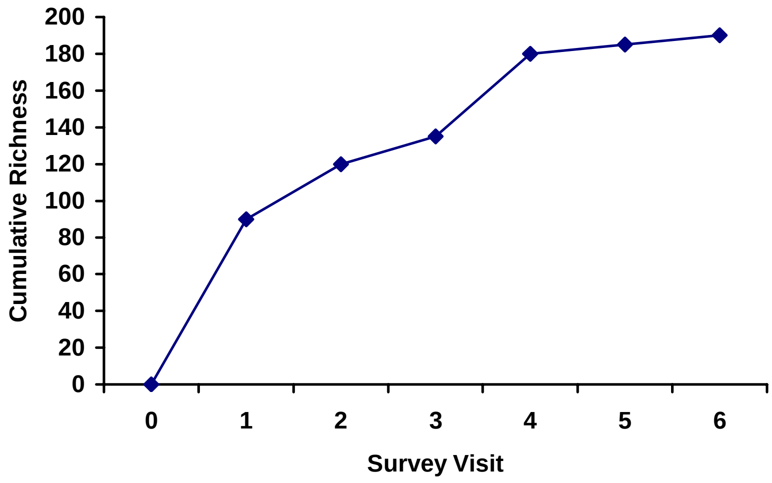


Figure 48 - Accumulation by survey visit of observed terrestrial vertebrate richness.

The greatest number of terrestrial vertebrates observed at a site (sixty-four) was at a grassy ecotone site beside the mangroves of a riparian site in the vicinity of Betteridge Landing in the Andoom region, while the least number of species observed at a site (twelve) was at an ecotone site at Vicce’s Crossing in the Andoom region. The number of terrestrial vertebrates recorded at sites were normally distributed (Figure 49; Shapiro-Wilk W Test; W=0.953, $P = 0.2311$), with a median of forty species.

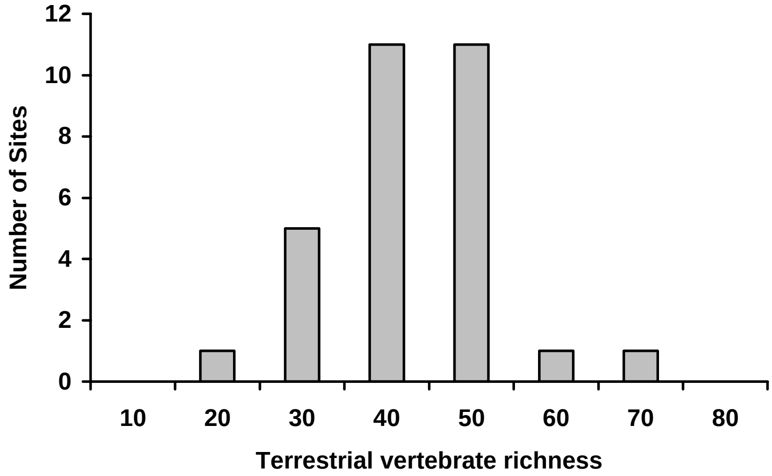


Figure 49 - Distribution of terrestrial vertebrate richness of all thirty sites based on systematic and incidental sampling.

The greatest number of individuals recorded at a site (318) was from a riparian site at a swamp in the north of the Andoom region - while the lowest number of individuals recorded at a site (thirty-seven) were from an ecotone site at Vicce's Crossing in the Andoom region. The median number of individual terrestrial vertebrates recorded at a site was about 150, and abundances at sites were normally distributed (Figure 50; Shapiro-Wilk W Test; W=0.967, P = 0.4995).

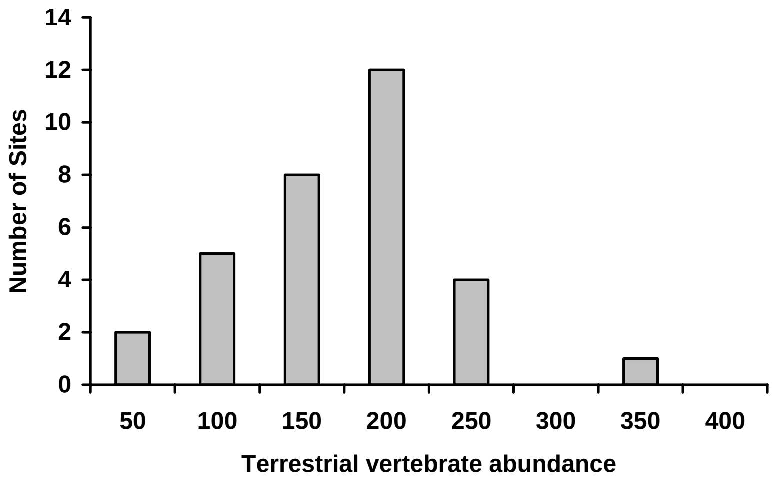


Figure 50 - Distribution of terrestrial vertebrate abundances at all sites, for all systematically observed species and all survey visits.

The reader's attention is drawn to the following observations on the observed terrestrial vertebrates:

- the most diverse site did not have the most number of individuals,

- the least diverse site (AC102) had the least number of individuals.

Pitfence trapping, day ground searching and bird censusing were the most productive trapping methods, although these alone would not have effectively sampled the mammal fauna (Table 16).

Table 34 - Relative effort and cost-benefit of sampling methods

Number of Observations	Census Type							
	Trapping			Searching				Incidental
	Pitfall	Cage	Elliott	Bird Census	Day Ground	Night Arboreal	Night Ground	
Mammals	3	4	45	-	3	17	2	84
Birds	-	6	-	1525	-	7	-	
Reptiles	324	-	20	-	387	129	124	155
Frogs	324	24	21	-	133	63	180	102
All	651	34	86	1525	523	216	307	565
Effort [a]	2412	816	8256	634	204	138	173	
Cost-Benefit [b]	93%	14%	4%	83%	88%	54%	61%	

(a) trap nights or hours, (b) inverse ratio of effort by ratio of observations.

4 Discussion

4.1 Principal conclusions

The principal conclusions from the results are that whilst woodland above uneconomic ore is very probably a substitute for woodland above uneconomic ore, the ‘ecotone’ buffer habitats fringing remnant riparian habitats are not. The evidence is very strong for the conclusion that in respect to the vertebrate fauna recorded in this survey the woodland habitats above un-economic ore are probably substitutable for woodland habitats above economic bauxite ore, as every test found that observed differences in species richness, diversity and composition were not significant. In contrast and due to their distinct fauna, the fringing ‘ecotone’ buffers cannot be considered substitutes for woodland habitats, and that ‘ecotone’ buffers around swamps very probably need to differ (most likely by being expanded in size) from those along creek or marine riparian habitats.

The second principal conclusion of this study was the finding that, with the exception of frogs, there were no statistically significant differences in either the species richness or abundance of the terrestrial vertebrate fauna of woodland, ecotone and riparian habitats. However, and in an affirmation of commonsense, there were strong and significant differences in the compositions of the terrestrial vertebrates between riparian and woodland habitats. This paradox of non-significance in species richness and abundance yet significance in compositional difference is simply due to grouping of all of the species, a practice that has the effect of hiding significant species-specific differences.

The third principal conclusion of this study is the finding that the strength of the difference in composition between woodland and riparian habitats affirms the particular need to conserve woodland habitat, a conclusion which is reinforced by the finding that there are species (in particular the arboreal geckos) which occur exclusively or principally in woodland habitat. Even though the gecko *Heteronotia binoei* occurs throughout most parts of the Australian continent, and co-occurs with the morphologically similar but regionally restricted gecko *Nactus pelagicus*.

Because finding even one species exclusive to woodland is grounds for habitat conservation on a scientific, moral and ethical basis (Hargrove 1989; Laszlo 1989; Potter 1990; Beattie 1995; Elliot 1995), it logically follows that the specific conservation of woodland habitat is now a requirement.

The scientific significance of these results is twofold. First, they reinforce Prendergast, *et al's* (1993) cautionary insight that habitats which are biodiverse for one class of fauna are not necessarily biodiverse for another, and second, the dataset is an empirical contribution to the knowledge of how terrestrial vertebrate fauna co-occur within a landscape.

The study also reinforces the need to conserve riparian habitats, because of their unique terrestrial vertebrate fauna composition, although riparian habitats would appear to be relatively comprehensively conserved if the guidelines in Winter's (1989) strategy are followed. It requires emphasis here that while the need to conserve riparian habitats is broadly accepted, the need to conserve woodland habitats is not so generally accepted.

The fourth principal conclusion is that the unique composition of the terrestrial vertebrate fauna of swamps compared to creek and marine riparian habitats means that swamps and creeks may require independent conservation measures. The composition of the avifauna, the absence of a few otherwise abundant skinks (e.g. the

Jewel Skink *Carlia jarnoldae*) and the preference of many of the frogs distinguishes swamp habitats, while creek and marine riparian habitats are characterised by the presence of specific reptiles (e.g. *Carlia storri*). The significance of this finding is that Winter’s (1989) tactic of having a strip of equivalently wide woodland around creek, swamp and marine riparian habitats may require review, with specific reference to detailed seasonal use of riparian and adjacent woodland habitat by these species and species groups. It may be that fauna populations on swamp margins are substantially flooded during the wet season, and have an insufficient buffer of woodland to occupy as the swamp’s water margin enlarges.(Woinarski *et al.* 2001)

The fifth principal conclusion is that there were no significant differences in the richness, abundance or composition of the terrestrial vertebrate faunas of the Andoom and Weipa regions, despite the finding that there were some species-specific differences between riparian habitat types which may be expected to have some influence. This particular finding is probably due to the occurrence of a representative amount of the sampled habitats within the Andoom and Weipa regions as defined in this survey, a situation which may not necessarily occur if other regions were to be compared.

The sixth principal conclusion is that at the time of the survey the Northern Quoll *Dasyurus hallactatus* was the only terrestrial vertebrate species whose population had almost certainly declined. The evidence for this is that while the Northern Quoll was trapped seventeen times and considered ‘highly detectable’ by Winter and Atherton (1985), it was never recorded on this survey despite specifically sampling their preferred habitat (creeks). However, the decline of the Northern Quoll population is probably not due to the mining operation, but is more likely to be related to the well-documented invasion of the Cane Toad *Bufo marinus* (Burnett

1997). It was pleasing to observe that the three rare species known to occur on the mine lease - the Square-tailed Kite *Lophoictinia isura*, Star Finch *Neochimia ruficauda* and Palm Cockatoo *Probosciger aterrimus* - were present, however the threat of a local decline of these species remains, given the continued loss of woodland habitat and the absence of stock-free creek habitats (Garnett 1992).

As with all ecological studies there were compromises. The principal compromise was that only small to medium sized terrestrial vertebrates were effectively sampled – the results may not apply to larger vertebrates. A second significant compromise is that in this study species preference has been based on the observation of simple presence within habitats, with no attempt to determine the detailed nature of actual habitat use. A habitat may be infrequently used and yet absolutely required by a species, for any number of reasons (eg seasonal nesting sites).

4.2 Contribution to ecological theory

The finding that riparian habitats in this region of the continent were not significantly richer and did not support more individuals than woodland habitats is a contrast to other worker's findings that diversity and abundance are concentrated in riparian elements (Braithwaite 1991a; Williams 1994). Likewise, this study did not find that the diversity of birds is higher in woodlands than in riparian habitats, a comparison which is broadly analogous to earlier work that found that at a regional and continental scale the diversity of birds is higher in woodlands than in rainforests (Kikkawa and Pearse 1969; Brereton and Kikkawa 1974; Kikkawa 1974). However, the results of this survey do support these same worker's findings of significant differences in the composition of the fauna among woodland, ecotone and riparian habitats of the wet-dry tropical landscape of northern Australia. What this suggests is that studies and conclusions on the patterns of richness, abundance and composition of Australia's tropical northern terrestrial vertebrate fauna are susceptible to scale effects, and that extreme caution should be exercised when results of such studies are extrapolated from a local scale to a regional scale.

As a contribution to ecological theory an opportunity exists for the habitat preference results of the birds to be reused in a test of Braithwaite's (1991a) assertion that for birds the woodland habitats sustain proportionally more habitat generalists than riparian habitats. To undertake this would require categorising each observed species according to their ecological flexibility, rather than their taxonomy, and replicating the analysis and interpretation of the dataset as it has been done in this study.

The implication of knowing whether woodland habitats support proportionally more habitat generalists than specialists is that if affirmed it would be the basis of an argument that the fauna of the woodland habitat being lost through the mining process is possibly more resilient to the disturbance compared to the fauna of riparian habitats. The weaknesses to this argument are: firstly, that the mining process is extinguishing woodland habitat and not merely disturbing it, and secondly, while regeneration may well support most of the woodland fauna precisely because the majority of woodland species are generalists, there are a suite of species (such as arboreal geckos) which very probably specifically require a mature forest habitat for their populations to persist.

The finding that the ecotones as defined in this study had intermediate levels of species richness and abundance is contrary to the theory that they support higher levels of diversity (Leopold 1933; Holland *et al.* 1992). Comparisons of the composition of the terrestrial vertebrate fauna showed that habitats which were considered ‘ecotones’ had intermediate levels of species richness and abundance, with an overall composition best described as a riparian-supplemented woodland. Spain (pers. comm.) has suggested that it is more appropriate to consider the expanse of woodland habitat as an ecotone separating forests from grasslands, and the results of this study support this novel interpretation. Alternatively, ecotones in the savanna woodlands of northern Australia may be much narrower than the 100m scale at which this study sampled. If so the indistinguishable nature of ecotones in this survey is more a problem of either having placed sites so that they just missed an actual ecotone, or because the site samples were shaped in a way which caused neighbouring woodland and riparian habitats to be sampled, and so confusion occurred. An improvement to the square shape of the discreet sample sites used in this study, which were inappropriate for sampling narrow ecotones, would be to have either linear sites of equal area. or gradsects - a continuous sampling regime oriented at right angles to the habitat gradient (Gillison and Brewer 1985; Austin and Heyligers 1989; Austin and Heyligers 1991).

One of the consequences of considering the expanse of woodlands as an ecotone is that it could be the basis of an argument that woodlands may be more resilient to intermediate levels of disturbance than previously acknowledged, although this argument suffers the same weakness raised in the previous paragraph of the contrast between disturbance and extinguishment.

The results of this study affirm Lamotte's (1983) assertion that the abundance and distribution of savanna amphibians is influenced by the nature and distribution of water bodies. The evidence for the influence of water bodies on amphibian richness can be seen in Figure 37, which shows that the mean number of frog species in riparian habitat sites is significantly greater than the number of frogs in woodland habitat sites.

The finding that the differences between riparian, ecotone and woodland habitats were not always significant for all classes, or if they were then they are not always to the same degree, is a clear illustration of Prendergast, *et al.'s* (1993) warning that habitat which is a diversity 'hot-spot' for one group of taxa (eg. birds) may not be the same for another (eg. reptiles). This study is an empirical contribution to this important 'coincident diversity' debate (Prendergast *et al.* 1993; Balmford 1998; Wright and Samways 1998), which has cast some doubt on the usefulness of single-species or species-specific surveys - such as bird surveys or surveys of 'umbrella species' - in the design of conservation reserves.

The results of the survey provide data which can be directly applied to models of population dynamics, allowing risk estimates of extinction under proposed landscape configurations (Turner and Gardner 1991; Rhodes *et al.* 1996).

Intuition and dogma suggest that riparian habitat patches are net exporters of individuals, while woodlands are net importers. This study (particularly Appendix I) does not contain much evidence for this. The absence of significant seasonal differences suggests that the woodlands of Weipa may be "pseudo-sinks", however a density-reduction experiment or mark-recapture survey would be needed to make such a distinction.

This study has contributed to the science of ecology by the use of a formal, hypothesis-testing experimental design that it gives its conclusions power. Formal designs for field surveys are comparatively rare in ecological practice, with most surveys adopting a more informal design that maximises descriptive outcomes. As equally rare in ecological practice is the use of resampling tests, with this tactic not mentioned in Margules, *et* *al.*(1991). This study has demonstrated two ways in which the use of resampling has significantly improved the analysis of fauna survey data.

Firstly, by resampling the chi-square distribution for values below the minimum sample size conventionally used in this test, it has been possible to confidently identify a species with a habitat preference with about half the number of observations previously required for any one site. This is significant for biodiversity surveying because most species are not frequently observed - particularly rare species - yet they are often the ones which are of the most interest. This contribution to the treatment of data from regional surveys increases the usefulness of the data from rarely observed species, and thus the usefulness of these surveys overall.

Secondly, by resampling the Euclidean distance between the centroids of site clusters projected in their species space and grouped by their habitat, it became possible to estimate how frequently the observed data would have occurred. This contrasts with the conventional use of the Euclidean distance measure, which requires an assumption to be made about how the site clusters should be distributed, and an interpretation of how the observed distribution of site clusters differs from this.

4.3 Implications for practice

In this section the discussion differentiates between minesite practice and conservation practice. Minesite practices apply essentially to the Comalco operation at Weipa, although they may also have application to similar bauxite operations in close proximity to the Comalco operation, or in the Northern Territory. References to conservation practices apply essentially to conservation reserve design in Cape York Peninsula, although they may also apply to conservation reserve design in northern

Australian woodlands generally. Where there is discussion of the methods of analysing field data, the implications for practice apply to any biological survey which scientifically compares the richness, abundance and composition either between or amongst habitats.

One implication of the results of this study is that it confirms the existing minesite practice of not conserving areas of woodland habitat above specifically economic ore. This conclusion is reached because of the finding that the terrestrial vertebrate fauna of woodland habitats above un-economic ore had the same pattern of species richness, abundance and composition as woodland habitats above economic ore.

A second implication of this study is that it confirms and reinforces the existing minesite practice of conserving riparian habitats, which is not particularly surprising. The basis for this conclusion is the finding that riparian habitats have a unique composition, and that at least nineteen terrestrial vertebrates were either exclusive to, or had a significant preference for, riparian habitats. Species which are exclusive to, or prefer, riparian habitats can be considered secure while the policy and practice of the company is to conserve these habitats. However, use of these habitats for purposes that are incompatible with habitat conservation (eg. temporary or permanent cattle agistment, harvesting of native species, access routes, community recreation facilities) are compromises which do nothing except threaten their otherwise secure status. Broadly speaking, the practice of reserving riparian habitats in conservation reserve design is an essential element in the dogma of the science of conservation ecology as practiced in northern Australia, and the results of this study support this practice.

A third implication for minesite practice is that this study affirms the need to independently conserve woodland habitat. This implication follows the finding that the terrestrial vertebrates of woodland habitats have a unique composition and include fauna which are predominantly occur in or are exclusive to woodland habitats. It is the need to conserve woodland habitats that may require a modification of minesite conservation practices, and presents more of a challenge. The challenge arises because in the absence of contrary information it is reasonable and precautionary to assume that there is a dependency on this habitat for the maintenance of viable populations for those species (at least) which had a strong and significant preference for woodland habitat. In essence, there is a risk that existing minesite practice (as different to strategy) has emphasised protection of the fauna of essentially safe riparian habitats, without equally (if not more so) emphasising the need to conserve knowingly threatened woodland habitats. Addressing this historical imbalance of concentrating on the less threatened habitats while deferring effort on the most threatened habitat, is the essence of the challenge facing minesite conservation practice today. It is suggested that as a minesite practice the woodland-specific species which can be considered the most threatened with local extinction by the mining operation should be used as a priority list when commissioning, reviewing or benchmarking species-specific terrestrial vertebrate research proposals.

The fourth implication of this study for conservation practice is that it cannot be assumed that remnant strips around the margin of riparian habitats are of the same quality as the woodland habitat. This is because the findings of this survey suggest that while the fauna of ecotone habitats have strong similarities compared to woodland habitats, they were clearly not the same because of similarities to riparian habitat faunas as well. Because these ecotone habitats were not significantly richer or more abundant it suggests that there may be a complex of species displacements or population suppressions which were not sufficiently obvious to be detected without additional experimental sampling. For example, it is possible that the population abundances of some woodland species are depleted around riparian habitats, and that higher levels are sustained only in relatively extensive and continuous woodland habitat. This possibility was comparatively poorly examined by the design of this survey, which traded depth of sampling for breadth of coverage.

The fifth implication for minesite and conservation practice is that using the same width of remnant woodland habitat around the three different riparian habitats sampled in this survey requires review. The review is necessary because this survey found that particular species have a preference for particular types of riparian habitat types, and as a consequence existing arrangements may not be sufficient to meet the needs of some species. By direct observation it was apparent that swamp margins extended into the woodlands during the wet season, whereas the course of the creeks were much more defined. This means that a larger buffer of woodland may be required around swamps than is currently scheduled.

A sixth implication of this study for minesite and conservation practice is raised pre-emptively, in that the results could not support any propositions to conserve more of one type of riparian habitat as compensation for eroding another type of riparian habitat. This is because the composition of the terrestrial vertebrate fauna of riparian habitats depends on whether it is a creek, swamp or marine habitat.

The seventh implication for minesite practice is that there is no apparent requirement for a difference in the fauna conservation strategies of Andoom and Weipa regions for the terrestrial vertebrates. At the higher level the overall strategy of retaining a network of riparian habitats and core areas of woodland habitats is supported, yet at a lower level there is a requirement to design habitat conservation reserves using habitat-specific tactics such as different widths around different riparian habitats.

The information generated by this study can be taken as a benchmark for minesite regeneration practice, not only as an aid in identifying fauna which are functionally significant in regeneration, but also in the identification of fauna which could function as diagnostic indicators of patch health at any particular time - a sort of "taking the pulse". In turn, this means that where regeneration habitat is departing from a desired ecological trajectory, it can be identified more rapidly and efficiently, and provides more opportunity to direct it toward a desired outcome (preferably using a cheaper and specific management practice).

The finding that the fauna of woodland habitat above un-economic ore has a similar pattern of species richness, abundance and composition as woodland habitat above economic ore, suggests that any relationship between the modal diameter at breast height of trees and the quality of the underlying orebody (Reddell, P., pers. comm.), is not apparent in the richness, abundance or composition of the woodland fauna. There remains an opportunity to examine the possibility that the distribution and abundance of species with a dependency on arboreal hollows is determined by the value of the underlying ore, a finding which if affirmative may have profound significance for minesite conservation practice. The results of this study could be used to estimate the amount of surveying effort required to detect such an effect, and the ability to reuse the data from the this survey in this manner illustrates the value which can be added to systematically collected field survey data.

The study has also found that in future studies the practice of marking trapped individuals would be particularly valuable. Determination of re-traps has required a post-hoc parsimonious judgement to exclude potential retraps of individuals. This means that a bias is introduced on the abundance figures for species observed in each site's sample, and while it is conservative it is also inestimable. Future studies could also employ improved ways of conducting bird and ground surveys (e.g. Watson 2003), reducing the bias inherent in the fixed effort sampling methods used in this study.

4.4 Unresolved issues

The primary unresolved issue following this survey is the status of the Northern Quoll *Dasyurus hallactatus*. Confirming the presence of this now 'missing' species would provide significant re-assurance that the fauna of the mine lease has not sustained a significant loss of terrestrial vertebrate biodiversity up until 1993. Two other terrestrial vertebrates not confirmed as occurring on the mine lease, but which possibly could, include the rare Knob-tailed Gecko *Nephrus asper* and the cryptic Frill-necked Lizard *Chlamydosaurus kingii*.

The progressive scarcity of large trees and termite mounds within the landscape may be particularly affecting the Frill-necked Lizard as these habitat structures are used as shelter during late-season intense fires (Griffiths and Christian 1996). There may also be an effect on the varanids, as *V. tristis* in WA appear to be strictly arboreal foragers during the mating season (Thompson *et al.* 1999).

Although this report has provided good information on differences in the common birds, reptiles (other than snakes) and frogs, it has not reported on scat or bat datasets and did not attempt to sample freshwater vertebrates. It remains unresolved what the influence of including seabirds and freshwater birds in the survey would be, however it would certainly add weight to argument that riparian habitats are significant habitats.

This bias against sampling the rarer, much smaller and much larger taxa, in favour of sampling scansorial groups such as the small vertebrates is both a strength and a weakness of the study. For example, virtually nothing can be said of the Antilopine Wallaroo *Macropus antilinopus* even though it is a vertebrate of major cultural significance to the Napranum community (pers. obs.), nor of termites, even though they almost certainly have a major role in the ecology of the landscape (Josens 1983; Anderson and Braithwaite 1996). Also, while this study dealt with surface effects, there are also atmospheric and sub-surface effects to consider. For example, is there any difference in the aerial insect column between woodland and regeneration habitats, and if so does this have any implications for the persistence of insectivorous birds and bats? This study has no information which helps with these questions.

In retrospect there was considerable variation in habitat type between ecotone sites (see Site descriptions on page 56), which does limit the generality of the conclusions that can be drawn from the results of this study. Land units 5k and 7d were not otherwise replicated. Land unit 5k is restricted to Andoom, and is considered honorary 2b at the Betteridge Landing locality.

In addition, the occurrence in woodland habitat sites of frogs that are most frequently observed in swamps is suggestive of a ‘source-sink’ dynamic to their population, in which connectivity and adjacency of habitat may be important to their local viability.

The finding that woodland habitats are distinct leaves unresolved the issue of the amount and configuration of remnant woodland habitats required to fulfil their function as local refugia during mining, and as subsequent sources of colonising fauna during regeneration. The quantitative results of this study could be used as the basis of further species-specific studies, such as determining the risk of extirpation under various landscape configurations.

As part of a conservation strategy based on a network of corridors and patches, Winter (1989) has proposed that (2b) woodland habitats could be represented by a core habitat patch of grassy layered woodland (5e) located at the headwaters of the Trunding Creek corridor. As this core patch becomes seasonally waterlogged it may not be substitutable for the (2b) woodland that many of the herpetofauna appear to have some dependence on.

The assumption that the woodland remnants will have a collective or individual capacity to sustain viable populations after their isolation requires scrutiny.

The operations of the present custodian are changing the nature number, type and arrangements of habitat patches in the landscape, and there remain opportunities to make choices about the composition and arrangement of habitat patches in a post-mining landscape. Consideration could be given to ensuring that the connectivity of woodland habitat remnants is maintained, and provision made for nodes of woodland habitats (core areas).

A number of species exhibited a shift in habitat preference associated with seasonal changes. This is significant because it means that the habitats these species occupy during seasonal extremes need to be conserved, as well as habitats which are traversed during their period of dispersal.

Development of a model of the landscape should be undertaken to identify population persistence under alternate landscape design strategies, and to aid the allocation of effort in future studies. The specifications of the model should include the incorporation of existing traditional and scientific knowledge on habitat preferences, landscape mosaic attributes, population dynamics, species behaviours and the cost-benefits of mining operations into a system that can generate, priorities and visualise optimal and feasible landscape configuration options, with associated population viability estimates for species at risk of local extinction and an operational cost-benefit analysis.

Likewise, it is unknown whether particular ecological processes are restricted to certain habitats. The significance of this information is that if, for arguments sake, the process of inoculation of soil by fungi was critical to the success of Eucalypt species in regeneration habitats, then it is important to know that the only known faunal vectors that sustain this process are dependant upon woodland habitats. This would require categorisation of the species according to their ecological function, and re-analysis of preference patterns.

While this study has demonstrated that habitat preferences exist, the reasons for these preferences are poorly known, are known only through traditional knowledge or are based on studies from habitats of different environments. Understanding the basis for preferences is highly desirable, because the suitability of regenerating habitats for these species could assessed, and if considered deficient the information focuses effort on improvement by supplying appropriate analogues. A modest amount of information was recorded on microhabitat preferences, and a review of this could be a small but potentially useful contribution.

Reporting on the impact of climate change would be desirable. Changes in conditions that may particularly affect fauna conservation and regeneration practice could include a shift in tree-grass ratios, rising sea levels inundating habitats, and the erection of bias against anticipated outcomes of existing practices. For example, there may be a loss of woodland habitat (rather than its conservation) if riparian habitats were to quickly expand into the specifically established woodland corridors.

In conclusion, the survey has found that the distribution and abundance patterns of the fauna of the Andoom and Weipa regions, the creek, swamp and marine riparian habitats and the woodland habitats supports maintenance of all existing minesite conservation practices, and requires conservation of an indeterminate amount and configuration of extra woodland habitat, which can be above uneconomic ore, but is not ecotone habitat.

The study has raised the concern that the existing fauna conservation strategy does not cater to species-specific habitat preference patterns, and warrants a review. Avenues for further studies that have been identified include modelling population viability under alternative landscape configurations, replicate sampling in the remote but undisturbed habitat to the south of the lease, replicate analysis of existing data using alternate species categories and extension of the analysis using data on invertebrates which has been collected but not included in this report.

Bibliography

Abrahams, H., Mulvaney, M., Glasco, D. and Bugg, A. (1995). '*Areas of conservation significance on Cape York Peninsula*', Cape York Peninsula Land Use Strategy, Ofice of the Co-ordinator General of Queensland, Brisbane, Department of the Environment, Sport and Territories, Canberra, and Queensland Department of Environment and Heritage, Brisbane.

Adamson, N. (1991). '*Landunits in the vicinity of Weipa*', Weipa:Comalco Mineral Products.

Alford, R. (1995). '*Ramanat: Multivariate statistical resampling software V 0.98*', Townsville:James Cook University.

Anderson, A. N. and Braithwaite, R. W. (1996). '*Plant-animal interactions*', in *Landscape and vegetation ecology of the Kakadu region, Northern Australia* Eds. Finlayson, C. M. and von Oertzen, L. Netherlands:Kluwer Academic Publishers. Pp. 137 - 154

Austin, M. P. and Heyligers, P. C. (1989). 'Vegetation survey design for conservation: Gradsect sampling of forests in north-eastern New South Wales', *Biological Conservation*, **50**: 13-32.

Austin, M. P. and Heyligers, P. C. (1991). '*New approaches to vegetation survey design: Gradsect sampling*', in *Nature Conservation: Cost effective biological surveys and data analysis* Eds. Margules, C. R. and Austin, M. P. Melbourne:CSIRO. Pp. 31-36

Austin, M. P. and McKenzie, N. J. (1988). '*Data analysis*', in *(1988) 'Data analysis' . 'Australian soil and land survey handbook: Guidelines for conducting surveys* Eds. Gunn, R. H., Beattie, J. A., Reid, R. E. and van de Graaff, R. H. M. Melbourne:Inkata Press. Pp. 210-232

Australian Surveying and Land Information Group (1993). '*Land tenure of Australia*', Canberra:AGPS.

Balmford, A. (1998). 'On hotspots and the use of indicators for reserve selection', *Trends and Research in Evolution and Ecology*, **13**(10): 409.

Baxter, G. S. and Fairweather, P. G. (1995). 'Phosphorous and nitrogen in wetlands with and without egret colonies', *Australian Journal of Ecology*, **19**(4): 409-416.

Beattie, A. and Oliver, I. (1994). 'Taxonomic minimalism', *Trends and Research in Evolution and Ecology*, **9**: 448-490.

Beattie, A. J. (1995). '*Why conserve biodiversity?*' in *Conserving biodiversity: threats and solutions* Eds. Bradstock, R. A., Auld, T. D., Keith, D. A., Kingsford, R. T., Lunney, D. and Sivertsen, D. P. Sydney:Surrey Beatty & Sons. Pp. 3-10

Beeton, R. J. S. (1985). '*The little corella - a seasonally adapted species*', Ecology of the wet-dry tropics, Darwin, Darwin Institute of Technology & The Ecological Society of Australia Inc.

Bennett, A. F. (1990). '*Habitat corridors: their role in wildlife management and conservation*.' Melbourne:Department of Conservation & Environment, Arthur Rylah Institute for Environmental Research.

Bennett, A. F. (1998). '*Linkages in the landscape: the role of corridors and connectity in wildlife conservation*.' Gland, Switzerland:IUCN.

Bennett, A. F., Henein, K. and Merriam, G. (1994). 'Corridor use and the elements of corridor quality - chipmunks and fencerows in a farmland mosaic', *Biological Conservation*, **68**(2): 155-165.

Beruldson, G. (1979). 'Ten days at Weipa, Cape York Peninsula', *The Australian Bird Watcher*, **8**(4): 128-132.

Biological Environmental Research Services (1982). '*Pre-feasibility environmental assessment. Lease SMBL 9, North Queensland: Fauna*', Shell (Australia) Pty Ltd.

Birkin, R., Boxer, Z. and George, J. (1988). '*Aborigines and their environment: Life during the seasons*', in *Unigan Guide: A handbook to the Unigan Bicentennial Nature and Recreation Reserve* Ed. Wharton, G. Weipa:Weipa Bicentennial Community Committee. Pp. 6-17

Blackman, J. G., Spain, A. V., Preece, H. J. and Whiteley, L. A. (1995). '*Queensland*', in *A directory of important wetlands in Australia* Eds. Usback, S. and James, R. Canberra:Australian Nature Conservation Agency. Pp. Sec. 6:1-3

Blakers, M., Davies, S. J. J. F. and Reilly, P. N. (1984). '*The atlas of Australian birds*.' Melbourne:Royal Australian Ornithologists Union & Melbourne University Press.

Bolton, B. L., Newsome, A. E. and Merchant, J. C. (1985). '*Reproduction in the Agile Wallaby: oppourtunistic breeding in a seasonal environment*', Ecology of the wet-dry tropics, Darwin Institute of Technology, The Ecological Society of Australia, Inc.

Bonner, J. (1994). 'Wildlife's roads to nowhere?' *New Scientist*, 20th Aug. 1994, Pp. 30-34.

Bourliére, F. (1983). '*Ecosystems of the World 13: Tropical savannas*.' Amsterdam:Elsevier Scientific Publishing Company.

Bowman, D. M. J. S. and Woinarski, J. C. Z. (1994). 'Biogeography of Australian monsoon rainforest mammals: implications for the conservation of rainforest mammals', *Pacific Conservation Biology*, **1**(2): 98-106.

Boyce, M. S. and McDonald, L. L. (1999). 'Relating populations to habitats using resource selection functions', *Trends and Research in Evolution and Ecology*, **14**(7): 268-272.

Braby, M. F. (1995). 'Reproductive seasonality in tropical satyrine butterflies: strategies for the dry season', *Ecological Entomology*, **20**: 5-17.

Braithwaite, R. W. (1990). 'Australia's unique biota', *Journal of Biogeography*, **17**: 347-354.

Braithwaite, R. W. (1991a). '*Australia's unique biota: implications for ecological processes*', in *Savanna ecology and management: Australian perspectives and intercontinental comparisons* Ed. Werner, P. A. Melbourne:Blackwell Scientific Publications. Pp. 3-10

Braithwaite, R. W. (1991b). '*Fauna and habitat surveys as ecological pathfinders*', in *Nature Conservation: Cost effective biological surveys and data analysis* Eds. Margules, C. R. and Austin, M. P. Melbourne:CSIRO. Pp. 23-28

Brereton, J. L. and Kikkawa, J. (1974). 'Diversity of avian species', *Australian Journal of Science*, **26**: 12-14.

Bridgewater, P. W. (1987). '*Connectivity: An Australian perspective*', in *Nature Conservation: The role of remnants of natve vegetation* Eds. Saunders, D. A., Arnold, G. W., Burbidge, A. A. and Hopkins, A. J. M. Sydney:Surrey Beatty & Sons in association with CSIRO & CALM. Pp. 195-200

Bryce, S. (1991). '*Weipa SiO*^{2} *Map*', Weipa, Cape York Peninsula:Comalco Mineral Products.

Bureau of Meterology (1992). '*Climate of Queensland*.' Canberra:AGPS.

Burgman, M. A. and Lindenmayer, D. B. (1998). '*Conservation biology for the Australian environment*.' Sydney:Surrey Beatty & Sons.

Burnett, S. (1997). 'Colonizing Cane Toads cause population declines in native predators: reliable anecdotal information and management implications', *Pacific Conservation Biology*, **3**(1): 65-72.

Busby, J. R. (1991). '*BIOCLIM - A Bioclimate Analysis and Prediction System*', in *Nature Conservation: Cost effective biological surveys and data analysis* Ed. Margules, C. R. a. A., M.P. Melbourne.:CSIRO. Pp.

Cade, B. S. and Richards, J. D. (1999). '*User Manual for Blossom Statistical Software*', US Geological Survey.

Cameron, E. E. and Cogger, H. G. (1992). '*The herpetofauna of the Weipa region, Cape York Peninsula*', Technical Report 4, Australian Museum.

Cato, L., Ed. (1995). '*The business of ecology: Australian organisations tackling environmental issues*', Sydney:Allen & Unwin.

Christian, C. S. (1958). '*The concept of land units and land systems*', Ninth Pacific Science Congress,

Christian, C. S. and Stewart, G. A. (1953). '*General report on survey of Katherine-Darwin region 1946*', 1, CSIRO Aust. Land Res. Ser.

Christidis, L. and Boles, W. E. (1994). '*The taxonomy and species of birds of Australia and its territories*.' Melbourne:RAOU.

Clarke, K. R. and Gorley, R. N. (2001). '*Primer v5: User Manual/Tutorial*', Plymouth:PRIMER-E.

Clarkson, R. and Reeders, P. (1988). '*Birds*', in *Unigan Guide: A handbook to the Unigan Bicentennial Nature and Recreation Reserve* Ed. Wharton, G. Weipa:Weipa Bicentennial Community Committee. Pp. 46-50

Clerke, R. B. and Alford, R. A. (1993). 'Reproductive cycling in four species of tropical Australian lizards, and comments on the factors regulating lizard reproductive cycles', *Journal of Herpetology*, **27**: 400-406.

Close, D. H. and Teese, D. (1978). 'Yellow-tinted Honeyeater at Weipa', *Sunbird*, **9**: 59-60.

Cogger, H. G. (1986). '*Reptiles and amphibians of Australia*.' Sydney:Reed Books.

Commonwealth of Australia (1992). '*Endangered Species Protection Act 1989*', Commonwealth of Australia.

Covacevich, J. and Easton, A. (1974). '*Rats and mice in Queensland*.' Brisbane:Queenslnd Museum.

Covacevich, J. and Ingram, G. (1980). '*The endemic frogs and reptiles of Cape York Peninsula*', in *Contemporary Cape York Peninsula* Eds. Stevens, N. C. and Bailey, A. Brisbane:Royal Society of Queensland. Pp. 49-57

Crossland, M. R. and Alford, R. A. (1998). 'Evaluation of the toxicity of eggs, hatchlings and tadpoles of the introduced toad *Bufo marinus* (Anura: bufonidae) to native Australian aquatic predators', *Australian Journal of Ecology*, **23**(2): 129-137.

CYPLUS (1995). '*CYPLUS Infoback*', Cape York Peninsula Land Use Study.

Dahle, N. W. and Mulligan, D. R. (1996). '*Environmental Management at Weipa - Bauxite Mining in the Tropical North*', in *Environmental Management in the Australian Minerals and Energies Industries: Principles and Practices* Ed. Mulligan, D. Sydney:UNSW Press. Pp. 403-420

Dangerfield, J. M., Pik, A. J., Britton, D., Holmes, A., Gillings, M., Oliver, I., Briscoe, D. and Beattie, A. J. (2003). 'Patterns of invertebrate biodiversity across a natural edge', *Austral Ecol*, **28**(3): 227-236.

Diaconis, P. and Efron, B. (1983). 'Computer-intensive methods in statistics', *Scientific American*: 96-108.

Diamond, J. A. (1975). 'The island dilemma: lessons of modern biogeographic studies for the design of nature reserves', *Biological Conservation*, **7**: 129-146.

Dickman, C. R., Predavec, M. and Downey, F. J. (1995). 'Long-range movements of small mammals in arid australia - implications for land management', *Journal of Arid Environments*, **31**(4): 441-452.

Driscoll, P. V. (1995). '*Wetland definition and fauna assessment*', NRAP - NR09 Wetland fauna survey Queensland Department of Environment and Heritage.

Dwyer, P. D. (1972). 'Feature, patch and refuge area: Some influences on diversity of bird species', *Emu*, **72**: 149-156.

Dyne, G. R. and Walton, D. W., Eds. (1987). '*Fauna of Australia. 1A General Articles*', Canberra:Australian Government Publishing Service.

Elliot, R., Ed. (1995). '*Environmental ethics*', Oxford readings in philosophy. Oxford:Oxford University Press.

Environment Australia (2001). Environment Protection & Biodiversity Conservation Act website. Commonwealth of Australia. **2001:** Pp.

Friend, G. R. (1990). '*Breeding and population dynamics of Isoodon macrourus (Marsupialia:Peramelidae): studies from the wet-dry tropics of Australia*', in *Bandicoots and bilbies* Eds. Seebeck, J. H., Brown, P. R., Wallis, R. L. and Kemper, K. M. Sydney:Surrey Beatty & Sons. Pp. 357-365

Friend, G. R. and Cellier, K. M. (1990). 'Wetland herpetofauna of Kakadu National Park, Australia: seasonal richness trends, habitat preferences and the effects of feral ungulates', *Journal of Tropical Ecology*, **6**: 131-152.

Friend, G. R., Dudzinski, M. L. and Cellier, K. M. (1988). '*Rattus colleti* (Rodentia: Muridae) in the Australian wet-dry tropics: Seasonal habitat preferences, population dynamics and the effects of buffalo (*Bubalus bubalis*)', *Australian Journal of Ecology*, **13**(1): 51-66.

Friend, G. R. and Taylor, J. A. (1985). 'Habitat preferences of small mammals in tropical open-forest of the Northern Territory', *Australian Journal of Ecology*, **10**: 173-186.

Frith, C. and Frith, D. (1991). '*Australia's Cape York Peninsula*.' Malanda:Frith & Frith Books.

Frith, D. W., Frith, C. B. and Trapnell, K. (1995). '*Cape York Peninsula: A natural history*.' Chatswood:Reed Books.

Garnett, S. T. (1992). '*Threatened and extinct birds of Australia*', RAOU Report 82, Royal Australian Ornithological Union.

Garnett, S. T. and Crowley, G. M. (1995). 'The decline of the Black Treecreeper Climacteris picumnus melanota on Cape York Peninsula', *Emu*, **95**: 66-68.

Garthwaite, P. H., Jolliffe, I. T. and Jones, B. (1995). '*Statistical inference*.' London and New York:Prentice Hall.

Gibbons, P. and Lindenmayer, D. (2002). '*Tree hollows and wildlife conservation in Australia*.' Melbourne:CSIRO.

Gillison, A. N. (1983). '*Tropical savannas of Australia and the southwest pacific*', in *Ecosystems of the world: Tropical savannas* Ed. Bourliére, F. Amsterdam:Elselvier Scientific Publishing Company. Pp. 183-244

Gillison, A. N. (1988). '*A plant functional proforma for dynamic vegetation studies and natural resource surveys*', Technical Memorandum 88/3, CSIRO Division of Water Resources.

Gillison, A. N. and Brewer, K. R. W. (1985). 'The use of gradient directed transects or gradsects in natural resource surveys', *Journal of Environmental Management*, **20**: 103-127.

Glanznig, A. (1995). '*Native vegetation clearance, habitat loss and biodiversity decline*', Biodiversity Series Paper No. 6, DEST Biodiversity Unit.

Godwin, M. D. (1985). '*Land units of the Weipa region, Cape York Peninsula*', Comalco Aluminium Limited.

Graetz, R. D., Wilson, M. A. and Campbell, S. K. (1995). '*Landcover disturbance over the Australian continent: a contemporary assesment*', Biodiversity Series Paper No. 7, DEST Biodiversity Unit.

Greer, A. E. (1989). '*The biology and evolution of Australian lizards*.' Sydney:Surrey Beatty & Sons.

Griffin, A. and Swaby, R. J. (c. 1990). Bird calls of tropical eastern Australia. Paluma, A. C. M. Griffin. Pp.

Griffiths, A. D. and Christian, A. K. (1996). 'The effects of fire on the frillneck lizard (Chlamydosaurus kingii) in northern Australia', *Australian Journal of Ecology*, **21**(4): 386-398.

Gunness, A. G., Lawrie, J. W. and Foster, M. B. (1986). '*Land units of the Weipa environs - Final Report*', Final Comalco Aluminium Limited.

Gunness, A. G., Lawrie, J. W. and Foster, M. B. (1987). '*Land units of the Weipa environs - 1:24 000 map and explanatory notes*', Comalco Aluminium Limited.

Hansen, A. J. and di Castri, F., Eds. (1991). '*Landscape boundaries: Consequences for biotic diversity and ecological flows*', Ecological Studies. Berlin:Springer-Verlag.

Hansson, L., Fahrig, L. and Merriam, G. (1995). '*Mosaic landscapes and ecological processes*.' Chapman & Hall.

Hargrove, E. C. (1989). '*Foundations of environmental ethics*.' Prentice-Hall.

Harrington, G. N. and Sanderson, K. D. (1994). 'Recent contraction of wet sclerophyll forest in the wet tropics of Queensland due to invasion by rainforest', *Pacific Conservation Biology*, **1**(4): 319-327.

Hartigan, J. A. and Kleiner, B. (1981). '*Mosaics for contingency tables*', Proceedings of the 13th symposium on the interface between computer science and statistics, New York, Springer-Verlag.

Heatwole, H. (1987). '*Major components and distributions of the terrestrial fauna*', in *Fauna of Australia* Eds. Dyne, G. R. and Walton, D. W. Canberra:AGPS. Pp. 101-135

Hempel, C. G. (1966). '*Philosophy of natural science*.' New Jersey:Prentice-Hall.

Hero, J. M. (1995). Frog calls of northeast Queensland. Townsville, James Cook University. Pp.

Hero, J.-M. (1998). 'Amazon tadpoles and fish assemblages':

Hobbs, R. J. (1992). 'The role of corridors in conservation: solution or bandwagon?' *Trends and Research in Evolution and Ecology*, **7**: 389-392.

Holland, M. M., Risser, P. G. and Naiman, R. J., Eds. (1992). '*Ecotones: The role of landscape boundaries in the management and restoration of changing environments*',

Horne, J. (1991). '*Analysis of animal survey data*', in *Nature Conservation: Cost effective biological surveys and data analysis* Ed. Margules, C. R. a. A., M.P. Melbourne.:CSIRO. Pp. 42-46

Horner, P. (1992). '*Skinks of the Northern Territory*.' Darwin:Northern Territory Museum.

Howitt, R. (1992). 'Weipa: Industrialisatian and indigenous rights in a remote Australian mining operation', *Geography*, **77**(3): 223-235.

Hughes, L. (2003). 'Climate change and Australia: Trends, projections and impacts', *Austral Ecol*, **28**(4): 423-443.

Hussey, B. M. J., Hobbs, R. J. and Saunders, D. A. (1989). '*Guidelines for bush corridors*', CSIRO Division of Wildlife & Ecology - Western Australian Laboratory.

Ingram, G. J. and Raven, R. J., Eds. (1991). '*An atlas of Queensland's frogs, reptiles, birds and mammals*', Brisbane:Queensland Museum.

Josens, G. (1983). '*The soil fauna of tropical savannas. III. The termites*', in *Ecosystems of the world* Ed. Bourli│││││ere, F. Amsterdam:Elsevier Scientific Publishing Company. Pp. 505-524

Kavanagh, R. P. and Bamkin, K. L. (1995). 'Distribution of nocturnal forest birds and mammals in relation to the logging mosaic in south-eastern New South Wales, Australia', *Biological Conservation*, **71**(1): 41-53.

Kikkawa, J. (1974). 'Comparison of avian communities between wet and semi-arid habitats of eastern Australia', *Australian Wildlife Research*, **1**: 107-116.

Kikkawa, J. and Pearse, K. (1969). 'Geographical distribution of land birds in Australia - a numerical analysis', *Australian Journal of Zoology*, **17**: 821-840.

Krebs, C. J. (1985). '*Ecology: The experimental analysis of distribution and abundance*.' New York:Harper & Row.

Kutt, A. S. and Skull, S. D. (1995). 'Fauna in the riparian zone on the middle Burdekin River, with reference to vegetation, habitat condition and conservation status', *Queensland Naturalist*, **33**(3-4): 57-63.

Lamotte, M. (1983). '*Amphibians in savanna ecosystems*', in *Ecosystems of the world* Ed. Bourliere, F. Amsterdam:Elsevier Scientific Publishing Company. Pp. 313-324

Laszlo, E. (1989). 'Global survival and responsibilities of science', *Environmental Conservation*, **16**(2): 103-106.

Laurance, W. F. (1991). 'Edge effects in tropical forest fragments: Application of a model for the design of nature reserves', *Biological Conservation*, **57**: 205-219.

Leopold, A. (1933). '*Game management*.' New York:Scribners.

Lesslie, R., Abrahams, H. and Maslen, M. (1992). '*Wilderness quality on Cape York Peninsula*', National Wilderness Inventory Stage III, Australian Heritage Commission.

Lethbridge, P. J. and Macmillan, K. M. (1996). '*Terrestrial vertebrate survey of Andoom vine forest patches*', Comalco Aluminium Limited.

Lewontin, R. C. and Felsenstein, J. (1965). 'The robustness of homogeneity tests in 2 x n tables', *Biometrics*, **21**: 19-33.

Lindenmayer, D. B., Cunningham, R. B., Donnelly, C. F., Tanton, M. T. and Nix, H. A. (1993). 'The abundance and development of cavities in montane ash-type eucalypt trees in the montane forests of the central highlands of Victoria, south-eastern Australia', *Forest Ecology and Management*, **60**: 77-104.

Low, T. (2002). '*The new nature: winners and losers in wild Australia*.' Melbourne:Penguin.

Mac Nally, R., Ellis, M. and Barrett, G. (2004). 'Avian biodiversity monitoring in Australian rangelands', *Austral Ecology*, **29**(1): 93-99.

MacArthur, R. H. and Wilson, E. O. (1963). 'An equilibrium theory of insular zoogeography', *Evolution*, **17**(4): 373-387.

MacArthur, R. H. W., E.O. (1967). '*The theory of island biogeography*.' Princeton:Princeton University Press.

Mace, G. M. and Collar, N. J. (2002). '*Priority-setting in species conservation*', in *Conserving Bird Diversity: General principals and their application* Eds. Norris, K. and Pain, D. J. Cambridge:Cambridge University Press. Pp. 6?-??

Madsen, T. and Shine, R. (1999). 'Rainfall and rats: Climatically-driven dynamics of a tropical rodent population', *Australian Journal of Ecology*, **24**(1): 80-89.

Manly, B. F. J. (1991). '*Randomization and Monte-Carlo methods in biology*.' New York:Chapman & Hall.

Manly, B. F. J. (1997). '*Randomization, Bootstrap and Monte Carlo methods in Biology*.' London:Chapman & Hall.

Margules, C. R. and Austin, M. P. (1991). '*Nature Conservation: Cost effective biological surveys and data analysis*.' Melbourne:CSIRO.

Mawson, P. R. (1986). '*A comparative study of arachnid community structure in rehabilitated bauxite mines*', Biology Bulletin No. 46, Western Australian Institute of Technology.

May, R. M. (1991). 'The role of ecological theory in planning re-introduction of endangered species', *Symposium of the Zoological Society of London*, **62**: 145-163.

McArdle, B. (1994). '*Multivariate analyses: A biologists guide*.' Townsville:Department of Marine Biology, James Cook University.

McCune, B. and Grace, J. B. (2002). '*Analysis of ecological communities*.' Gleneden Beach, Oregon:MjM Software Design.

McCune, B. and Mefford, M. J. (1999). '*PC-ORD*', Oregon:MjM Software Design.

McDonald, K. B. and Mandla, R. (1993). '*Bauxite mining and beneficiation by Comalco Aluminium Ltd at Weipa, Qld.*' in *Australasian Mining and Metallurgy*. Australian Institute for Mining and Metallurgy. 2nd., ed. Pp. 750-754

McDonald, R. C., Isbell, R. F., Speight, J. G., Walker, J. and Hopkins, M. S. (1990). '*Australian soil and land survey field handbook*.' Melbourne:

McFarland, D. C. (1993). '*Fauna of the Cape York Peninsula Biogeographic Region*', in *Terrestrial vertebrate fauna of Cape York Peninsula* Eds. Winter, J. W. and Lethbridge, P. J. Cairns:Queensland Department of Environment & Heritage. Pp.

McIntyre, S., McIvor, J. G. and Heard, K. M., Eds. (2002). '*Managing and conserving grassy woodlands*', Melbourne:CSIRO.

McKenzie, N. L., Belbin, L., Margules, C. R. and Keighery, G. J. (1989). 'Selecting representative reserve systems in remote areas: A case study in the Nullarbor region, Australia', *Biological Conservation*, **50**: 239-261.

McKenzie, N. L., Robinson, A. C. and Belbin, L. (1991). '*Biogeographic survey of the Nullarbor District, Australia*', in *Nature Conservation: Cost effective biological surveys and data analysis* Eds. Margules, C. R. and Austin, M. P. Melbourne:CSIRO. Pp. 109-126

Merriam, G. (1991). '*Corridors and connectivity: animal populations in heterogenous environments*', in *Nature Conservation 2: The role of corridors* Eds. Saunders, D. A. and Hobbs, R. J. Sydney:Surrey Beatty & Sons. Pp. 133-142

Miller, C. J. (2000). 'Vegetation and habitat are not synonyms', *Ecological Management & Restoration*, **1**(2): 102-104.

Monteith, G. B. and Thomae, D. B. J. (1976). '*Ecological biogeography of Cape York Peninsula*', Interim 4, Australian Biological Resources Study Project.

Moss, R. and Schneider, S. H. (1997). '*Characterizing and communicating scientific uncertainty: moving ahead from the IPCC second assessment*', in *Elements of Change* Ed. Katzenberger, J. Aspen, CO:Aspen Global Change Institute. Pp. 90-135

Myers, K., Margules, C. R. and Musto, I. (1983). '*Survey methods for nature conservation*', Adelaide University,

National Land & Water Resources Audit (2002). '*Australian Terrestrial Biodiversity Assessment 2002*', National Land & Water Resources Audit.

Natural Learning Pty Ltd (1996). '*Birds of Australia 3.0*', West Pennant Hills:Natural Learning Pty Ltd.

Naveh, Z. and Lieberman, A. (1994). '*Landscape ecology*.' New York:Springer-Verlag.

Neldner, V. J. and Clarkson, J. R. (1994). '*Vegetation survey of Cape York Peninsula*', Cape York Peninsula Land Use Study (CYPLUS), Office of the Co-ordinator General and Department of Environment and Heritage,.

Nichols, O. G. and Watkins, D. (1984). 'Bird utilization of rehabilitated bauxite minesites in Western Australia', *Biological Conservation*, **30**: 109-131.

Norris, K. C., Mansergh, I. M., Ahern, L. D., Belcher, C. A., Temby, I. D. and Walsh, N. G. (1983). '*Vertebrate fauna of the Gippsland Lakes catchment, Victoria*', Occasional Paper Series Number 1, Ministry for Conservation, Victoria - Fisheries & Wildlife Division.

Odum, E. P. (1959). '*Fundamentals of ecology*.' Philadelphia:W. B. Saunders.

Office of the Chief Scientist (1992a). '*Scientific aspects of major environmental issues: Biodiversity*', Working Group Paper Department of the Prime Minister & Cabinet.

Office of the Chief Scientist (1992b). '*Scientific aspects of major environmental issues: Climate change*', Working Group Paper Department of the Prime Minister & Cabinet.

Oliver, I. and Beattie, A. J. (1993). 'A possible method for the rapid assessment of biodiversity', *Conservation Biology*, **7**: 562-568.

Parker, T. and Schaap, A. (1988). '*Geology of the reserve*', in *Uningan guide* Ed. Wharton, G. Weipa:Weipa Bicentenial Community Committee. Pp. 22-23

Pearcey, G. (1994). 'Weipa: Bauxite town in the Cape York wilderness' *Australian Geographic*, Oct-Dec, Pp. 88-109.

Pearson, R. and Tait, J. (unpub.). '*Freshwater fish of RAAF Base Scherger*', Australian Centre for Tropical Freshwater Research, James Cook University.

Pielou, E. C. (1984). '*The interpretation of ecological data: a primer on classification and ordination*.' New York:Wiley.

Plowman, K. P. (1981). 'Comparison of invertebrate ground fauna of three habitats at Cooloola, Queensland', *Memoirs of the Queensland Museum*, **92**: 43-47.

Pollack, S., Bruce, P., Borenstein, M. and Lieberman, J. (1994). 'The resampling method of statistical analysis', *Psychopharmacology Bulletin*, **30**(2): 227-234.

Potter, V. R. (1990). 'Getting to the year 3000: Can global bioethics overcome evolution's fatal flaw?' *Perspectives in Biology and Medicine*, **34**(1): 89-98.

Prendergast, J. R., Quinn, R. M., Lawton, J. H., Eversham, B. C. and Gibbons, D. W. (1993). 'Rare species, the coincidence of diversity hotspots and conservation strategies', *Nature*, **365**: 335-337.

Price, O. F. (2004). 'Indirect evidence that frugivorous birds track fluctuating fruit resources among rainforest patches in the Northern Territory, Australia', *Austral Ecology*, **29**(2): 137-144.

Pulliam, H. R. (1996). '*Sources and sinks: Empirical evidence and population consequences*', in *Population dynamics in ecological space and time* Eds. Rhodes, O., E., Chesser, R. K. and Smith, M. H. Chicago:The University of Chicago Press. Pp. 45 - 69

Queensland Government (1989). '*Fauna Conservation Regulations*', Queensland Government.

Queensland Government (1992). '*Nature Conservation Act*', Queensland Government.

Queensland Government (1994). '*Nature Conservation (Wildlife) Regulations*', Queensland Government.

Reeders, A. P. F. (1983). '*Vertebrate fauna in the regenerated mines at Weipa, North Queensland*', North Australian mine rehabilitation workshop No. 9, Weipa, Comalco Aluminium Limited.

Reeders, A. P. F. and Morton, A. G. (1983). '*Vertebrate fauna in the regenerated mines at Weipa*', Comalco Aluminium Limited.

Reid, J. R. W., Kerle, J. A. and Morton, S. R. (1993). '*Vertebrates of Uluru (Ayers Rock - Mount Olga) National Park, N. T.*' Canberra:Australian National Parks & Wildlife Service.

Reid, R. E., Gunn, R. H., Stackhouse, K. M. and Galloway, R. W. (1988). '*Framework for soil and land resource surveys*', in *Australian soil and land survey handbook* Eds. Gunn, R. H., Beattie, J. A., Reid, R. E. and van de Graaff, R. H. M. Melbourne:Inkata Press. Pp. 7-19

Rhodes, O., E., Chesser, R. K. and Smith, M. H., Eds. (1996). '*Population dynamics in ecological space and time*', Chicago:The University of Chicago Press.

Ridpath, M. G. (1985). '*Ecology in the wet-dry tropics: how different?*' Ecology of the wet-dry tropics, Darwin, Darwin Institute of Technology & The Ecological Society of Australia, Inc.

Ridpath, M. G. and Corbett, L. K., Eds. (1985). '*Ecology of the wet-dry tropics*', Darwin:Darwin Institute of Technology & The Ecological Society of Australa Inc.

Ruefenacht, B. and Knight, R. L. (1995). 'Influences of corridor continuity and width on survival and movement of Deermice *Peromyscus maniculatus*', *Biological Conservation*, **71**(3): 269-274.

SAS Institute (1997). '*JMP 3.1.6*', Cary:SAS Institute, Inc.

Schneider, S. H. (1997). 'Defining and teaching environmental literacy', *Trends and Research in Evolution and Ecology*, **12**(11): 457.

Shine, R. (1985). '*The reproductive biology of Australian reptiles: A search for general patterns*', in *Biology of Australasian frogs and reptiles* Eds. Grigg, G., Shine, R. and Ehmann, H. Sydney:Surrey Beatty & Sons in assoc. with the Royal Zoological Society of New South Wales. Pp. 297-303

Simberloff, D. and Cox, J. (1987). 'Consequences and costs of conservation corridors', *Conservation Biology*, **1**: 63-71.

Simberloff, D., Farr, J. A., Cox, J. and Mehlman, D. W. (1992). 'Movement corridors: conservation bargains or poor investments?' *Biological Conservation*, **35**: 19-40.

Simon, J. L. and Bruce, P. (1995). 'The new biostatistics of resampling', *MD Computing*, **12**(2): 115.

Sioli, H. (1986). '*Tropical continental aquatic habitats*', in *Conservation biology: The science of scarcity and diversity* Ed. Soulé, M. E. Massachusetts:Sinauer Associates, Inc. Pp. 383-393

Slater, P., Slater, P. and Slater, R. (1986). '*The Slater field guide to Australian birds*.' Sydney:Weldon.

Smyth, A. K. and James, C. D. (2004). 'Characteristics of Australia's rangelands and key design issues for monitoring biodiversity', *Austral Ecology*, **29**(1): 3-15.

Sokal, R. R. and Rohlf, F. J. (1995). '*Biometry*.' New York, USA:Freeman.

Sokal, R. R. and Sneath, P. H. A. (1963). '*Principals of numerical taxonomy*.' San Francisco:W. H. Freeman.

Soulé, M. E. (1986a). '*Conservation biology and the "Real World"*', in *Conservation biology: The science of scarcity and diversity* Ed. Soulé, M. E. Massachusetts:Sinauer Associates, Inc. Pp. 1-12

Soulé, M. E., Ed. (1986b). '*Conservation biology: The science of scarcity and diversity*', Massachusetts:Sinauer Associates.

Southwood, T. R. E. (1978). '*Ecological Methods*.' London:Chapman & Hall.

Speight, J. G. (1990). '*Land classification*', in *Australian soil and land survey handbook: Guidelines for conducting surveys* Eds. Gunn, R. H., Beattie, J. A., Reid, R. E. and van de Graaff, R. H. M. Melbourne:Inkata Press. Pp. 38-59

Spellerberg, I. F. (1991). '*Monitoring ecological change*.' Cambridge:Cambridge University Press.

Stocker, G. C., Unwin, G. L. and West, P. W. (1985). 'Measures of richness, evenness and diversity in tropical rainforest', *Australian Journal of Botany*, **33**(2): 131-137.

Strahan, R., Ed. (1983). '*The Australian Museum complete book of Australian mammals*', The National Photographic Index of Australian Wildlife. Sydney:Cornstalk Publishing.

Strahan, R., Ed. (1985). '*The Australian Museum complete book of Australian mammals*', The National Photographic Indeex of Australian Wildlife. Sydney:Cornstalk Publishing.

Strahan, R. (1992). '*Encyclopedia of Australian animals: Mammals*.' Sydney:Harper-Collins.

Strahan, R. (1995). '*A photographic guide to mammals of Australia*.' Sydney:New Holland (Publishers) Ltd.

Street, A. and Alexander, W. (1994). '*Metals in the service of man*.' London:Penguin.

Taylor, J. A. and Dunlop, C. R. (1985). '*Plant communities of the wet-dry tropics of Australia: the Alligator Rivers region, Northern Territory*', in *Ecology of the wet-dry tropics* Eds. Ridpath, M. G. and Corbett, L. K. Proceedings of the Ecological Society of Australia. Pp. 83-127

Thackway, R. and Cresswell, I. D. (1994). 'Toward an interim biogeographic regionalization of Australia' *ErinEyes*, June 1994, Pp. 4-5.

Thompson, D. F. (1935). '*Birds of Cape York Peninsula*.' Melbourne:Australian Government Printer.

Thompson, G. G., De Boer, M. and Pianka, E. R. (1999). 'Activity areas and daily movements of an arboreal monitor lizard, Varanus tristis (Squamata:Varanidae) during the breeding season', *Australian Journal of Ecology*, **24**(2): 117-122.

Thompson, G. G. and Withers, P. C. (2003). 'Effect of species richness and relative abundance on the shape of the species accumulation curve', *Austral Ecol*, **28**(4): 355-360.

Tracey, J. G. (1982). '*The vegetation of the humid tropical region of North Queensland*.' Melbourne:CSIRO.

Turner, M. G. and Gardner, R. H. (1991). '*Quantitative methods in landscape ecology*.' New York:Springer-Verlag.

Underwood, A. J. (1995). 'Ecological research (and research into) environmental management', *Ecological Applications*, **5**(1): 232-247.

Vermeulen, H. J. W. (1994). 'Corridor function of a road verge for dispersal of stenotopic heathland ground beetles carabidae', *Biological Conservation*, **69**(3): 339-349.

Walton, D. W. and Richardson, B. J., Eds. (1989). '*Fauna of Australia. 1B Mammalia*', Canberra:Australian Government Publishing Service.

Ward, S. C., Koch, J. M. and Nichols, O. G. (1990). '*Bauxite mine rehabilitation in the Darling Range, Western Australia*', Australian ecosystems: 200 years of utilization, degredation and reconstruction, Geraldton, WA, The Ecological Society of Australia, Inc.

Watson, D. M. (2003). 'The 'standardized search': An improved way to conduct bird surveys', *Australian Journal of Ecology*, **28**(5): 515-525.

Webster Publishing (c. 1996). '*Australian Mammals*', Webster Publishing.

Wharton, G., Ed. (1988). '*Unigan Guide*', Weipa:Weipa Bicentenial Community Committee.

Wharton, G. (1998). Comments on thesis. Pp.

Wheeler, R. and Wheeler, V. (1977). 'We visit Weipa, Cape York Peninsula', *Bird Observer*, **543**: 9-10.

Whittaker, R. H. (1972). 'Evolution and measurement of diversity', *Taxon*, **21**: 213-251.

Williams, S. (1994). 'The importance of riparian habitats to vertebrate assemblages in North Queensland woodlands', *Memoirs of the Queensland Museum*, **35**(1): 248.

Williams, S., Pearson, R. and Burnett, S. (1993). 'Survey of vertebrate fauna of the Dotswood area, North Queensland', *Memoirs of the Queensland Museum*, **35**(1): 361-378.

Williams, S. E. (1995). '*Measuring and monitoring wildlife communities: the problem of bias*', in *Conservation through sustainable use of wildlife* Eds. Grigg, G. C., Hale, P. T. and Lunney, D. Brisbane:University of Queensland. Pp.

Winter, J. W. (1988). '*Ecological specialization of mammals in Australian tropical and sub-tropical rainforest: refugial or ecological determinism?*' The ecology of Australia's wet tropics, University of Queensland, Brisbane, Ecological Society of Australia, Inc.

Winter, J. W. (1989). '*Weipa land use study: fauna conservation strategy*', Comalco Aluminium Limited.

Winter, J. W. and Alford, R. A. (1999). '*Fauna of regeneration*', Comalco.

Winter, J. W. and Atherton, R. G. (1985). '*Survey of the mammals and other vertebrates of the Weipa region, Cape York Peninsula - Final Report*', Queensland National Parks & Wildlife Service.

Winter, J. W. and Lethbridge, P. J. (1995). '*Terrestrial vertebrate fauna of Cape York Peninsula*', Cape York Peninsula Land Use Strategy, Office of the Co-ordinator General, Brisbane, Department of the Environment, Sport and Territories, Canberra.

Woinarski, J. C. Z. and Ash, A. J. (2002). 'Responses of vertebrates to pastoralism, military land use and landscape position in an Australian tropical savanna', *Austral Ecology*, **27**(3): 311-323.

Woinarski, J. C. Z., Horner, P., Fisher, A., Brennan, K., Lindner, D. A., Gambold, N., Chatto, R. and Morris, I. (1999). 'Distributional patterning of terrestrial herpetofauna on the Wessel and English Company Island groups, northeastern Arnhem land, Northern territory, Australia', *Australian Journal of Ecology*, **24**(1): 60-79.

Woinarski, J. C. Z., Milne, D. J. and Wanganeen, G. (2001). 'Changes in mammal populations in relatively intact landscapes of Kakadu National Park, Northern Territory, Australia', *Austral Ecol*, **26**(4): 360-370.

Wright, M. G. and Samways, M. J. (1998). 'Insect species richness tracking plant species richness in a diverse flora: gall-insects in the Cape Floristic Region, South Africa', *Oecologia*, **115**(3): 427-433.

Zar, J. H. (1984). '*Biostatistical analysis*.' New Jersey:Prentice-Hall International.

Appendices

General Legend

Class

The Class (mammal, bird, reptile or frog) to which the vertebrate belongs.

Name

The scientific and common name of the species according to version 8.0 of the Census of Australian Vertebrate Species.

Observations

The total number of observations recorded during the study, either systematic or incidental.

Abundance

The sum of abundances estimated from only those species systematically observed.

Values within summary breaks give total number of species for observation columns, and the sum of abundances for abundance columns.

Appendix A - Site list

Legend

Site codes

A four character alphanumeric code which indicates what level of each of the four factors the site represents and the replicate number of the site. For example, with a site code of AC11 the first character indicates that the site is in the **A**ndoom region (compared to the **W**eipa region), the second character that the riparian site closest to it is located in **C**reek habitat (compared to a **S**wamp or **M**arine habitat), the third character (a digit) that the group of sites is the first (**1**) of at most two (**2**) replicate sets of sites, and the last character (a digit) that this site is located within Riparian (**1**) habitat (compared to Ecotone (**2**) habitat, Economic Woodland (**3**) habitat or Uneconomic Woodland (**4**) habitat).

Landunit

The dominant landunit (Godwin 1985; Gunness *et al.* 1986) for the site.

Ore Value

The economic value of the the underlying orebody - **E**conomic or **U**neconomic.

Proximity

The proximal habitat of the site, relative to a riparian habitat - **R**iparian, **E**cotone or **W**oodland

RiparianType

The riparian habitat type the site was located in - **C**reek, **S**wamp or **M**arine.

Region

The region the site was located in - **A**ndoom or **W**eipa.

Appendix A - Site list

Site Name (1)	Site Code	Land Unit (2)	Site Factors: Value	Habitat Type	Mesic Type	Region	Geocode (3): Latitude	Longitude	Northing	Easting	Horizontal Accuracy	Altitude	Altitude Accuracy	Source	Observer
Vyces	AC11	4a		Mesic	Creek	Andoom	12° 28' 48" N	141° 54' 09" E'	20,017	43,525	±200 m	10 m	±10 m	Topo.100	AJ Thomas
Crossing	AC12	5e		Ecotone			0.64	141° 54' 10" E'	20,445	39,616	±100 m	10 m	±10 m	GPS fix	AJ Thomas
(off-lease)	AC13	2b	Economic	Woodland			12° 29' 43" N	141° 54' 30" E'	22,554	38,174	±100 m	10 m	±10 m	GPS fix	AJ Thomas
Betteridge	AM11	7d		Mesic	Marine		12° 28' 30" N	141° 46' 57" E'	-22,783	41,739	±100 m	10 m	±10 m	GPS fix	AJ Thomas
Landing	AM12	5e		Ecotone			12° 28' 31" N	141° 47' 00" E'	-22,478	41,664	±100 m	10 m	±10 m	GPS fix	AJ Thomas
	AM13	5k	Economic	Woodland			12° 28' 56" N	141° 46' 53" E'	-22,957	39,094	±100 m	10 m	±10 m	GPS fix	AJ Thomas
	AM14	5k	Uneconomic	Woodland			12° 28' 47" N	141° 47' 13" E'	-21,059	40,165	±100 m	10 m	±10 m	GPS fix	AJ Thomas
North	AS11	7b		Mesic	Swamp		12° 28' 37" N	141° 50' 03" E'	-4,361	42,586	±100 m	10 m	±10 m	GPS fix	AJ Thomas
Andoom	AS12	5e		Ecotone			12° 28' 38" N	141° 50' 06" E'	-4,057	42,511	±100 m	10 m	±10 m	GPS fix	AJ Thomas
Swamp	AS13	2b	Economic	Woodland			12° 28' 41" N	141° 50' 37" E'	-971	42,467	±100 m	30 m	±10 m	GPS fix	AJ Thomas
(Nundah)	AS14	2b	Uneconomic	Woodland			12° 28' 01" N	141° 50' 34" E'	-1,606	46,461	±100 m	30 m	±10 m	GPS fix	AJ Thomas
Botchet	AS21	7b		Mesic	Swamp		12° 30' 44" N	141° 48' 01" E'	-15,328	28,811	±100 m	10 m	±10 m	GPS fix	AJ Thomas
Swamp	AS22	5e		Ecotone			12° 30' 42" N	141° 47' 59" E'	-15,542	28,996	±100 m	10 m	±10 m	GPS fix	AJ Thomas
	AS23	2b	Economic	Woodland			12° 30' 27" N	141° 47' 37" E'	-17,841	30,319	±100 m	10 m	±10 m	GPS fix	AJ Thomas
	AS24	2b	Uneconomic	Woodland			12° 30' 28" N	141° 47' 52" E'	-16,352	30,344	±100 m	10 m	±10 m	GPS fix	AJ Thomas
Barkly Yard	WC11	4b		Mesic	Creek	Weipa	12° 37' 05" N	141° 59' 05" E'	31,757	29,485	±100 m	25 m	±10 m	GPS fix	AJ Thomas
Creek	WC12	2b		Ecotone			12° 37' 07" N	141° 59' 08" E'	32,072	29,313	±100 m	25 m	±10 m	GPS fix	AJ Thomas
	WC13	2b	Economic	Woodland			12° 37' 38" N	141° 59' 17" E'	33,269	26,292	±100 m	25 m	±10 m	GPS fix	AJ Thomas
(Salmon)	WC14	2b	Uneconomic	Woodland			12° 37' 07" N	141° 59' 42" E'	35,422	29,648	±100 m	25 m	±10 m	GPS fix	AJ Thomas
Uningan	WC21	4b		Mesic	Creek		12° 37' 17" N	141° 56' 27" E'	16,310	26,725	±100 m	10 m	±10 m	GPS fix	AJ Thomas
Springs	WC22	2b		Ecotone			12° 37' 16" N	141° 56' 27" E'	16,300	26,826	±100 m	10 m	±10 m	GPS fix	AJ Thomas
	WC23	2b	Economic	Woodland			12° 36' 47" N	141° 56' 29" E'	16,206	29,755	±100 m	10 m	±10 m	GPS fix	AJ Thomas
(Pike)	WC24	2b	Uneconomic	Woodland			12° 36' 40" N	141° 56' 01" E'	13,377	30,181	±100 m	10 m	±10 m	GPS fix	AJ Thomas
Rhum Point	WM11	7d		Mesic	Marine		12° 43' 22" N	141° 56' 48" E'	22,040	-9,685	±100 m	10 m	±10 m	GPS fix	AJ Thomas
Dunes	WM12	2b		Ecotone			12° 43' 17" N	141° 56' 48" E'	21,989	-9,183	±100 m	10 m	±10 m	GPS fix	AJ Thomas
	WM13	2b	Economic	Woodland			12° 42' 45" N	141° 56' 57" E'	22,555	-5,884	±100 m	10 m	±10 m	GPS fix	AJ Thomas
(Whiting)	WM14	2b	Uneconomic	Woodland			12° 42' 36" N	141° 56' 47" E'	21,480	-5,080	±100 m	10 m	±10 m	GPS fix	AJ Thomas
Willum	WS11	7b		Mesic	Swamp		12° 39' 24" N	141° 59' 39" E'	36,498	15,874	±100 m	25 m	±10 m	GPS fix	AJ Thomas
Swamp	WS12	5e		Ecotone			12° 39' 23" N	141° 59' 32" E'	35,799	15,906	±100 m	25 m	±10 m	GPS fix	AJ Thomas
	WS13	2b	Economic	Woodland			12° 39' 09" N	141° 59' 03" E'	32,802	17,025	±100 m	25 m	±10 m	GPS fix	AJ Thomas

Notes:
1) Site names from Commonwealth of Australia map 'Weipa QLD 1:100,000 R631 7272', Commonwealth of Australia. Site names in brackets refer to minesite regions used at Comalco's Weipa operation
2) Land units are from Godwin, M. D. (1985). 'Land units of the Weipa region, Cape York Peninsula', Comalco Aluminium Limited.
3) Northing and easting values are minegrid references used in Comalco's Weipa operation

Appendix B - Land unit descriptions

The following descriptions are extracts from Gunness, *et al.* (1987).

Unit 2b - Woodland

Tall Darwin stringybark (*Eucalyptus tetrodonta*) woodland on red earth soils.

Sites (15): AS13, AS14, AS23, AS24, AC13, WC12, WC13, WC14, WC22, WC23, WC24, WS13, WM12, WM13, WM14.

Unit 4a - Riparian

Gallery forest along permanent and semi-permanent watercourses.

Sites (1): AC11.

Unit 4b - Riparian

Mesophyll palm forest and swamp forest or woodland on gleyed moist soils.

Sites (2): WC11, WC21.

Unit 5c - Riparian

Woodland on low beach dunes with horse-tail she-oak.

Sites (1): WM11

Unit 5e - Ecotone

Woodland on colluvial upper reaches of broad drainage basins - yellow podzolic soils.

Sites (5): AM12, AC12, WC22, WS12, AS22.

Unit 5k - Woodland

Melville Island Bloodwood and Darwin Stringybark (*E. tetrodonta*) open shrubby woodland on shallow yellowish red soils with outcropping ironstone.

Appendix C - Species list

Species list with count of systematic and incidental observations, the sum of individuals recorded using systematic sampling and the date first seen.

Legend

Date first seen

The date the species was first recorded during the study using systematic survey methods.

Appendix C - Species list

Class	Species		Count of observations	Abundance	Date first observed (1)
Mammalia	*Tachyglossus aculeatus*	Short-beaked Echidna	1		01 Nov 1991
	Sminthopsis virginiae	Red-cheeked Dunnart	2		16 Aug 1992
	Isoodon macrourus	Northern Brown Bandicoot	11	5	31 Jan 1992
	Petaurus breviceps	Sugar Glider	4	2	02 Jul 1992
	Possum complex A	Possum complex A	4	4	18 Aug 1992
	Macropus agilis	Agile Wallaby	21		10 Oct 1991
	Macropus antilopinus	Antilopine Kangaroo	5		12 Oct 1991
	Pteropus alecto	Black Flying Fox	1		10 Oct 1991
	Mesembriomys gouldii	Black-footed Tree-rat	1		01 Jun 1993
	Melomys burtoni	Grassland Melomys	49	12	05 Mar 1992
	Canis familiaris	Dingo	15	2	10 Oct 1991
	Felis catus	Feral Cat	9	1	14 Jun 1992
	Sus scrofa	Feral Pig	14	1	11 Oct 1991
	Bos taurus	European Cattle	1		09 Dec 1992
Total count of mammal species observed and number used in abundance comparison			14	7	
Aves	*Dromaius novaehollandiae*	Emu	1	1	10 Feb 1992
	Alectura lathami	Australian Brush-turkey	2		10 Oct 1991
	Megapodius reinwardt	Orange-footed Scrubfowl	7	1	10 Oct 1991
	Tadorna radjah	Radjah Shelduck	1		08 Feb 1992
	Anas superciliosa	Pacific Black Duck	1		28 Aug 1992
	Anas gracilis	Grey Teal	1		26 Aug 1992
	Tachybaptus novaehollandiae	Australasian Grebe	3		11 Oct 1991
	Phalacrocorax melanoleucos	Little Pied Cormorant	3		11 Oct 1991
	Phalacrocorax sulcirostris	Little Black Cormorant	1		18 Sep 1992
	Pelecanus conspicillatus	Australian Pelican	2		19 May 1992
	Fregata sp.	Frigatebird sp.	3		20 Sep 1992
	Egretta novaehollandiae	White-faced Heron	1		18 Sep 1992
	Ardea alba	Great Egret	4		11 Oct 1991
	Threskiornis molucca	Australian White Ibis	5		21 Oct 1991
	Threskiornis spinicollis	Straw-necked Ibis	3		11 Oct 1991
	Platalea regia	Royal Spoonbill	1		08 Sep 1992
	Ephippiorhynchus asiaticus	Black-necked Stork (Jabiru)	4		01 Nov 1991
	Lophoictinia isura	Square-tailed Kite	1		11 Apr 1993
	Milvus migrans	Black Kite	5	3	11 Oct 1991
	Haliastur sphenurus	Whistling Kite	4		11 Oct 1991
	Haliastur indus	Brahminy Kite	11	3	11 Oct 1991
	Haliaeetus leucogaster	White-bellied Sea-Eagle	3		01 Nov 1991
	Falco berigora	Brown Falcon	5	1	20 May 1992
	Grus rubicunda	Brolga	2		01 Nov 1991
	Amaurornis olivaceus	Bush-hen	2		12 Feb 1992
	Ardeotis australis	Australian Bustard	1		26 May 1992
	Limosa lapponica	Bar-tailed Godwit	2		18 Sep 1992
	Numenius phaeopus	Whimbrel	2		18 Sep 1992
	Numenius madagascariensis	Eastern Curlew	2		18 Sep 1992
	Tringa nebularia	Common Greenshank	2		25 Aug 1992
	Heteroscelus brevipes	Grey-tailed Tattler	1		18 Sep 1992
	Calidris tenuirostris	Great Knot	1		18 Sep 1992
	Calidris acuminata	Sharp-tailed Sandpiper	1		18 Sep 1992
	Irediparra gallinacea	Comb-crested Jacana	1		11 Oct 1991
	Burhinus grallarius	Bush Stone-curlew	1		21 May 1993
	Haematopus longirostris	Pied Oystercatcher	3		16 Sep 1992
	Himantopus himantopus	Black-winged Stilt	3		01 Nov 1991
	Pluvialis fulva	Pacific Golden Plover	2		18 Sep 1992
	Vanellus miles	Masked Lapwing	1		11 Oct 1991
	Larus novaehollandiae	Silver Gull	2		18 Sep 1992
	Sterna nilotica	Gull-billed Tern	3		16 Sep 1992
	Sterna caspia	Caspian Tern	1		22 Sep 1992
	Sterna bengalensis	Lesser Crested Tern	2		18 Sep 1992
	Sterna bergii	Crested Tern	2		16 Aug 1992
	Sterna albifrons	Little Tern	3		16 Sep 1992
	Sterna hybrida	Whiskered Tern	1		22 Sep 1992
	Geopelia striata	Peaceful Dove	31	77	11 Oct 1991
	Geopelia humeralis	Bar-shouldered Dove	52	58	11 Oct 1991
	Ptilinopus regina	Rose-crowned Fruit-Dove	1		10 Oct 1991
	Ducula bicolor	Pied Imperial-Pigeon	14	11	10 Oct 1991
	Probosciger aterrimus	Palm Cockatoo	10	13	23 May 1992
	Calyptorhynchus banksii	Red-tailed Black-Cockatoo	2		26 Aug 1992
	Cacatua galerita	Sulphur-crested Cockatoo	79	61	10 Oct 1991
	Trichoglossus haematodus	Rainbow Lorikeet	118	344	10 Oct 1991
	Aprosmictus erythropterus	Red-winged Parrot	44	94	21 Oct 1991
	Platycercus adscitus	Pale-headed Rosella	16	39	11 Feb 1992
	Cacomantis flabelliformis	Fan-tailed Cuckoo	1		19 Jun 1992
	Chrysococcyx minutillus	Little Bronze-Cuckoo	1		15 Sep 1992

Class	Species		Count of observations	Abundance	Date first observed (1)
	Eudynamys scolopacea	Common Koel	17	21	10 Oct 1991
	Centropus phasianinus	Pheasant Coucal	47	48	11 Oct 1991
	Ninox novaeseelandiae	Southern Boobook	5	2	23 May 1992
	Podargus strigoides	Tawny Frogmouth	9		10 Oct 1991
	Podargus papuensis	Papuan Frogmouth	5	2	10 Oct 1991
	Podargus ocellatus	Marbled Frogmouth	1		22 May 1992
	Aegotheles cristatus	Australian Owlet-nightjar	2		11 Oct 1991
	Collocalia sp.	Swiftlet sp.	2		27 Jan 1992
	Alcedo azureus	Azure Kingfisher	3		01 Nov 1991
	Dacelo novaeguineae	Laughing Kookaburra	46	87	12 Oct 1991
	Dacelo leachii	Blue-winged Kookaburra	73	126	10 Oct 1991
	Syma torotoro	Yellow-billed Kingfisher	6	6	31 Aug 1992
	Todirhamphus macleayii	Forest Kingfisher	38	62	11 Oct 1991
	Todirhamphus sanctus	Sacred Kingfisher	2		23 Feb 1992
	Merops ornatus	Rainbow Bee-eater	49	138	02 Feb 1992
	Eurystomus orientalis	Dollarbird	1		13 Apr 1993
	Climacteris picumnus	Brown Treecreeper	9	11	10 Oct 1991
	Malurus amabilis	Lovely Wren	1		10 Oct 1991
	Malurus melanocephalus	Red-backed Fairy-wren	2		08 Feb 1992
	Pardalotus striatus	Striated Pardalote	19	35	18 Jun 1992
	Smicrornis brevirostris	Weebill	12	28	10 Jun 1992
	Gerygone palpebrosa	Fairy Gerygone	3		26 Aug 1992
	Gerygone olivacea	White-throated Gerygone	1		19 Aug 1992
	Philemon corniculatus	Noisy Friarbird	42	108	30 Jan 1992
	Philemon citreogularis	Little Friarbird	93	253	11 Oct 1991
	Entomyzon cyanotis	Blue-faced Honeyeater	9	19	12 Oct 1991
	Xanthotis chrysotis	Tawny-breasted Honeyeater	5	7	10 Oct 1991
	Meliphaga notata	Yellow-spotted Honeyeater	2		10 Oct 1991
	Meliphaga gracilis	Graceful Honeyeater	1		18 Sep 1992
	Lichenostomus versicolor	Varied Honeyeater	1		23 Feb 1992
	Lichenostomus flavus	Yellow Honeyeater	36	79	11 Oct 1991
	Melithreptus albogularis	White-throated Honeyeater	113	575	10 Oct 1991
	Lichmera indistincta	Brown Honeyeater	3		01 Jul 1992
	Ramsayornis modestus	Brown-backed Honeyeater	3		11 Oct 1991
	Ramsayornis fasciatus	Bar-breasted Honeyeater	3		11 Oct 1991
	Certhionyx pectoralis	Banded Honeyeater	2		24 Sep 1992
	Myzomela obscura	Dusky Honeyeater	7	9	10 Oct 1991
	Myzomela erythrocephala	Red-headed Honeyeater	1		18 Sep 1992
	Myzomela sanguinolenta	Scarlet Honeyeater	2		15 Aug 1992
	Microeca flavigaster	Lemon-bellied Flycatcher	83	216	11 Oct 1991
	Pomatostomus temporalis	Grey-crowned Babbler	15	35	11 Oct 1991
	Daphoenositta chrysoptera	Varied Sittella	14	60	16 Jun 1992
	Pachycephala simplex	Grey Whistler	10	10	21 Oct 1991
	Pachycephala rufiventris	Rufous Whistler	3		10 Oct 1991
	Colluricincla megarhyncha	Little Shrike-thrush	5	6	10 Oct 1991
	Colluricincla harmonica	Grey Shrike-thrush	48	62	13 Feb 1992
	Monarcha trivirgatus	Spectacled Monarch	2		15 Aug 1992
	Myiagra rubecula	Leaden Flycatcher	38	60	11 Oct 1991
	Myiagra alecto	Shining Flycatcher	1		17 Dec 1992
	Grallina cyanoleuca	Magpie Lark	2		11 Oct 1991
	Rhipidura fuliginosa	Grey Fantail	1		26 Jun 1993
	Dicrurus bracteatus	Spangled Drongo	6	5	12 Oct 1991
	Coracina novaehollandiae	Black-faced Cuckoo-shrike	14	14	16 Feb 1992
	Coracina papuensis	Childrens Python	83	201	11 Oct 1991
	Coracina tenuirostris	Cicadabird	6	5	17 Feb 1992
	Lalage sueurii	White-winged Triller	3		19 Aug 1992
	Lalage leucomela	Varied Triller	8	38	10 Oct 1991
	Oriolus flavocinctus	Yellow Oriole	11	9	10 Oct 1991
	Oriolus sagittatus	Olive-backed Oriole	4	6	09 Sep 1992
	Sphecotheres viridis	Figbird	2		11 Oct 1991
	Artamus minor	Little Woodswallow	1		15 Dec 1992
	Cracticus quoyi	Black Butcherbird	3	1	12 Feb 1992
	Cracticus mentalis	Black-backed Butcherbird	37	66	12 Oct 1991
	Cracticus nigrogularis	Pied Butcherbird	12	21	27 Jan 1992
	Gymnorhina tibicen	Australian Magpie	8	17	18 Jun 1992
	Ptiloris magnificus	Magnificent Riflebird	6	1	10 Oct 1991
	Manucodia keraudrenii	Trumpet Manucode	1		10 Oct 1991
	Corvus orru	Torresian Crow	46	41	11 Oct 1991
	Chlamydera nuchalis	Great Bowerbird	9	5	24 May 1992
	Neochmia ruficauda	Star Finch	1		14 Dec 1992
	Neochmia temporalis	Red-browed Finch	3		22 Oct 1991
	Nectarinia jugularis	Yellow-bellied Sunbird	4	2	12 Oct 1991
	Dicaeum hirundinaceum	Mistletoebird	6	8	13 Jun 1992
	Hirundo ariel	Fairy Martin	3		09 Jun 1992

Class	Species		Count of observations	Abundance	Date first observed (1)
Total count of bird species observed and number used in abundance comparison			132	55	
Reptilia	*Chelodina rugosa*	Northern Snake-necked Turtle	1		28 May 1993
	Gehyra dubia	Gehyra dubia	26	12	11 Jun 1992
	Heteronotia binoei	Bynoe's Gecko	9	7	11 Oct 1991
	Nactus pelagicus	Pelagic Gecko	165	130	11 Oct 1991
	Oedura castelnaui	Northern Velvet Gecko	16	7	02 Nov 1991
	Oedura rhombifer	Oedura rhombifer	41	27	01 Nov 1991
	Rhacodactylus australis	Giant Tree-gecko	13	8	11 Oct 1991
	Delma tincta	Delma tincta	2		14 Feb 1992
	Lialis burtonis	Burton's Snake-lizard	7	6	11 Jun 1992
	Diporiphora sp. A	Unidentified Diporiphora	122	91	11 Oct 1991
	Lophognathus temporalis	Lophognathus temporalis	5	3	21 Oct 1991
	Varanus panoptes	Varanus panoptes	1		14 Aug 1992
	Varanus tristis	Varanus tristis	15	9	30 Jan 1992
	Carlia jarnoldae	Jewel Skink	32	23	28 Jan 1992
	Carlia longipes	Carlia longipes	190	168	10 Oct 1991
	Carlia storri	Carlia storri	54	39	16 Oct 1991
	Cryptoblepharus virgatus	Cryptoblepharus virgatus	59	42	02 Nov 1991
	Ctenotus spaldingi	Ctenotus spaldingi	42	34	27 Jan 1992
	Egernia frerei	Major Skink	8	3	08 Mar 1992
	Glaphyromorphus nigricaudis	Glaphyromorphus nigricaudis	62	47	10 Oct 1991
	Morethia taeniopleura	Fire-tailed Skink	15	12	03 Feb 1992
	Ramphotyphlops sp. aff. minimus	Ramphotyphlops sp. aff. minimus	1		10 Jun 1993
	Ramphotyphlops polygrammicus	Ramphotyphlops polygrammicus	2		01 Feb 1992
	Liasis maculosa	Childrens Python	1		15 Dec 1992
	Morelia spilota	Carpet Python	1		21 May 1993
	Boiga irregularis	Brown Tree Snake	1		16 Jun 1992
	Dendrelaphis punctulata	Common Tree Snake	5	2	01 Feb 1992
	Tropidonophis mairii	Freshwater Snake	1		03 Feb 1992
	Demansia vestigiata	Demansia vestigiata	11	4	03 Feb 1992
	Furina ornata	Orange-naped Snake	2		19 Sep 1992
	Oxyuranus scutellatus	Taipan	1		01 Oct 1992
	Rhinoplocephalus nigrostriatus	Black-striped Snake	4	3	07 Dec 1992
Total count of reptile species observed and number used in abundance comparison			32	21	
Amphibia	*Limnodynastes convexiusculus*	Marbled Frog	5	2	26 Feb 1992
	Limnodynastes ornatus	Ornate Burrowing Frog	60	42	17 Feb 1992
	Uperoleia mimula	Torres Gungan	139	124	29 Jan 1992
	Crinia remota	Torrid Froglet	151	110	29 Jan 1992
	Litoria bicolor	Northern Sedgefrog	64	38	12 Oct 1991
	Litoria caerulea	Green Treefrog	2		05 Feb 1992
	Litoria gracilenta	Graceful Treefrog	4	1	17 Feb 1992
	Litoria infrafrenata	White-lipped Treefrog	15	6	02 Mar 1992
	Litoria nasuta	Striped Rocketfrog	99	72	02 Nov 1991
	Litoria nigrofrenata	Tawny Rocketfrog	12	6	23 Feb 1992
	Litoria pallida	Peach-sided Rocketfrog	2		17 Feb 1992
	Litoria rothii	Red-eyed Treefrog	4		29 Jan 1992
	Litoria rubella	Naked Treefrog	8	1	19 Aug 1992
	Cyclorana novaehollandiae	Eastern Snapping-Frog	2		17 Feb 1992
	Sphenophryne gracilipes	Shrill Chirper	39	30	12 Feb 1992
	Rana daemeli	Australian Bullfrog	3		05 Jan 1993
	Bufo marinus	Cane Toad	213	131	10 Oct 1991
Total count of frog species observed and number used in abundance comparison			17	12	
Total count of vertebrate species observed and number used in abundance comparison			195	95	

Notes:
(1) Date first observed is for this survey only.

Appendix D - Species distribution maps

Species recorded in this survey are located in solid black 5' blocks, and observations by Winter and Atherton (Winter and Atherton 1985) are located in dark grey blocks. Light grey blocks represent blocks searched. First genus or species name where separated by / is current, and second is as in Winter and Atherton (Winter and Atherton 1985).

Sites (2): AM13, AM14.

Unit 7b - Riparian

Melaleuca/Swamp Mahogany on the outer margins of circular drainage depressions and sinkholes in flat plains.

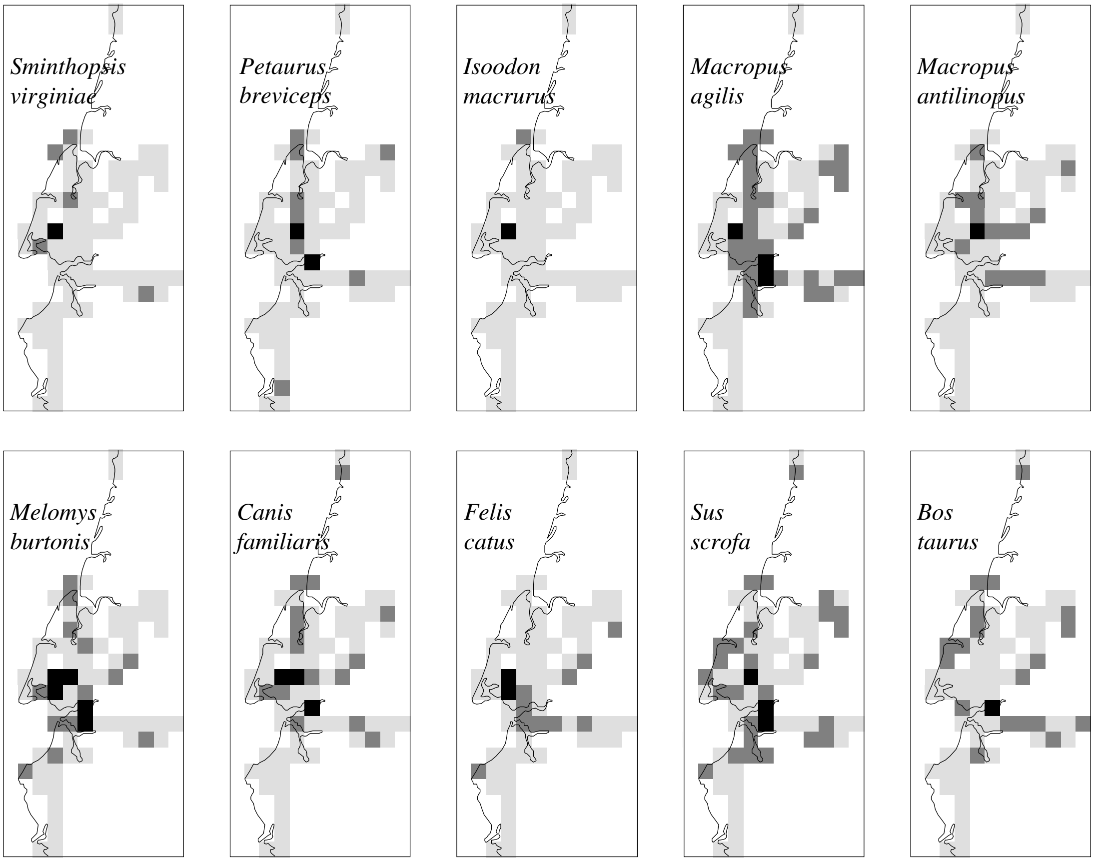
Sites (3): AS11, AS21, WS11.

Unit 7d - Riparian

Paperbark (*Melaleuca viridiflora*) grassy woodland.

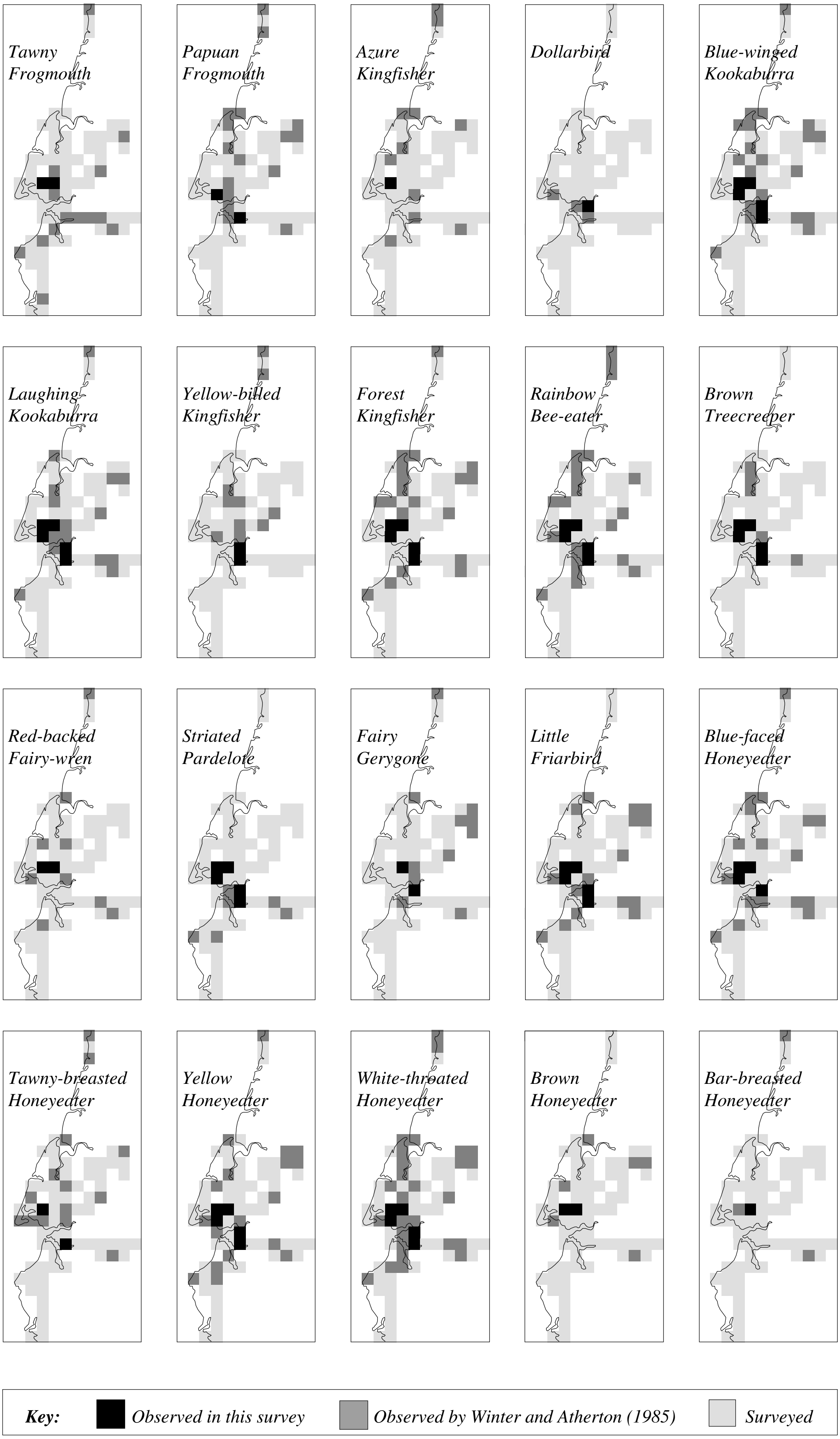
Sites (1): AM11.

Appendix D - Distribution maps for a selection of terrestrial vertebrates of the Weipa region based on this survey and Winter and Atherton (1985).

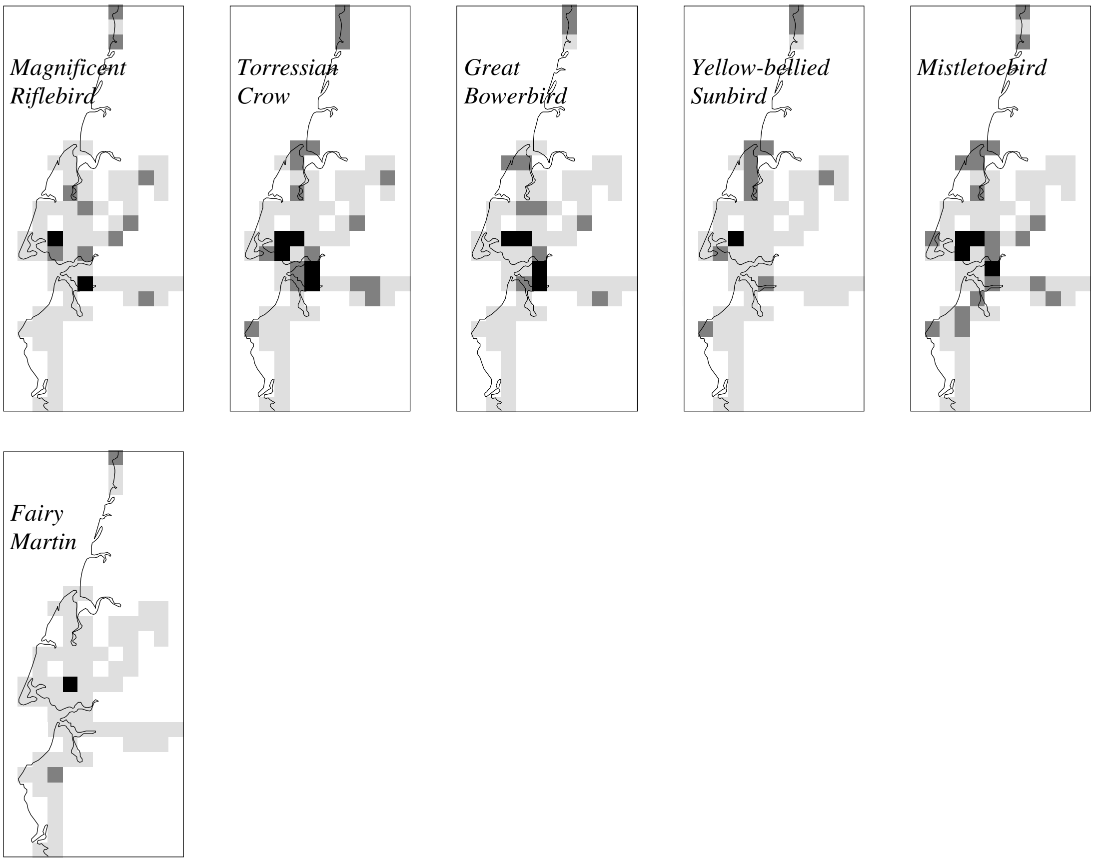


Key: ■ *Observed in this survey* ■ *Observed by Winter and Atherton (1985)* □ *Surveyed*


Australian Brush-turkey
Orange-footed Scrubfowl
Litle Pied Cormorant
Black Kite
Whistling Kite
Brown Falcon
Brolga
Bush Stone-curlew
Pied Imperial-pigeon
Peaceful Dove
Bar-shouldered Dove
Palm Cockatoo
Sulpher-creasted Cockatoo
Rainbow lorikeet
Red-winged Parrot
Pale-headed Rosella
Fan-tailed Cuckoo
Common Koel
Pheasant Coucal
Southern Boobook
Key:
Observed in this survey
Observed by Winter and Atherton (1985)
Surveyed

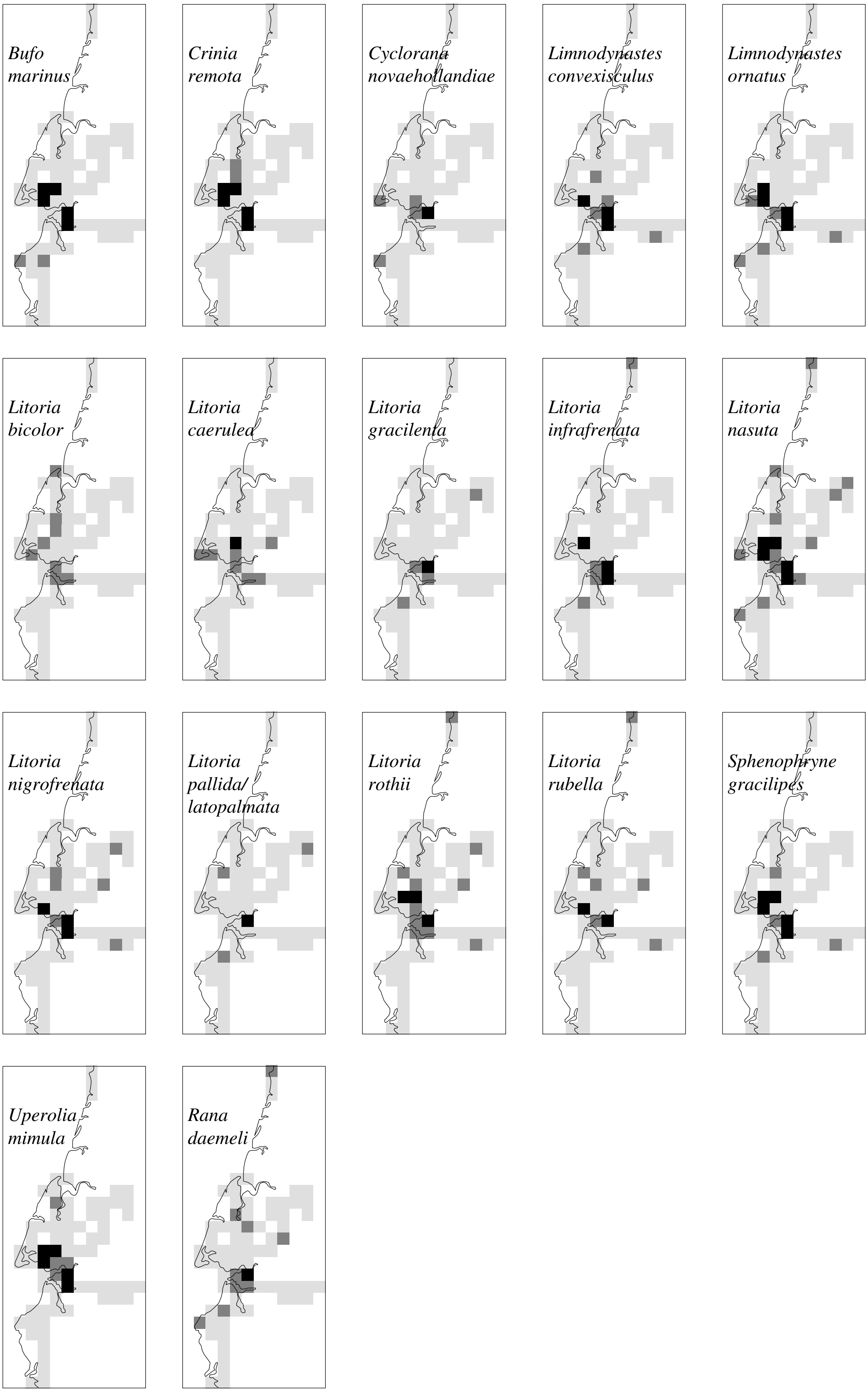

Tawny Frogmouth
Papuan Frogmouth
Azure Kingfisher
Dollarbird
Blue-winged Kookaburra
Laughing Kookaburra
Yellow-billed Kingfisher
Forest Kingfisher
Rainbow Bee-eater
Brown Treecreeper
Red-backed Fairy-wren
Striated Pardelote
Fairy Gerygone
Little Friarbird
Blue-faced Honeyeater
Tawny-breasted Honeyeater
Yellow Honeyeater
White-throated Honeyeater
Brown Honeyeater
Bar-breasted Honeyeater
Key:
Observed in this survey
Observed by Winter and Atherton (1985)
Surveyed


Banded Honeyeater
Dusky Honeyeater
Lemon-bellied Flycatcher
Grey-crowned Babbler
Varied Sitella
Little Shrike-thrush
Grey Shrike-thrush
Spangled Drongo
Spectacled Monarch
Leaden Flycatcher
Shining Flycatcher
Black-faced Cuckoo-shrike
Varied Triller
White-bellied Cuckoo-shrike
Cicadabird
Yellow Oriole
Olive-backed Oriole
Black Butcherbird
Black-backed Butcherbird
Pied Butcherbird
Key:
Observed in this survey
Observed by Winter and Atherton (1985)
Surveyed



Key: *Observed in this survey* *Observed by Winter and Atherton (1985)* *Surveyed*


Boiga irregularis
Carlia longipes
Carlia storri/bicarinata
Chelonia rugosa
Cryptoblepharus virgatus
Ctenotus spaldingi
Demansia atra
Diporiphora species A
Furina ornata
Gehyra dubia
Glaphyromorphus nigricaudis
Heteronotia binoei
Lialis burtonis
Lophognathus temporalis
Oedura castelnaui
Oedura rhombifer
Pseudothecadactylus australis
Ramphotyphlops polygrammicus
Varanus tristis/timorensis
Key:
Observed in this survey
Observed by Winter and Atherton (1985)
Surveyed



Key: *Observed in this survey* *Observed by Winter and Atherton (1985)* *Surveyed*

Appendix E - Species list for woodland habitats above economic and uneconomic ore

Species list for woodland habitats above economic and uneconomic ore, with a count of all observations (including incidental), relative species abundances and the significance of observed differences (if any) in abundance between habitats.

Legend

Economic
Woodland habitat above economic bauxite ore.

Uneconomic
Woodland habitat above uneconomic bauxite ore.

Significance
Indicates the probability that the observed difference in number of observations or systematically recorded abundance is significant.

Appendix E - Species list for woodland habitats above economic and uneconomic ore

Class	Scientific Name	Common Name		Observations *(1)*		Abundance *(2)*		χ^2	Prob	Sig
				Economic	Uneconom	Economic	Uneconom	*(3)*	*(4)*	*(5)*
Mammalia	Tachyglossus aculeatus	Short-beaked Echidna			1					
	Isoodon macrourus	Northern Brown Bandicoot		1	5	1	3	0.5	0.6399	
	Possum complex A	Possum complex A		2						
	Macropus agilis	Agile Wallaby		1	1		1	0.8	1.0000	
	Macropus antilopinus	Antilopine Wallaroo			1					
	Pteropus complex	Flying Fox complex		4	3	1				
	Melomys burtoni	Grassland Melomys			1					
	Canis familiaris	Dingo		3	3	1	2	0.1	1.0000	
	Felis catus	Feral Cat		4		1		1.3	0.4293	
	Sus scrofa	Feral Pig		2	2		1	0.8	1.0000	
	Bos taurus	European Cattle		1						
	Count of mammal (species) and sums of individuals observed		(11)	(8)	(8)	4	7	(5)		
Aves	Tadorna radjah	Radjah Shelduck		1						
	Fregata sp.	Frigatebird sp.			1		1	0.8	1.0000	
	Threskiornis molucca	Australian White (Sacred) Ibis			1		1	0.8	1.0000	
	Lophoictinia isura	Square-tailed Kite		1		1		1.3	0.4266	
	Haliastur indus	Brahminy Kite		2	1	2	1	0.7	0.5810	
	Falco berigora	Brown Falcon			1		1	0.8	1.0000	
	Geopelia striata	Peaceful Dove		5	1	5	1	4.0	0.0899	
	Geopelia humeralis	Bar-shouldered Dove		5	10	5	10	0.6	0.6024	
	Ducula bicolor	Pied Imperial-Pigeon		1	2	1	2	0.1	1.0000	
	Probosciger aterrimus	Palm Cockatoo		2	2	2	2	0.1	1.0000	
	Calyptorhynchus banksii	Red-tailed Black-Cockatoo		1		1		1.3	0.4303	
	Cacatua galerita	Sulphur-crested Cockatoo		20	20	19	19	0.8	0.4130	
	Trichoglossus haematodus	Rainbow Lorikeet		31	27	31	26	3.1	0.0824	
	Aprosmictus erythropterus	Red-winged Parrot		11	14	10	13	0.0	1.0000	
	Platycercus adscitus	Pale-headed Rosella		3	5	3	5	0.1	1.0000	
	Eudynamys scolopacea	Common Koel		4	1	4	1	2.8	0.1707	
	Centropus phasianinus	Pheasant Coucal		14	11	14	10	2.3	0.1504	
	Ninox novaeseelandiae	Southern Boobook			1					
	Podargus strigoides	Tawny Frogmouth			1					
	Podargus papuensis	Papuan Frogmouth		1		1		1.3	0.4302	
	Podargus ocellatus	Marbled Frogmouth		1						
	Collocalia sp.	Swiftlet sp.			1		1	0.8	1.0000	
	Dacelo novaeguineae	Laughing Kookaburra		15	14	15	14	0.9	0.3526	
	Dacelo leachii	Blue-winged Kookaburra		15	19	15	16	0.4	0.5865	
	Todirhamphus macleayii	Forest Kingfisher		5	8	5	8	0.1	0.7879	
	Merops ornatus	Rainbow Bee-eater		10	8	10	8	1.2	0.3410	
	Climacteris picumnus	Brown Treecreeper		1	3	1	3	0.5	0.6393	
	Malurus melanocephalus	Red-backed Fairy-wren			1					
	Pardalotus striatus	Striated Pardalote		5	7	5	7	0.0	1.0000	
	Smicrornis brevirostris	Weebill		8	3	8	3	4.0	0.0658	
	Gerygone olivacea	White-throated Gerygone		1		1		1.3	0.4297	
	Philemon corniculatus	Noisy Friarbird		16	13	16	13	1.8	0.1935	
	Philemon citreogularis	Little Friarbird		28	21	28	21	4.1	0.0596	
	Entomyzon cyanotis	Blue-faced Honeyeater		1	1	1	1	0.0	1.0000	
	Lichenostomus flavus	Yellow Honeyeater		1	2	1	2	0.1	1.0000	
	Melithreptus albogularis	White-throated Honeyeater		28	24	28	24	2.6	0.1243	
	Ramsayornis modestus	Brown-backed Honeyeater		1		1		1.3	0.4280	
	Certhionyx pectoralis	Banded Honeyeater			1		1	0.8	1.0000	
	Microeca flavigaster	Lemon-bellied Flycatcher		20	19	20	19	1.1	0.3309	
	Pomatostomus temporalis	Grey-crowned Babbler		5	3	4	3	0.6	0.7060	
	Daphoenositta chrysoptera	Varied Sittella		6	5	6	5	0.6	0.5461	
	Pachycephala simplex	Grey Whistler		3	2	3	2	0.6	0.6582	
	Pachycephala rufiventris	Rufous Whistler		13	8	12	8	2.4	0.1742	
	Colluricincla harmonica	Grey Shrike-thrush		14	13	14	13	0.9	0.4347	
	Myiagra rubecula	Leaden Flycatcher		8	4	8	4	2.8	0.1427	
	Grallina cyanoleuca	Magpie Lark		1	2	1	2	0.1	1.0000	
	Rhipidura fuliginosa	Grey Fantail		1		1		1.3	0.4261	
	Coracina novaehollandiae	Black-faced Cuckoo-shrike		6	4	5	3	1.3	0.2996	
	Coracina papuensis	White-bellied Cuckoo-shrike		21	23	20	22	0.4	0.6402	
	Coracina tenuirostris	Cicadabird			1		1	0.8	1.0000	
	Lalage sueurii	White-winged Triller		2		2		2.7	0.1860	
	Lalage leucomela	Varied Triller		3	2	3	2	0.6	0.6565	
	Oriolus sagittatus	Olive-backed Oriole		1	1	1	1	0.0	1.0000	
	Cracticus mentalis	Black-backed Butcherbird		16	12	16	12	2.3	0.1810	
	Cracticus nigrogularis	Pied Butcherbird		6	3	6	3	2.1	0.1841	
	Corvus orru	Torresian Crow		12	9	12	9	1.8	0.2679	
	Neochmia ruficauda	Star Finch			1		1	0.8	1.0000	
	Dicaeum hirundinaceum	Mistletoebird		3	1	3	1	1.7	0.3229	
	Count of bird (species) and sums of individuals observed		(58)	(48)	(49)	371	326	(53)		
Reptilia	Gehyra dubia	Gehyra dubia		8	8	7	7	0.3	0.7897	
	Heteronotia binoei	Bynoe's Gecko		7	1	6	1	5.3	0.0471	*
	Nactus pelagicus	Pelagic Gecko		66	68	61	61	2.5	0.1220	
	Oedura castelnaui	Northern Velvet Gecko		7	5	7	5	1.2	0.3828	
	Oedura rhombifer	Oedura rhombifer		12	20	10	15	0.1	0.8393	
	Rhacocadactylus australis	Giant Tree-gecko		5	4	5	3	1.3	0.3005	
	Delma tincta	Delma tincta		1		1		1.3	0.4296	
	Lialis burtonis	Burton's Snake-lizard		1	1		1	0.8	1.0000	
	Diporiphora bilineata	Two-lined Dragon		37	25	31	20	6.7	0.0105	*
	Varanus tristis	Varanus tristis		3	4	2	3	0.0	1.0000	
	Carlia longipes	Carlia longipes		26	53	22	46	3.1	0.0863	
	Cryptoblepharus virgatus	Cryptoblepharus virgatus		6	9	4	9	0.8	0.4169	
	Ctenotus spaldingi	Ctenotus spaldingi		5	4	4	3	0.6	0.7059	
	Egernia frerei	Major Skink		1		1		1.3	0.4260	
	Morethia taeniopleura	Fire-tailed Skink		1	8	1	6	2.3	0.2480	
	Ramphotyphlops polygrammicus	Ramphotyphlops polygrammicus		1		1		1.3	0.4262	
	Boiga irregularis	Brown Tree Snake		1		1		1.3	0.4283	

Class	Scientific Name	Common Name		Observations *(1)*		Abundance *(2)*		χ^2	Prob	Sig
				Economic	Uneconom	Economic	Uneconom	*(3)*	*(4)*	*(5)*
	Dendrelaphis punctulata	Common Tree Snake			1		1	0.8	1.0000	
	Demansia vestigiata	Demansia vestigiata			1		1	0.8	1.0000	
	Oxyuranus scutellatus	Taipan		1						
	Rhinoplocephalus nigrostriatus	Black-striped Snake			3		3	2.3	0.2668	
		Count of reptile (species) and sums of individuals observed	(21)	(18)	(16)	164	185	(20)		
Amphibia	Limnodynastes ornatus	Ornate Burrowing Frog		9	14	5	10	0.6	0.6042	
	Uperoleia mimula	Torres Gungan		8	6	6	4	1.2	0.3454	
	Crinia remota	Torrid Froglet		4		1		1.3	0.4288	
	Litoria bicolor	Northern Sedgefrog		5	5	3	2	0.6	0.6537	
	Litoria gracilenta	Graceful Treefrog		1						
	Litoria pallida	Peach-sided Rocketfrog			2					
	Cyclorana novaehollandiae	Eastern Snapping-Frog			1					
	Sphenophryne gracilipes	Shrill Chirper		3	1	2	1	0.7	0.5807	
	Bufo marinus	Cane Toad		1	3	1	2	0.1	1.0000	
		Count of frog (species) and sums of individuals observed	(9)	(7)	(7)	18	19	(6)		
		Total number of (species) observed	(99)	(81)	(80)	(72)	(71)	(84)		
		Total sum of individuals and (species) observed by systematic sampling				557	537			

Notes:
1) Gives the number of incidental and systematic observations of the species within the given habitat.
2) Gives the relative abundance or number of individuals of the species within the sample of the given habitat, as observed through systematic sampling.
3) Gives the Chi-square statistic for comparison of abundances using a 3:4 hypothesis
4) The test of significance is based on resampling the chi-square statistic.
5) * P < 0.05 ** P <.01 *** P < 0.001.
6) Excluding marine and freshwater birds.

Appendix F - Species list for woodland, ecotone and riparian habitats

Legend

Riparian

The total number of individuals recorded within riparian habitats during the study using systematic survey methods.

Ecotone

The total number of individuals recorded within ecotone habitats during the study using systematic survey methods.

Woodland

The total number of individuals recorded within uneconomic woodland habitats during the study using systematic survey methods.

Significance

Indicates the probability that the observed difference in systematically recorded abundance is significant.

Appendix F - Species list for woodland, ecotone and riparian habitats

Class	Scientific Name	Common Name	Observations *(1)*			Abundance *(2)*			χ^2	Prob	Sig
			Woodland	Ecotone	Riparian	Woodland	Ecotone	Riparian	*(3)*	*(4)*	*(5)*
Mammalia	Tachyglossus aculeatus	Short-beaked Echidna	1								
	Sminthopsis virginiae	Red-cheeked Dunnart			2			2	6.0	0.1257	
	Isoodon macrourus	Northern Brown Bandicoot	6	1	1	4	1	1	0.7	0.7656	
	Petaurus breviceps	Sugar Glider		3			3		9.0	0.0319	*
	Possum complex A	Possum complex A	2	2							
	Macropus agilis	Agile Wallaby	6	2	1	1			1.0	1.0000	
	Macropus antilopinus	Antilopine Kangaroo	1	2	1						
	Pteropus complex	Flying Fox complex	7	1	2	2	1	2			
	Melomys burtoni	Grassland Melomys	1	4	44		4	32	79.6	0.0001	***
	Canis familiaris	Dingo	7		1	3			3.0	0.4376	
	Felis catus	Feral Cat	4			1			1.0	1.0000	
	Sus scrofa	Feral Pig	4	1	4	1	1	1	0.3	1.0000	
	Bos taurus	European Cattle	1								
		Count of mammal (species) and sums of individuals observed (13)	(11)	(8)	(8)	12	10	38	(8)		
Aves	Alectura lathami	Australian Brush-turkey		1			1		3.0	0.5005	
	Megapodius reinwardt	Orange-footed Scrubfowl		1	5		1	5	11.3	0.0017	***
	Tadorna radjah	Radjah Shelduck	1								
	Tachybaptus novaehollandiae	Australasian Grebe			2			1	3.0	0.5016	
	Phalacrocorax melanoleucos	Little Pied Cormorant			1			1	3.0	0.4978	
	Fregata sp.	Frigatebird sp.	1	1	1	1	1	1	0.3	1.0000	
	Threskiornis molucca	Australian White (Sacred) Ibis	1	1	1	1	1		1.0	1.0000	
	Ephippiorhynchus asiaticus	Black-necked Stork (Jabiru)			1						
	Lophoictinia isura	Square-tailed Kite	1			1			1.0	1.0000	
	Milvus migrans	Black Kite		1	1		1	1	2.0	0.4995	
	Haliastur sphenurus	Whistling Kite		1			1		3.0	0.5018	
	Haliastur indus	Brahminy Kite	3	2		3	2		1.8	0.6091	
	Haliaeetus leucogaster	White-bellied Sea-Eagle			1						
	Falco berigora	Brown Falcon	3			1			1.0	1.0000	
	Grus rubicunda	Brolga		1	1		1		3.0	0.4998	
	Amaurornis olivaceus	Bush-hen		1	1		1	1	2.0	0.4999	
	Himantopus himantopus	Black-winged Stilt			1						
	Geopelia striata	Peaceful Dove	6	13	8	6	13	8	10.2	0.0068	**
	Geopelia humeralis	Bar-shouldered Dove	15	17	18	15	16	17	6.8	0.0375	*
	Ducula bicolor	Pied Imperial-Pigeon	3	5	1	3	5	1	4.6	0.1215	
	Probosciger aterrimus	Palm Cockatoo	4	4	2	4	4	2	1.2	0.6070	
	Calyptorhynchus banksii	Red-tailed Black-Cockatoo	1		1	1			1.0	1.0000	
	Cacatua galerita	Sulphur-crested Cockatoo	40	19	13	38	18	13	1.4	0.5067	
	Trichoglossus haematodus	Rainbow Lorikeet	58	27	28	57	27	28	0.1	0.9920	
	Aprosmictus erythropterus	Red-winged Parrot	25	12	6	23	11	6	2.2	0.3810	
	Platycercus adscitus	Pale-headed Rosella	8	4	4	8	4	4			
	Cacomantis flabelliformis	Fan-tailed Cuckoo			1			1	3.0	0.5009	
	Chrysococcyx minutillus	Little Bronze-Cuckoo			1			1	3.0	0.4985	
	Eudynamys scolopacea	Common Koel	5	4	5	5	4	5	1.3	0.6140	
	Centropus phasianinus	Pheasant Coucal	25	10	10	24	9	9	0.9	0.6851	
	Ninox novaeseelandiae	Southern Boobook	1	2			2		6.0	0.1265	
	Podargus strigoides	Tawny Frogmouth	1	1							
	Podargus papuensis	Papuan Frogmouth	1	1	2	1		1	1.0	1.0000	
	Podargus ocellatus	Marbled Frogmouth	1								
	Collocalia sp.	Swiftlet sp.	1	1		1	1		1.0	1.0000	
	Alcedo azureus	Azure Kingfisher			3			2	6.0	0.1252	
	Dacelo novaeguineae	Laughing Kookaburra	31	10	2	29	10	2	10.2	0.0061	**
	Dacelo leachii	Blue-winged Kookaburra	34	19	15	31	18	15	0.3	0.8793	
	Syma torotoro	Yellow-billed Kingfisher		4	2		4	2	7.3	0.0128	*
	Todirhamphus macleayii	Forest Kingfisher	13	13	8	13	13	8	3.4	0.1940	
	Todirhamphus sanctus	Sacred Kingfisher			1			1	3.0	0.4991	
	Merops ornatus	Rainbow Bee-eater	18	15	13	18	15	13	2.3	0.3479	
	Eurystomus orientalis	Dollarbird			1			1	3.0	0.4979	
	Climacteris picumnus	Brown Treecreeper	4	3	1	4	3	1	1.0	0.5942	
	Malurus melanocephalus	Red-backed Fairy-wren	1	1			1		3.0	0.5015	
	Pardalotus striatus	Striated Pardalote	12	5	1	12	5	1	3.8	0.1518	
	Smicrornis brevirostris	Weebill	11		1	11		1	8.5	0.0140	*
	Gerygone palpebrosa	Fairy Gerygone			3			3	9.0	0.0323	*
	Gerygone olivacea	White-throated Gerygone	1			1			1.0	1.0000	
	Philemon corniculatus	Noisy Friarbird	29	8	5	29	8	5	6.5	0.0376	*
	Philemon citreogularis	Little Friarbird	49	20	20	49	20	20	0.9	0.6552	
	Entomyzon cyanotis	Blue-faced Honeyeater	2	2	3	2	2	3	1.6	0.4741	
	Xanthotis chrysotis	Tawny-breasted Honeyeater			4			3	9.0	0.0304	*
	Lichenostomus versicolor	Varied Honeyeater			1			1	3.0	0.5001	
	Lichenostomus flavus	Yellow Honeyeater	3	13	16	3	13	16	21.7	0.0001	***
	Melithreptus albogularis	White-throated Honeyeater	52	26	30	52	26	29	0.3	0.8964	
	Lichmera indistincta	Brown Honeyeater		1	1		1	1	2.0	0.4979	
	Ramsayornis modestus	Brown-backed Honeyeater	1		1	1		1	1.0	1.0000	
	Ramsayornis fasciatus	Bar-breasted Honeyeater			2			2	6.0	0.1247	
	Certhionyx pectoralis	Banded Honeyeater	1	1		1	1		1.0	1.0000	
	Myzomela obscura	Dusky Honeyeater		1	4		1	4	8.6	0.0114	*
	Myzomela erythrocephala	Red-headed Honeyeater			2			2	6.0	0.1253	
	Microeca flavigaster	Lemon-bellied Flycatcher	39	24	17	39	23	17	0.9	0.6502	
	Pomatostomus temporalis	Grey-crowned Babbler	8	3		7	3		3.4	0.2790	
	Daphoenositta chrysoptera	Varied Sittella	11	2	1	11	2	1	4.7	0.1378	
	Pachycephala simplex	Grey Whistler	5	2	2	5	2	2	0.1	1.0000	
	Pachycephala rufiventris	Rufous Whistler	21	4	4	20	4	4	5.1	0.0821	
	Colluricincla megarhyncha	Little Shrike-thrush			4			4	12.0	0.0080	**
	Colluricincla harmonica	Grey Shrike-thrush	27	12	9	27	12	8	1.7	0.4340	
	Monarcha trivirgatus	Spectacled Monarch			2			2	6.0	0.1247	
	Myiagra rubecula	Leaden Flycatcher	12	12	13	12	10	13	4.0	0.1369	
	Myiagra alecto	Shining Flycatcher			1			1	3.0	0.4990	
	Grallina cyanoleuca	Magpie Lark	3	2	2	3	2	2	0.1	1.0000	
	Rhipidura fuliginosa	Grey Fantail	1			1			1.0	1.0000	
	Dicrurus bracteatus	Spangled Drongo		3	2		3	2	5.4	0.0518	
	Coracina novaehollandiae	Black-faced Cuckoo-shrike	10		2	8		2	4.4	0.1131	
	Coracina papuensis	White-bellied Cuckoo-shrike	44	19	17	42	19	16	0.9	0.6593	
	Coracina tenuirostris	Cicadabird	1	4	1	1	4	1	5.7	0.0953	
	Lalage leucomela	Varied Triller	5	1		5	1		3.0	0.2482	
	Lalage sueurii	White-winged Triller	2	1		2	1		1.0	0.8127	
	Oriolus flavocinctus	Yellow Oriole		3	3		3	3	6.0	0.0656	
	Oriolus sagittatus	Olive-backed Oriole	2	2		2	2		2.0	0.3743	
	Artamus minor	Little Woodswallow		1			1		3.0	0.4981	
	Cracticus quoyi	Black Butcherbird			1			1	3.0	0.5003	
	Cracticus mentalis	Black-backed Butcherbird	29	5	2	28	5	2	13.1	0.0019	***
	Cracticus nigrogularis	Pied Butcherbird	9	1	2	9	1	2	3.2	0.2046	
	Ptiloris magnificus	Magnificent Riflebird		1	2		1	1	2.0	0.4994	
	Corvus orru	Torresian Crow	21	12	11	21	11	11	0.0	1.0000	

Class	Scientific Name	Common Name		Observations *(1)*			Abundance *(2)*			χ^2	Prob	Sig
				Woodland	Ecotone	Riparian	Woodland	Ecotone	Riparian	*(3)*	*(4)*	*(5)*
	Chlamydera nuchalis	Great Bowerbird			3	5		3	5	9.0	0.0101	*
	Neochmia ruficauda	Star Finch		1			1			1.0	1.0000	
	Neochmia temporalis	Red-browed Finch				1						
	Nectarinia jugularis	Yellow-bellied Sunbird				2			2	6.0	0.1250	
	Dicaeum hirundinaceum	Mistletoebird		4	1	1	4	1	1	0.7	0.7652	
	Hirundo ariel	Fairy Martin				1			1	3.0	0.4996	
	Count of bird (species) and sums of individuals observed		(94)	(58)	(61)	(74)	697	379	347	(86)		
Reptilia	Chelodina rugosa	Northern Snake-necked Turtle				1						
	Gehyra dubia	Gehyra dubia		16	7	3	14	5	3	2.0	0.3807	
	Heteronotia binoei	Bynoe's Gecko		8			7			7.0	0.0385	*
	Nactus pelagicus	Pelagic Gecko		134	25	3	122	21	3	70.2	0.0001	***
	Oedura castelnaui	Northern Velvet Gecko		12	3	1	12	1		9.5	0.0106	*
	Oedura rhombifer	Oedura rhombifer		32	9		25	7		13.2	0.0014	***
	Rhacocadactylus australis	Giant Tree-gecko		9	2	1	8	2	1	2.5	0.3592	
	Delma tincta	Delma tincta		1	1		1	1		1.0	1.0000	
	Lialis burtonis	Burton's Snake-lizard		2	2	3	1	2	3	3.0	0.2516	
	Diporiphora bilineata	Two-lined Dragon		63	40	14	51	30	11	8.9	0.0114	*
	Lophognathus temporalis	Lophognathus temporalis			1	3			3	9.0	0.0311	*
	Varanus tristis	Varanus tristis		7	4	4	5	4	4	0.7	0.7701	
	Carlia longipes	Carlia longipes		80	49	90	68	43	83	33.8	0.0001	***
	Carlia storri	Carlia storri			1	50			39	117.0	0.0001	***
	Cryptoblepharus virgatus	Cryptoblepharus virgatus		15	15	28	13	13	17	7.5	0.0237	*
	Ctenotus spaldingi	Ctenotus spaldingi		9	23	10	7	20	8	20.8	0.0001	***
	Egernia frerei	Major Skink		1		7	1		4	8.2	0.0309	*
	Glaphyromorphus nigricaudis	Glaphyromorphus nigricaudis			4	56		4	46	120.6	0.0001	***
	Morethia taeniopleura	Fire-tailed Skink		9	5	1	7	4	1	1.8	0.5205	
	Ramphotyphlops sp. aff. minimus	Ramphotyphlops sp. aff. minimus				1						
	Ramphotyphlops polygrammicus	Ramphotyphlops polygrammicus		1	1		1			1.0	1.0000	
	Liasis maculosa	Childrens Python			1			1		3.0	0.5018	
	Boiga irregularis	Brown Tree Snake		1			1			1.0	1.0000	
	Dendrelaphis punctulata	Common Tree Snake		2	1		1	1		1.0	1.0000	
	Demansia vestigiata	Demansia vestigiata		1	1	7	1		6	13.9	0.0027	***
	Furina ornata	Orange-naped Snake				1			1	3.0	0.5024	
	Oxyuranus scutellatus	Taipan		1								
	Rhinoplocephalus nigrostriatus	Black-striped Snake		3	1		3	1		1.5	0.8149	
	Count of reptile (species) and sums of individuals observed		(28)	(21)	(21)	(19)	349	160	233	(25)		
Amphibia	Limnodynastes convexiusculus	Marbled Frog			1	4		1	2	3.7	0.1248	
	Limnodynastes ornatus	Ornate Burrowing Frog		23	9	27	15	7	20	11.5	0.0042	***
	Uperoleia mimula	Torres Gungan		14	36	88	10	36	79	117.8	0.0001	***
	Crinia remota	Torrid Froglet		4	11	133	1	11	119	305.1	0.0001	***
	Litoria bicolor	Northern Sedgefrog		11	24	26	5	19	16	23.0	0.0000	***
	Litoria caerulea	Green Treefrog				1						
	Litoria gracilenta	Graceful Treefrog		1	2			1		3.0	0.5010	
	Litoria infrafrenata	White-lipped Treefrog			2	13		2	11	25.5	0.0001	***
	Litoria nasuta	Striped Rocketfrog			13	85		9	77	193.5	0.0001	***
	Litoria nigrofrenata	Tawny Rocketfrog				10			8	24.0	0.0001	***
	Litoria pallida	Peach-sided Rocketfrog		2								
	Litoria rothii	Red-eyed Treefrog			1	2			1	3.0	0.5009	
	Litoria rubella	Naked Treefrog				8			8	24.0	0.0001	***
	Cyclorana novaehollandiae	Eastern Snapping-Frog		1								
	Sphenophryne gracilipes	Shrill Chirper		4	14	21	3	13	14	19.3	0.0002	***
	Rana daemeli	Australian Bullfrog				3			1	3.0	0.5013	
	Bufo marinus	Cane Toad		4	55	152	3	51	121	219.2	0.0001	***
	Count of frog (species) and sums of individuals observed		(17)	(9)	(11)	(14)	37	150	477	(14)		
		Total number of (species) observed	(152)	(99)	(101)	(115)	(85)	(91)	(101)	(133)		
		Total sum of individuals and (species) observed by systematic sampling					1,095	699	1,095			

Notes:
1) Gives the number of incidental and systematic observations of the species within the given habitat
2) Gives the relative abundance or number of individuals of the species within the sample of the given habitat, as observed through systematic sampling
3) Gives the Chi-square statistic for comparison of abundances using a 2:1:1 hypothesis
4) The test of significance is based on resampling the chi-square statistic
5) * P < 0.05 ** P <.01 *** P < 0.001.
6) Excluding marine and freshwater birds

Appendix G - Species list for creek, swamp and marine riparian habitats

Legend

Creek

The total number of individuals recorded within creek riparian habitats during the study using systematic survey methods.

Swamp

The total number of individuals recorded within swamp riparian habitats during the study using systematic survey methods.

Marine

The total number of individuals recorded within marine riparian habitats during the study using systematic survey methods.

Significance

Indicates the probability that the observed difference in systematically recorded abundance is significant.

Appendix G - Species list for creek, swamp and marine riparian habitats

Class	Scientific Name	Common Name		Observations *(1)*			Abundance *(2)*			χ^2	Prob	Sig
				Creek	Swamp	Marine	Creek	Swamp	Marine	*(3)*	*(4)*	*(5)*
Mammalia	Sminthopsis virginiae	Red-cheeked Dunnart				2			2	6.0	0.0628	
	Isoodon macrourus	Northern Brown Bandicoot				1			1	3.0	0.2506	
	Macropus agilis	Agile Wallaby				1						
	Macropus antilopinus	Antilopine Kangaroo			1							
	Pteropus complex	Flying Fox complex		2								
	Melomys burtoni	Grassland Melomys		13	5	26	9	5	18	17.3	0.0001	***
	Canis familiaris	Dingo			1							
	Sus scrofa	Feral Pig		1	3		1			1.7	1.0000	
	Count of mammal (species) and sums of individuals observed		(8)	(3)	(4)	(4)	10	5	21	(4)		
Aves	Megapodius reinwardt	Orange-footed Scrubfowl				5			5	15.0	0.0010	***
	Tachybaptus novaehollandiae	Australasian Grebe			2			1		1.7	1.0000	
	Phalacrocorax melanoleucos	Little Pied Cormorant			1			1		1.7	1.0000	
	Fregata sp.	Frigatebird sp.				1						
	Threskiornis molucca	Australian White (Sacred) Ibis			1							
	Ephippiorhynchus asiaticus	Black-necked Stork (Jabiru)			1							
	Milvus migrans	Black Kite			1			1		1.7	1.0000	
	Haliaeetus leucogaster	White-bellied Sea-Eagle			1							
	Grus rubicunda	Brolga			1							
	Amaurornis olivaceus	Bush-hen				1			1	3.0	0.2493	
	Himantopus himantopus	Black-winged Stilt			1							
	Geopelia striata	Peaceful Dove		2	3	3	2	3	3	0.8	0.7563	
	Geopelia humeralis	Bar-shouldered Dove		5	6	7	4	6	7	2.7	0.2885	
	Ducula bicolor	Pied Imperial-Pigeon			1			1		1.7	1.0000	
	Probosciger aterrimus	Palm Cockatoo		1		1	1		1	1.3	0.7190	
	Calyptorhynchus banksii	Red-tailed Black-Cockatoo			1							
	Cacatua galerita	Sulphur-crested Cockatoo		4	5	4	4	5	4	0.3	0.9363	
	Trichoglossus haematodus	Rainbow Lorikeet		10	10	8	10	10	8	0.2	0.9411	
	Aprosmictus erythropterus	Red-winged Parrot		1	3	2	1	3	2	1.1	0.6659	
	Platycercus adscitus	Pale-headed Rosella		1	2	1	1	2	1	0.3	1.0000	
	Cacomantis flabelliformis	Fan-tailed Cuckoo			1			1		1.7	1.0000	
	Chrysococcyx minutillus	Little Bronze-Cuckoo			1			1		1.7	1.0000	
	Eudynamys scolopacea	Common Koel		3		2	3		2	3.0	0.3098	
	Centropus phasianinus	Pheasant Coucal		5	1	4	5	1	3	2.7	0.3215	
	Podargus papuensis	Papuan Frogmouth				2			1	3.0	0.2488	
	Alcedo azureus	Azure Kingfisher		1	1	1	1		1	1.3	0.7221	
	Dacelo novaeguineae	Laughing Kookaburra			1	1		1	1	1.3	0.7219	
	Dacelo leachii	Blue-winged Kookaburra		5	6	4	5	6	4	0.1	1.0000	
	Syma torotoro	Yellow-billed Kingfisher		1		1	1		1	1.3	0.7181	
	Todirhamphus macleayii	Forest Kingfisher		2	2	4	2	2	4	2.7	0.3262	
	Todirhamphus sanctus	Sacred Kingfisher			1			1		1.7	1.0000	
	Merops ornatus	Rainbow Bee-eater		2	5	6	2	5	6	4.0	0.1239	
	Eurystomus orientalis	Dollarbird		1			1		1	1.3	0.7161	
	Climacteris picumnus	Brown Treecreeper		1			1			1.7	1.0000	
	Pardalotus striatus	Striated Pardalote			1			1		1.7	1.0000	
	Smicrornis brevirostris	Weebill		1			1			1.7	1.0000	
	Gerygone palpebrosa	Fairy Gerygone		2	1		2	1		1.4	0.7882	
	Philemon corniculatus	Noisy Friarbird		2	1	2	2	1	2	0.9	0.8534	
	Philemon citreogularis	Little Friarbird		7	9	4	7	9	4	0.5	0.8481	
	Entomyzon cyanotis	Blue-faced Honeyeater			2	1		2	1	1.9	0.4724	
	Xanthotis chrysotis	Tawny-breasted Honeyeater				4			3	9.0	0.0156	*
	Lichenostomus versicolor	Varied Honeyeater			1			1		1.7	1.0000	
	Lichenostomus flavus	Yellow Honeyeater		4	8	4	4	8	4	1.3	0.5721	
	Melithreptus albogularis	White-throated Honeyeater		11	10	9	11	10	8	0.1	0.9707	
	Lichmera indistincta	Brown Honeyeater			1			1		1.7	1.0000	
	Ramsayornis modestus	Brown-backed Honeyeater			1			1		1.7	1.0000	
	Ramsayornis fasciatus	Bar-breasted Honeyeater			2			2		3.3	0.3427	
	Myzomela obscura	Dusky Honeyeater		1	2	1	1	2	1	0.3	1.0000	
	Myzomela erythrocephala	Red-headed Honeyeater		1		1	1		1	1.3	0.7209	
	Microeca flavigaster	Lemon-bellied Flycatcher		7	5	5	7	5	5	0.5	0.8652	
	Daphoenositta chrysoptera	Varied Sittella			1			1		1.7	1.0000	
	Pachycephala simplex	Grey Whistler			1	1		1	1	1.3	0.7170	
	Pachycephala rufiventris	Rufous Whistler		3		1	3		1	3.0	0.1985	
	Colluricincla megarhyncha	Little Shrike-thrush		3		1	3		1	3.0	0.1959	
	Colluricincla harmonica	Grey Shrike-thrush		4	2	3	3	2	3	0.8	0.7576	
	Monarcha trivirgatus	Spectacled Monarch				2			2	6.0	0.0635	
	Myiagra rubecula	Leaden Flycatcher		7	3	3	7	3	3	1.7	0.4370	
	Myiagra alecto	Shining Flycatcher				1			1	3.0	0.2503	
	Grallina cyanoleuca	Magpie Lark			2			2		3.3	0.3438	
	Dicrurus bracteatus	Spangled Drongo			2			2		3.3	0.3426	
	Coracina novaehollandiae	Black-faced Cuckoo-shrike		1		1	1		1	1.3	0.7168	
	Coracina papuensis	White-bellied Cuckoo-shrike		6	8	3	5	8	3	1.1	0.6309	
	Coracina tenuirostris	Cicadabird		1			1			1.7	1.0000	
	Oriolus flavocinctus	Yellow Oriole		1		2	1		2	3.2	0.2600	
	Cracticus quoyi	Black Butcherbird				1			1	3.0	0.2505	
	Cracticus mentalis	Black-backed Butcherbird		1	1		1	1		0.7	1.0000	
	Cracticus nigrogularis	Pied Butcherbird		2			2			3.3	0.3432	
	Ptiloris magnificus	Magnificent Riflebird				2			1	3.0	0.2496	
	Corvus orru	Torresian Crow		4	4	3	4	4	3	0.0	1.0000	
	Chlamydera nuchalis	Great Bowerbird		3		2	3		2	3.0	0.3084	
	Neochmia temporalis	Red-browed Finch			1							
	Nectarinia jugularis	Yellow-bellied Sunbird				2			2	6.0	0.0621	
	Dicaeum hirundinaceum	Mistletoebird				1			1	3.0	0.2498	
	Hirundo ariel	Fairy Martin			1			1		1.7	1.0000	
	Count of bird (species) and sums of individuals observed		(74)	(37)	(49)	(44)	114	120	113	(66)		
Reptilia	Chelodina rugosa	Northern Snake-necked Turtle			1							
	Gehyra dubia	Gehyra dubia			3			3		5.0	0.1214	
	Nactus pelagicus	Pelagic Gecko		3			3			5.0	0.1206	
	Oedura castelnaui	Northern Velvet Gecko				1						
	Rhacodactylus australis	Giant Tree-gecko			1			1		1.7	1.0000	
	Lialis burtonis	Burton's Snake-lizard		1		2	1		2	3.2	0.2621	
	Diporiphora bilineata	Two-lined Dragon		3	1	10	3		8	14.5	0.0005	***
	Lophognathus temporalis	Lophognathus temporalis		3			3			5.0	0.1221	
	Varanus tristis	Varanus tristis				4			4	12.0	0.0038	***
	Carlia longipes	Carlia longipes		18	7	65	16	3	64	122.9	0.0001	***
	Carlia storri	Carlia storri		31	8	11	26	5	8	15.5	0.0003	***
	Cryptoblepharus virgatus	Cryptoblepharus virgatus		3	23	2	2	13	2	11.1	0.0040	***
	Ctenotus spaldingi	Ctenotus spaldingi			4	6		4	4	5.3	0.0814	
	Egernia frerei	Major Skink		6		1	4			6.7	0.0433	*
	Glaphyromorphus nigricaudis	Glaphyromorphus nigricaudis		50		6	40		6	49.9	0.0001	***
	Morethia taeniopleura	Fire-tailed Skink		1			1			1.7	1.0000	
	Ramphotyphlops sp. aff. minimus	Ramphotyphlops sp. aff. minimus		1								
	Demansia vestigiata	Demansia vestigiata		3	3	1	2	3	1	0.4	0.8876	

Class	Scientific Name	Common Name		Observations *(1)* Creek	Swamp	Marine	Abundance *(2)* Creek	Swamp	Marine	χ² *(3)*	Prob *(4)*	Sig *(5)*
	Furina ornata	Orange-naped Snake		1			1			1.7	1.0000	
	Count of reptile (species) and sums of individuals observe		(19)	(13)	(9)	(11)	102	32	99	(16)		
Amphibia	Limnodynastes convexiusculus	Marbled Frog		1	2	1		1	1	1.3	0.7206	
	Limnodynastes ornatus	Ornate Burrowing Frog		2	1	24	2	1	17	38.5	0.0001	***
	Uperoleia mimula	Torres Gungan		24	35	29	18	34	27	7.9	0.0192	*
	Crinia remota	Torrid Froglet		1	128	4		116	3	182.8	0.0001	***
	Litoria bicolor	Northern Sedgefrog		2	23	1	2	13	1	13.1	0.0012	***
	Litoria caerulea	Green Treefrog		1								
	Litoria infrafrenata	White-lipped Treefrog		5	1	7	5	1	5	4.4	0.0983	
	Litoria nasuta	Striped Rocketfrog		29	51	5	28	44	5	18.5	0.0001	***
	Litoria nigrofrenata	Tawny Rocketfrog		3	3	4	3	2	3	0.8	0.7589	
	Litoria rothii	Red-eyed Treefrog			2			1		1.7	1.0000	
	Litoria rubella	Naked Treefrog		1	7		1	7		8.7	0.0120	*
	Sphenophryne gracilipes	Shrill Chirper		3	16	2	3	9	2	4.3	0.1356	
	Rana daemeli	Australian Bullfrog		3			1			1.7	1.0000	
	Bufo marinus	Cane Toad		8	93	51	7	75	39	54.3	0.0001	***
	Count of frog (species) and sums of individuals observe		(14)	(13)	(12)	(10)	70	304	103	(13)		
		Total number of (species) observed	(115)	(66)	(74)	(69)	(61)	(61)	(66)	(99)		
		Total sum of individuals and (species) observed by systematic samplin					296	461	336			

Notes:

1) Gives the number of incidental and systematic observations of the species within the given habit

2) Gives the relative abundance or number of individuals of the species within the sample of the given habitat, as observed through systematic sampli

3) Gives the Chi-square statistic for comparison of abundances using a 3:3:2 hypothes

4) The test of significance is based on resampling the chi-square statisti

5) * P < 0.05 ** P <.01 *** P < 0.001.

6) Excluding marine and freshwater birds

Appendix H - Species list for the Andoom and Weipa regions

Legend

Andoom

The total number of individuals recorded within the Andoom region during the study using systematic survey methods.

Weipa

The total number of individuals recorded within the Weipa region during the study using systematic survey methods.

Significance

Indicates the probability that the observed difference in systematically recorded abundance is significant.

Appendix H - Species list for woodland habitats in the Andoom and Weipa regions

Class	Scientific Name	Common Name		Observations *(1)*		Abundance *(2)*		χ²	Prob	Sig
				Andoom	Weipa	Andoom	Weipa	*(3)*	*(4)*	*(5)*
Mammalia	Tachyglossus aculeatus	Short-beaked Echidna		1						
	Isoodon macrourus	Northern Brown Bandicoot		6		4		4.0	0.1268	
	Possum complex A	Possum complex A		1	1					
	Macropus agilis	Agile Wallaby		3	3		1	1.0	1.0000	
	Macropus antilopinus	Antilopine Kangaroo		1						
	Melomys burtoni	Grassland Melomys		1						
	Canis familiaris	Dingo		4	3	1	2	0.3	1.0000	
	Felis catus	Feral Cat		2	2	1		1.0	1.0000	
	Sus scrofa	Feral Pig		1	3		1	1.0	1.0000	
	Bos taurus	European Cattle			1					
	Count of mammal (species) and sums of individuals observed		(10)	(9)	(6)	6	4	(5)		
Aves	Tadorna radjah	Radjah Shelduck		1						
	Fregata sp.	Frigatebird sp.			1		1	1.0	1.0000	
	Threskiornis molucca	Australian White (Sacred) Ibis			1		1	1.0	1.0000	
	Lophoictinia isura	Square-tailed Kite			1		1	1.0	1.0000	
	Haliastur indus	Brahminy Kite		2	1	2	1	0.3	1.0000	
	Falco berigora	Brown Falcon		2		1		1.0	1.0000	
	Geopelia striata	Peaceful Dove		2	4	2	4	0.7	0.6891	
	Geopelia humeralis	Bar-shouldered Dove		8	7	8	7	0.1	1.0000	
	Ducula bicolor	Pied Imperial-Pigeon			3		3	3.0	0.2479	
	Probosciger aterrimus	Palm Cockatoo		1	3	1	3	1.0	0.6288	
	Calyptorhynchus banksii	Red-tailed Black-Cockatoo		1		1		1.0	1.0000	
	Cacatua galerita	Sulphur-crested Cockatoo		17	23	16	22	0.9	0.4185	
	Trichoglossus haematodus	Rainbow Lorikeet		30	28	29	28	0.0	1.0000	
	Aprosmictus erythropterus	Red-winged Parrot		12	13	11	12	0.0	1.0000	
	Platycercus adscitus	Pale-headed Rosella		2	6	2	6	2.0	0.2884	
	Eudynamys scolopacea	Common Koel		2	3	2	3	0.2	1.0000	
	Centropus phasianinus	Pheasant Coucal		11	14	11	13	0.2	0.8390	
	Ninox novaeseelandiae	Southern Boobook			1					
	Podargus strigoides	Tawny Frogmouth		1						
	Podargus papuensis	Papuan Frogmouth		1		1		1.0	1.0000	
	Podargus ocellatus	Marbled Frogmouth			1					
	Collocalia sp.	Swiftlet sp.		1						
	Dacelo novaeguineae	Laughing Kookaburra		17	14	15	14	0.0	1.0000	
	Dacelo leachii	Blue-winged Kookaburra		14	20	13	18	0.8	0.4717	
	Todirhamphus macleayii	Forest Kingfisher		7	6	7	6	0.1	1.0000	
	Merops ornatus	Rainbow Bee-eater		9	9	9	9			
	Climacteris picumnus	Brown Treecreeper		3	1	3	1	1.0	0.6261	
	Malurus melanocephalus	Red-backed Fairy-wren		1						
	Pardalotus striatus	Striated Pardalote		8	4	8	4	1.3	0.3886	
	Smicrornis brevirostris	Weebill		6	5	6	5	0.1	1.0000	
	Gerygone olivacea	White-throated Gerygone		1		1		1.0	1.0000	
	Philemon corniculatus	Noisy Friarbird		19	10	19	10	2.8	0.1356	
	Philemon citreogularis	Little Friarbird		28	21	28	21	1.0	0.3930	
	Entomyzon cyanotis	Blue-faced Honeyeater			2		2	2.0	0.4999	
	Lichenostomus flavus	Yellow Honeyeater			3		3	3.0	0.2482	
	Melithreptus albogularis	White-throated Honeyeater		27	25	27	25	0.1	0.8891	
	Ramsayornis modestus	Brown-backed Honeyeater		1		1		1.0	1.0000	
	Certhionyx pectoralis	Banded Honeyeater			1		1	1.0	1.0000	
	Microeca flavigaster	Lemon-bellied Flycatcher		19	20	19	20	0.0	1.0000	
	Pomatostomus temporalis	Grey-crowned Babbler		4	4	4	3	0.1	1.0000	
	Daphoenositta chrysoptera	Varied Sittella		7	4	7	4	0.8	0.5458	
	Pachycephala simplex	Grey Whistler		4	1	4	1	1.8	0.3763	
	Pachycephala rufiventris	Rufous Whistler		7	14	6	14	3.2	0.1155	
	Colluricincla harmonica	Grey Shrike-thrush		16	11	16	11	0.9	0.4432	
	Myiagra rubecula	Leaden Flycatcher		5	7	5	7	0.3	0.7748	
	Grallina cyanoleuca	Magpie Lark		2	1	2	1	0.3	1.0000	
	Rhipidura fuliginosa	Grey Fantail		1		1		1.0	1.0000	
	Coracina novaehollandiae	Black-faced Cuckoo-shrike		6	4	4	4			
	Coracina papuensis	White-bellied Cuckoo-shrike		21	23	19	23	0.4	0.6442	
	Coracina tenuirostris	Cicadabird		1		1		1.0	1.0000	
	Lalage leucomela	Varied Triller		1	4	1	4	1.8	0.3738	
	Lalage sueurii	White-winged Triller		1	1	1	1			
	Oriolus sagittatus	Olive-backed Oriole		1	1	1	1			
	Cracticus mentalis	Black-backed Butcherbird		18	11	18	10	2.3	0.1860	
	Cracticus nigrogularis	Pied Butcherbird		3	6	3	6	1.0	0.5073	
	Corvus orru	Torresian Crow		12	9	12	9	0.4	0.6665	
	Neochmia ruficauda	Star Finch		1		1		1.0	1.0000	
	Dicaeum hirundinaceum	Mistletoebird		3	1	3	1	1.0	0.6258	
	Count of bird (species) and sums of individuals observed		(58)	(49)	(46)	352	344	(48)		
Reptilia	Gehyra dubia	Gehyra dubia		2	14	2	12	7.1	0.0123	*
	Heteronotia binoei	Bynoe's Gecko		1	7		7	7.0	0.0152	*
	Nactus pelagicus	Pelagic Gecko		73	61	67	52	1.9	0.1986	
	Oedura castelnaui	Northern Velvet Gecko		3	9	3	9	3.0	0.1456	
	Oedura rhombifer	Oedura rhombifer		15	17	12	14	0.2	0.8458	
	Rhacodactylus australis	Giant Tree-gecko		3	6	2	6	2.0	0.2880	
	Delma tincta	Delma tincta		1		1		1.0	1.0000	
	Lialis burtonis	Burton's Snake-lizard		1	1	1		1.0	1.0000	
	Diporiphora bilineata	Two-lined Dragon		41	22	31	20	2.4	0.1630	
	Varanus tristis	Varanus tristis		2	5	2	3	0.2	1.0000	
	Carlia longipes	Carlia longipes		32	48	25	43	4.8	0.0390	*
	Cryptoblepharus virgatus	Cryptoblepharus virgatus		12	3	10	3	3.8	0.0926	
	Ctenotus spaldingi	Ctenotus spaldingi		6	3	6	1	3.6	0.1260	
	Egernia frerei	Major Skink		1		1		1.0	1.0000	
	Morethia taeniopleura	Fire-tailed Skink		7	2	5	2	1.3	0.4560	
	Ramphotyphlops polygrammicus	Ramphotyphlops polygrammicus			1		1	1.0	1.0000	
	Boiga irregularis	Brown Tree Snake		1		1		1.0	1.0000	
	Dendrelaphis punctulata	Common Tree Snake		1	1	1		1.0	1.0000	

Class	Scientific Name	Common Name		Observations *(1)* Andoom	Observations *(1)* Weipa	Abundance *(2)* Andoom	Abundance *(2)* Weipa	χ² *(3)*	Prob *(4)*	Sig *(5)*
	Demansia vestigiata	Demansia vestigiata		1		1		1.0	1.0000	
	Oxyuranus scutellatus	Taipan			1					
	Rhinoplocephalus nigrostriatus	Black-striped Snake		2	1	2	1	0.3	1.0000	
	Count of reptile (species) and sums of individuals observed		(21)	(19)	(17)	173	174	(20)		
Amphibia	Limnodynastes ornatus	Ornate Burrowing Frog			23		15	15.0	0.0001	***
	Uperoleia mimula	Torres Gungan			14		10	10.0	0.0020	***
	Crinia remota	Torrid Froglet		2	2		1	1.0	1.0000	
	Litoria bicolor	Northern Sedgefrog		8	3	4	1	1.8	0.3745	
	Litoria gracilenta	Graceful Treefrog			1					
	Litoria pallida	Peach-sided Rocketfrog			2					
	Cyclorana novaehollandiae	Eastern Snapping-Frog			1					
	Sphenophryne gracilipes	Shrill Chirper		1	3	1	2	0.3	1.0000	
	Bufo marinus	Cane Toad		4		3		3.0	0.2509	
	Count of frog (species) and sums of individuals observed		(9)	(4)	(8)	8	29	(6)		
	Total number of (species) observed		(98)	(81)	(77)	(69)	(66)	(79)		
	Total sum of individuals and (species) observed by systematic sampling					539	551			

Notes:

1) Gives the number of incidental and systematic observations of the species within the given habitat.
2) Gives the relative abundance or number of individuals of the species within the sample of the given habitat, as observed through systematic sampling.
3) Gives the Chi-square statistic for comparison of abundances using a 1:1 hypothesis
4) The test of significance is based on resampling the chi-square statistic.
5) * $P < 0.05$ ** $P < .01$ *** $P < 0.001$.
6) Excluding marine and freshwater birds.

Appendix I - Species abundances by visit and habitat, arranged in traditional seasonal order

Appendix I - Species abundances by visit and habitat, arranged in traditional seasonal order

Class	Species Name	Common Name	Habitat	Agahay	Prul kun njin	Alan payn	Tharang	Ngwor mbwor	Signif (1)
				Season & Visit					
				Build up	Wet	Break up	Early Dry	Middle Dry	
			Visit	5	2	6	3	0.5208	
Mammalia	*Sminthopsis virginiae*	Red-cheeked Dunnart	Mesic	-	-	-	-	2	
	Isoodon macrourus	Northern Brown Bandicoot	Mesic	-	-	-	-	1	
			Ecotone	-	-	-	-	1	
			Woodland	2	-	-	2	2	
				2	-	-	2	4	<25
	Petaurus breviceps	Sugar Glider	Ecotone	-	-	1	1	1	
			Woodland	-	-	1	-	-	
				-	-	2	1	1	<25
	Macropus agilis	Agile Wallaby	Mesic	1	-	-	-	-	
			Woodland	1	-	1	-	-	
				2	-	1	-	-	<25
	Macropus antilopinus	Antilopine Kangaroo	Ecotone	-	1	-	-	-	
	Melomys burtoni	Grassland Melomys	Mesic	-	1	31	6	6	
			Ecotone	-	-	4	-	-	
			Woodland	-	-	-	1	-	
				-	1	35	7	6	***
	Canis familiaris	Dingo	Mesic	-	-	-	-	1	
			Woodland	1	1	1	1	1	
				1	1	1	1	2	<25
	Felis catus	Feral Cat	Ecotone	-	-	1	-	-	
			Woodland	-	-	1	2	-	
				-	-	2	2	-	<25
	Sus scrofa	Feral Pig	Mesic	1	-	-	-	2	
			Ecotone	-	-	-	-	1	
			Woodland	-	1	-	1	1	
				1	1	-	1	4	<25
	Bos taurus	European Cattle	Woodland	1	-	-	-	-	
		Count of mammals observed	10	5	4	5	6	6	ns
Aves	*Alectura lathami*	Australian Brush-turkey	Ecotone	-	-	-	1	-	<25
	Megapodius reinwardt	Orange-footed Scrubfowl	Mesic	1	-	1	2	1	
			Ecotone	-	-	-	-	1	
				1	-	1	2	2	<25
	Tachybaptus novaehollandiae	Australasian Grebe	Mesic	-	-	-	-	2	<25
	Phalacrocorax melanoleucos	Little Pied Cormorant	Mesic	-	-	-	-	1	<25
	Threskiornis molucca	Australian White Ibis	Ecotone	-	-	-	-	1	
			Woodland	-	-	-	-	1	
				-	-	-	-	2	<25
	Lophoictinia isura	Square-tailed Kite	Woodland	-	-	1	-	-	<25
	Milvus migrans	Black Kite	Mesic	-	-	-	-	1	
			Ecotone	-	-	-	-	1	
				-	-	-	-	2	<25
	Haliastur sphenurus	Whistling Kite	Ecotone	1	-	-	-	-	<25
	Haliastur indus	Brahminy Kite	Ecotone	-	1	-	1	-	
			Woodland	-	-	-	2	1	
				-	1	-	3	1	<25
	Falco berigora	Brown Falcon	Woodland	-	-	-	1	-	<25
	Grus rubicunda	Brolga	Ecotone	-	-	1	-	-	<25
	Amaurornis olivaceus	Bush-hen	Mesic	-	1	-	-	-	
			Ecotone	-	1	-	-	-	
				-	2	-	-	-	<25
	Burhinus grallarius	Bush Stone-curlew	Mesic	-	-	1	-	-	<25
	Geopelia striata	Peaceful Dove	Mesic	-	-	1	2	5	
			Ecotone	1	-	4	1	7	
			Woodland	-	-	-	1	5	
				1	-	5	4	17	***
	Geopelia humeralis	Bar-shouldered Dove	Mesic	-	3	5	3	6	
			Ecotone	1	3	5	3	5	
			Woodland	-	1	7	4	3	
				1	7	17	10	14	**

Class	Species Name	Common Name	Habitat	Season & Visit					Signif (1)
				Agahay	Prul kun njin	Alan payn	Tharang	Ngwor mbwor	
				Build up	Wet	Break up	Early Dry	Middle Dry	
			Visit	5	2	6	3	0.5208	
	Ducula bicolor	Pied Imperial-Pigeon	Mesic	-	-	-	-	1	
			Ecotone	1	1	-	-	3	
			Woodland	-	-	-	-	3	
				5	15	44	28	69	***
	Probosciger aterrimus	Palm Cockatoo	Mesic	-	-	-	-	2	
			Ecotone	-	-	1	1	2	
			Woodland	-	-	-	1	3	
				6	16	45	30	83	***
	Calyptorhynchus banksii	Red-tailed Black-Cockatoo	Mesic	-	-	-	-	1	
			Woodland	-	-	1	-	-	
				-	-	1	-	1	<25
	Cacatua galerita	Sulphur-crested Cockatoo	Mesic	-	2	3	2	6	
			Ecotone	2	4	6	2	5	
			Woodland	6	3	11	8	12	
				8	9	20	12	23	*
	Trichoglossus haematodus	Rainbow Lorikeet	Mesic	2	6	6	5	8	
			Ecotone	2	7	7	4	7	
			Woodland	7	11	14	12	14	
				11	24	27	21	29	ns
	Aprosmictus erythropterus	Red-winged Parrot	Mesic	-	3	2	1	-	
			Ecotone	1	3	4	-	4	
			Woodland	-	3	9	8	5	
				1	9	15	9	9	*
	Platycercus adscitus	Pale-headed Rosella	Mesic	1	1	2	-	-	
			Ecotone	1	1	1	1	-	
			Woodland	1	2	1	2	2	
				3	4	4	3	2	<25
	Cacomantis flabelliformis	Fan-tailed Cuckoo	Mesic	-	-	-	1	-	<25
	Chrysococcyx minutillus	Little Bronze-Cuckoo	Mesic	-	-	-	-	1	<25
	Eudynamys scolopacea	Common Koel	Mesic	2	-	-	-	3	
			Ecotone	1	-	1	-	2	
			Woodland	2	-	-	-	3	
				5	-	1	-	8	<25
	Centropus phasianinus	Pheasant Coucal	Mesic	2	2	1	2	3	
			Ecotone	3	2	3	1	1	
			Woodland	5	9	5	1	5	
				10	13	9	4	9	ns
	Ninox novaeseelandiae	Southern Boobook	Ecotone	1	-	-	1	-	
			Woodland	1	-	-	-	-	
				2	-	-	1	-	<25
	Podargus strigoides	Tawny Frogmouth	Mesic	-	-	1	-	-	
			Ecotone	-	-	1	-	-	
			Woodland	1	-	-	-	-	
				1	-	2	-	-	<25
	Podargus papuensis	Papuan Frogmouth	Mesic	-	-	-	2	-	
			Woodland	-	-	-	-	1	
				-	-	-	2	1	<25
	Collocalia sp.	Swiftlet UID	Ecotone	1	-	-	-	-	
			Woodland	-	1	-	-	-	
				1	1	-	-	-	<25
	Alcedo azureus	Azure Kingfisher	Mesic	-	1	-	-	-	<25
	Dacelo leachii	Blue-winged Kookaburra	Mesic	2	1	2	1	8	
			Ecotone	2	2	4	4	7	
			Woodland	6	6	5	6	11	
				10	9	11	11	26	**
	Dacelo novaeguineae	Laughing Kookaburra	Mesic	-	-	-	1	1	
			Ecotone	2	1	1	3	3	
			Woodland	5	6	4	6	8	
				7	7	5	10	12	ns
	Syma torotoro	Yellow-billed Kingfisher	Mesic	-	-	-	-	2	
			Ecotone	1	-	1	-	2	
				1	-	1	-	4	<25
	Todirhamphus macleayii	Forest Kingfisher	Mesic	-	2	1	2	3	
			Ecotone	1	3	3	1	5	
			Woodland	3	1	-	4	5	
				4	6	4	7	13	ns

Class	Species Name	Common Name	Habitat	Agahay	Prul kun njin	Alan payn	Tharang	Ngwor mbwor	Signif (1)
				Season & Visit					
				Build up	Wet	Break up	Early Dry	Middle Dry	
			Visit	5	2	6	3	0.5208	
	Todirhamphus sanctus	Sacred Kingfisher	Mesic	-	1	-	-	-	<25
	Merops ornatus	Rainbow Bee-eater	Mesic	2	-	3	5	3	
			Ecotone	1	-	6	4	4	
			Woodland	1	2	7	4	4	
				4	2	16	13	11	**
	Eurystomus orientalis	Dollarbird	Mesic	-	-	1	-	-	<25
				52	50	75	82	132	***
	Climacteris picumnus	Brown Treecreeper	Mesic	-	-	1	-	-	
			Ecotone	-	1	2	-	-	
			Woodland	1	-	3	-	-	
				53	51	82	82	132	***
	Malurus melanocephalus	Red-backed Fairy-wren	Ecotone	-	1	-	-	-	
			Woodland	1	-	-	-	-	
				1	1	-	-	-	<25
	Pardalotus striatus	Striated Pardalote	Mesic	-	-	-	-	1	
			Ecotone	1	-	3	-	1	
			Woodland	-	-	9	1	2	
				1	-	12	1	4	<25
	Smicrornis brevirostris	Weebill	Mesic	-	-	1	-	-	
			Woodland	2	-	5	1	3	
				2	-	6	1	3	<25
	Gerygone palpebrosa	Fairy Gerygone	Mesic	1	-	-	-	2	<25
	Gerygone olivacea	White-throated Gerygone	Woodland	-	-	-	-	1	<25
	Philemon corniculatus	Noisy Friarbird	Mesic	-	-	1	1	3	
			Ecotone	1	1	1	1	4	
			Woodland	2	3	8	4	12	
				-	-	-	-	-	
	Philemon citreogularis	Little Friarbird	Mesic	-	4	5	4	6	
			Ecotone	1	4	6	2	7	
			Woodland	5	9	13	7	15	
				9	21	34	19	47	***
	Entomyzon cyanotis	Blue-faced Honeyeater	Mesic	-	1	1	1	-	
			Ecotone	1	1	-	-	-	
			Woodland	-	-	-	-	2	
				1	2	1	1	2	<25
	Xanthotis chrysotis	Tawny-breasted Honeyeater	Mesic	2	-	2	-	-	<25
	Lichenostomus versicolor	Varied Honeyeater	Mesic	-	1	-	-	-	<25
	Lichenostomus flavus	Yellow Honeyeater	Mesic	1	4	5	3	3	
			Ecotone	2	1	4	1	5	
			Woodland	-	-	1	-	2	
				3	5	10	4	10	ns
	Melithreptus albogularis	White-throated Honeyeater	Mesic	3	7	6	5	8	
			Ecotone	2	6	7	4	7	
			Woodland	6	6	14	12	14	
				11	19	27	21	29	*
	Lichmera indistincta	Brown Honeyeater	Mesic	-	-	-	1	-	
			Ecotone	-	-	1	-	-	
				-	-	1	1	-	<25
	Ramsayornis modestus	Brown-backed Honeyeater	Mesic	-	1	-	-	-	
			Woodland	1	-	-	-	-	
				1	1	-	-	-	<25
	Ramsayornis fasciatus	Bar-breasted Honeyeater	Mesic	-	1	-	1	-	<25
	Certhionyx pectoralis	Banded Honeyeater	Ecotone	-	-	-	-	1	
			Woodland	-	-	-	-	1	
				-	-	-	-	2	<25
	Myzomela obscura	Dusky Honeyeater	Mesic	1	-	-	-	3	
			Ecotone	-	-	-	-	1	
				1	-	-	-	4	<25
	Myzomela sanguinolenta	Scarlet Honeyeater	Mesic	1	-	-	-	1	<25
	Microeca flavigaster	Lemon-bellied Flycatcher	Mesic	-	4	3	4	5	
			Ecotone	1	5	6	4	7	
			Woodland	4	7	12	10	6	
				5	16	21	18	18	*

Class	Species Name	Common Name	Habitat	Season & Visit: Agahay (Build up)	Prul kun njin (Wet)	Alan payn (Break up)	Tharang (Early Dry)	Ngwor mbwor (Middle Dry)	Signif (1)
			Visit	5	2	6	3	0.5208	
	Pomatostomus temporalis	Grey-crowned Babbler	Ecotone	-	1	-	1	1	
			Woodland	2	2	-	2	1	
				2	3	-	3	2	<25
	Daphoenositta chrysoptera	Varied Sittella	Mesic	-	-	-	1	-	
			Ecotone	-	-	-	-	2	
			Woodland	-	-	7	3	1	
				-	-	7	4	3	<25
	Pachycephala simplex	Grey Whistler	Mesic	-	-	1	1	-	
			Ecotone	1	-	1	-	-	
			Woodland	1	1	1	2	-	
				2	1	3	3	-	<25
	Colluricincla megarhyncha	Little Shrike-thrush	Mesic	1	2	-	-	1	<25
	Colluricincla harmonica	Grey Shrike-thrush	Mesic	-	-	3	3	3	
			Ecotone	2	3	4	-	3	
			Woodland	2	1	12	4	8	
				4	4	19	7	14	**
	Monarcha trivirgatus	Spectacled Monarch	Mesic	-	-	1	-	1	<25
	Myiagra rubecula	Leaden Flycatcher	Mesic	2	-	2	2	5	
			Ecotone	2	-	1	2	6	
			Woodland	1	1	2	5	3	
				5	1	5	9	14	**
	Myiagra alecto	Shining Flycatcher	Mesic	1	-	-	-	-	<25
	Rhipidura fuliginosa	Grey Fantail	Woodland	-	-	1	-	-	<25
	Dicrurus bracteatus	Spangled Drongo	Mesic	-	-	-	1	1	
			Ecotone	-	1	-	2	-	
				-	1	-	3	1	<25
	Coracina novaehollandiae	Black-faced Cuckoo-shrike	Mesic	-	-	-	-	2	
			Woodland	3	1	3	1	2	
				3	1	3	1	4	<25
	Coracina papuensis	White-bellied Cuckoo-shrike	Mesic	-	5	3	4	5	
			Ecotone	2	3	6	3	5	
			Woodland	5	7	9	12	11	
				7	15	18	19	21	ns
	Coracina tenuirostris	Cicadabird	Mesic	-	1	-	-	-	
			Ecotone	-	1	-	2	1	
			Woodland	-	-	1	-	-	
				-	2	1	2	1	<25
	Lalage sueurii	White-winged Triller	Ecotone	-	-	1	-	-	
			Woodland	-	-	-	-	2	
				-	-	1	-	2	<25
	Lalage leucomela	Varied Triller	Ecotone	-	-	-	-	1	
			Woodland	1	-	-	4	-	
				1	-	-	4	1	<25
	Oriolus flavocinctus	Yellow Oriole	Mesic	-	1	-	-	2	
			Ecotone	-	1	-	1	1	
				-	2	-	1	3	<25
	Oriolus sagittatus	Olive-backed Oriole	Ecotone	-	-	-	-	2	
			Woodland	-	-	1	-	1	
				-	-	1	-	3	<25
	Artamus minor	Little Woodswallow	Ecotone	1	-	-	-	-	<25
	Cracticus quoyi	Black Butcherbird	Mesic	-	1	-	-	-	<25
	Cracticus mentalis	Black-backed Butcherbird	Mesic	-	-	-	-	2	
			Ecotone	-	-	2	1	2	
			Woodland	3	6	9	5	5	
				3	6	11	6	9	ns
	Cracticus nigrogularis	Pied Butcherbird	Mesic	-	-	1	1	-	
			Ecotone	-	-	-	-	1	
			Woodland	2	1	1	2	3	
				2	1	2	3	4	<25
	Gymnorhina tibicen	Australian Magpie	Mesic	-	-	1	-	2	
			Ecotone	-	-	2	-	-	
			Woodland	-	-	1	2	-	
				-	-	4	2	2	<25

Class	Species Name	Common Name	Habitat	Agahay	Prul kun njin	Alan payn	Tharang	Ngwor mbwor	Signif (1)
				Season & Visit					
				Build up	Wet	Break up	Early Dry	Middle Dry	
			Visit	5	2	6	3	0.5208	
	Ptiloris magnificus	Magnificent Riflebird	Mesic	-	-	-	2	-	
			Ecotone	-	1	-	-	-	
				-	1	-	2	-	<25
	Corvus orru	Torresian Crow	Mesic	1	-	2	2	5	
			Ecotone	3	-	2	3	4	
			Woodland	1	3	2	3	12	
				5	3	6	8	21	***
	Chlamydera nuchalis	Great Bowerbird	Mesic	1	-	-	2	2	
			Ecotone	-	-	-	-	3	
				1	-	-	2	5	<25
	Finch sp.	Finch UID	Mesic	-	-	-	1	-	<25
	Neochmia ruficauda	Star Finch	Woodland	1	-	-	-	-	<25
	Nectarinia jugularis	Yellow-bellied Sunbird	Mesic	-	1	1	-	-	<25
	Dicaeum hirundinaceum	Mistletoebird	Mesic	-	-	-	1	-	
			Ecotone	-	-	1	-	-	
			Woodland	1	-	1	2	-	
				1	-	2	3	-	<25
	Hirundo spp.	Martin complex (Fairy/Tree)	Mesic	-	-	2	2	-	
			Ecotone	-	-	2	-	1	
			Woodland	-	-	3	-	-	
				-	-	7	2	1	<25
		Count of birds observed	88	50	43	50	49	57	ns
Reptilia	*Chelodina rugosa*	Northern Snake-necked Turtle	Mesic	-	-	1	-	-	<25

Class	Species Name	Common Name	Habitat	Agahay	Prul kun njin	Alan payn	Tharang	Ngwor mbwor	Signif (1)
				Season & Visit					
				Build up	Wet	Break up	Early Dry	Middle Dry	
			Visit	5	2	6	3	0.5208	
	Gehyra dubia	Gehyra dubia	Mesic	-	-	1	-	2	
			Ecotone	1	-	3	1	2	
			Woodland	6	-	5	-	4	
				7	-	9	1	8	<25
	Heteronotia binoei	Bynoe's Gecko	Woodland	4	-	-	2	2	<25
	Nactus pelagicus	Pelagic Gecko	Mesic	-	-	-	2	1	
			Ecotone	2	5	3	5	8	
			Woodland	33	8	14	22	57	
				35	13	17	29	66	***
	Oedura castelnaui	Northern Velvet Gecko	Mesic	-	-	1	-	-	
			Ecotone	-	-	1	-	-	
			Woodland	1	-	5	1	5	
				1	-	7	1	5	<25
	Oedura rhombifer	Oedura rhombifer	Ecotone	-	-	3	3	3	
			Woodland	6	1	1	7	14	
				6	1	4	10	17	***
	Rhacodactylus australis	Giant Tree-gecko	Mesic	-	-	-	-	1	
			Ecotone	-	-	-	1	1	
			Woodland	6	-	2	1	-	
				6	-	2	2	2	<25
	Delma tincta	Delma tincta	Ecotone	-	1	-	-	-	
			Woodland	-	-	-	1	-	
				-	1	-	1	-	<25
	Lialis burtonis	Burton's Snake-lizard	Mesic	-	-	-	-	3	
			Ecotone	-	-	-	1	1	
			Woodland	-	-	-	-	1	
				-	-	-	1	5	<25
	Diporiphora sp. A	Unidentified Diporiphora	Mesic	-	3	1	3	5	
			Ecotone	1	7	3	13	14	
			Woodland	1	6	5	23	26	
				2	16	9	39	45	***
	Lophognathus temporalis	Lophognathus temporalis	Mesic	1	-	-	1	1	
			Ecotone	-	-	-	-	1	
				1	-	-	1	2	<25
	Varanus tristis	Varanus tristis	Mesic	-	1	2	-	1	
			Ecotone	-	1	2	1	-	
			Woodland	-	2	2	2	1	
				-	4	6	3	2	<25
	Varanus sp	unidentified Goanna/Monitor	Woodland	-	1	-	-	-	<25
	Carlia jarnoldae	Jewel Skink	Mesic	-	2	5	7	-	
			Ecotone	1	3	-	2	-	
			Woodland	1	1	2	7	-	
				2	6	7	16	-	***
	Carlia longipes	Carlia longipes	Mesic	6	6	3	18	42	
			Ecotone	13	6	1	3	18	
			Woodland	14	16	4	9	24	
				33	28	8	30	84	***
	Carlia storri	Carlia storri	Mesic	8	17	2	6	17	
			Ecotone	-	1	-	-	-	
				8	18	2	6	17	***
	Cryptoblepharus virgatus	Cryptoblepharus virgatus	Mesic	7	8	-	4	9	
			Ecotone	4	4	-	1	6	
			Woodland	1	7	1	2	4	
				12	19	1	7	19	***
	Ctenotus spaldingi	Ctenotus spaldingi	Mesic	-	4	-	5	1	
			Ecotone	1	7	1	7	7	
			Woodland	-	2	-	2	5	
				1	13	1	14	13	***
	Egernia frerei	Major Skink	Mesic	-	-	2	4	-	
			Woodland	-	-	-	-	1	
				-	-	2	4	1	<25
	Glaphyromorphus nigricaudis	Glaphyromorphus nigricaudis	Mesic	7	5	4	15	23	
			Ecotone	-	1	-	-	3	
				7	6	4	15	26	***
	Morethia taeniopleura	Fire-tailed Skink	Mesic	-	1	-	-	-	
			Ecotone	-	1	-	3	1	
			Woodland	1	2	2	2	2	

Class	Species Name	Common Name	Habitat	Agahay	Prul kun njin	Alan payn	Tharang	Ngwor mbwor	Signif (1)
				Build up	Wet	Break up	Early Dry	Middle Dry	
			Visit	5	2	6	3	0.5208	
				1	4	2	5	3	<25
	Ramphotyphlops sp. aff. minimus	Ramphotyphlops sp. aff. minimus	Mesic	-	-	1	-	-	<25
	Ramphotyphlops polygrammicus	Ramphotyphlops polygrammicus	Ecotone	-	1	-	-	-	
			Woodland	-	1	-	-	-	
				-	2	-	-	-	<25
	Anteresia maculosa	Childrens Python	Ecotone	1	-	-	-	-	<25
	Morelia spilota	Carpet Python	Woodland	-	-	1	-	-	<25
	Boiga irregularis	Brown Tree Snake	Woodland	-	-	-	1	-	<25
	Dendrelaphis punctulata	Common Tree Snake	Ecotone	-	-	-	-	1	
			Woodland	-	-	-	-	1	
				-	-	-	-	2	<25
	Demansia vestigiata	Demansia vestigiata	Mesic	-	1	2	2	2	
			Ecotone	-	1	-	-	-	
			Woodland	-	-	1	-	-	
				-	2	3	2	2	<25
	Furina ornata	Orange-naped Snake	Mesic	-	-	-	-	1	<25
	Oxyuranus scutellatus	Taipan	Woodland	-	-	-	-	1	<25
	Rhinoplocephalus nigrostriatus	Black-striped Snake	Ecotone	-	-	1	-	-	
			Woodland	2	-	1	-	-	
				2	-	2	-	-	<25
		Count of reptiles observed	31	17	15	19	21	21	ns
Amphibia	*Limnodynastes convexiusculus*	Marbled Frog	Mesic	-	1	1	-	2	
			Ecotone	-	1	-	-	-	
				-	2	1	-	2	<25

(Columns Agahay to Ngwor mbwor are grouped under the heading "Season & Visit".)

Class	Species Name	Common Name	Habitat	Season & Visit					Signif (1)
				Agahay	Prul kun njin	Alan payn	Tharang	Ngwor mbwor	
				Build up	Wet	Break up	Early Dry	Middle Dry	
			Visit	5	2	6	3	0.5208	
	Limnodynastes ornatus	Ornate Burrowing Frog	Mesic	-	16	-	2	9	
			Ecotone	2	5	-	1	1	
			Woodland	-	22	-	-	1	
				2	43	-	3	11	***
	Uperoleia mimula	Torres Gungan	Mesic	3	15	1	45	24	
			Ecotone	1	24	-	7	4	
			Woodland	-	7	-	4	3	
				4	46	1	56	31	***
	Crinia remota	Torrid Froglet	Mesic	6	12	22	46	46	
			Ecotone	6	5	-	-	-	
			Woodland	-	3	1	-	-	
				12	20	23	46	46	***
	Litoria bicolor	Northern Sedgefrog	Mesic	-	5	1	6	14	
			Ecotone	-	6	6	10	2	
			Woodland	1	1	6	2	-	
				1	12	13	18	16	**
	Litoria caerulea	Green Treefrog	Mesic	-	1	-	-	-	
	Litoria gracilenta	Graceful Treefrog	Ecotone	-	-	-	2	-	
			Woodland	-	1	-	-	-	
				-	1	-	2	-	<25
	Litoria infrafrenata	White-lipped Treefrog	Mesic	-	1	4	4	2	
			Ecotone	-	-	1	-	1	
				-	1	5	4	3	<25
	Litoria nasuta	Striped Rocketfrog	Mesic	-	1	7	20	53	
			Ecotone	1	2	5	1	3	
				1	3	12	21	56	***
	Litoria nigrofrenata	Tawny Rocketfrog	Mesic	-	-	-	3	5	<25
	Litoria pallida	Peach-sided Rocketfrog	Woodland	-	1	-	-	-	<25
	Litoria rothii	Red-eyed Treefrog	Mesic	-	1	1	-	-	
			Ecotone	-	-	-	-	1	
				-	1	1	-	1	<25
	Litoria rubella	Naked Treefrog	Mesic	-	-	6	-	1	<25
	Cyclorana novaehollandiae	Eastern Snapping-Frog	Woodland	-	1	-	-	-	<25
	Sphenophryne gracilipes	Shrill Chirper	Mesic	2	2	10	1	6	
			Ecotone	1	-	13	-	-	
			Woodland	2	2	-	-	-	
				5	4	23	1	6	***
	Rana daemeli	Australian Bullfrog	Mesic	1	-	1	-	-	<25
	Bufo marinus	Cane Toad	Mesic	11	32	37	50	25	
			Ecotone	17	10	15	10	3	
			Woodland	1	2	-	1	-	
				29	44	52	61	28	***
		Count of frogs observed	17	8	14	11	10	12	ns
		Count of vertebrates observed	146	80	76	85	86	96	ns

Appendix J - List of specimens lodged with Queensland Museum

Appendix J - List of specimens lodged with Queensland Museum

Field No	Class	Species	Date	Latitude	Longitude	Geocode Accuracy	Survey Method
1	Reptilia	*Carlia storri*	07-Dec-1992	12° 37' 05" N	141° 59' 05" E'	100 m	Trapping Pitfall
2	Reptilia	*Nactus pelagicus*	27-Sep-1992	12° 36' 40" N	141° 56' 01" E'	100 m	Incidental
3	Reptilia	*Nactus pelagicus*	27-Sep-1992	12° 36' 40" N	141° 56' 01" E'	100 m	Incidental
4	Reptilia	*Dendrelaphis punctulata*	01-Feb-1992	12° 40' 59" N	141° 58' 00" E'	900 m	Incidental
5	Reptilia	*Diporiphora bilineata*	27-Jan-1992	12° 28' 38" N	141° 50' 06" E'	100 m	Trapping Pitfall
6	Reptilia	*Diporiphora bilineata*	28-Jan-1992	12° 28' 38" N	141° 50' 06" E'	100 m	Incidental
7	Reptilia	*Carlia storri*	28-Jan-1992	12° 28' 37" N	141° 50' 03" E'	100 m	Incidental
8	Reptilia	*Cryptoblepharus virgatus*	27-Jan-1992	12° 28' 41" N	141° 50' 37" E'	100 m	Incidental
9	Reptilia	*Nactus pelagicus*	28-Jan-1992	12° 28' 01" N	141° 50' 34" E'	100 m	Incidental
10	Reptilia	*Ctenotus spaldingi*	28-Jan-1992	12° 28' 38" N	141° 50' 06" E'	100 m	Incidental
11	Reptilia	*Carlia longipes*	28-Jan-1992	12° 28' 01" N	141° 50' 34" E'	100 m	Incidental
12	Amphibia	*Litoria rothii*	29-Jan-1992	12° 28' 37" N	141° 50' 03" E'	100 m	Incidental
13	Reptilia	*Carlia jarnoldae*	28-Jan-1992	12° 28' 59" N	141° 50' 30" E'	300 m	Incidental
14	Reptilia	*Diporiphora bilineata*	27-Jan-1992	12° 28' 01" N	141° 50' 34" E'	100 m	Incidental
15	Reptilia	*Ctenotus spaldingi*	27-Jan-1992	12° 28' 38" N	141° 50' 06" E'	100 m	Incidental
17	Reptilia	*Carlia longipes*	27-Jan-1992	12° 28' 41" N	141° 50' 37" E'	100 m	Trapping Pitfall
18	Reptilia	*Cryptoblepharus virgatus*	27-Jan-1992	12° 28' 38" N	141° 50' 06" E'	100 m	Incidental
19	Reptilia	*Oedura rhombifer*	01-Feb-1992	12° 37' 07" N	141° 59' 42" E'	100 m	Incidental
20	Amphibia	*Litoria bicolor*	29-Jan-1992	12° 28' 37" N	141° 50' 03" E'	100 m	Incidental
21	Amphibia	*Litoria bicolor*	29-Jan-1992	12° 28' 37" N	141° 50' 03" E'	100 m	Incidental
22	Amphibia	*Litoria bicolor*	29-Jan-1992	12° 28' 37" N	141° 50' 03" E'	100 m	Incidental
23	Reptilia	*Carlia longipes*	01-Feb-1992	12° 37' 07" N	141° 59' 08" E'	100 m	Trapping Pitfall
24	Reptilia	*Glaphyromorphus nigricaudis*	02-Feb-1992	12° 37' 05" N	141° 59' 05" E'	100 m	Trapping Elliott
25	Reptilia	*Carlia longipes*	02-Feb-1992	12° 37' 05" S'	141° 59' 04" E'	200 m	Incidental
26	Reptilia	*Carlia longipes*	31-Jan-1992	12° 37' 38" N	141° 59' 17" E'	100 m	Incidental
27	Reptilia	*Carlia longipes*	31-Jan-1992	12° 37' 38" N	141° 59' 17" E'	100 m	Incidental
28	Reptilia	*Varanus tristis*	30-Jan-1992	12° 28' 01" N	141° 50' 34" E'	100 m	Trapping Pitfall
29	Reptilia	*Nactus pelagicus*	29-Jan-1992	12° 28' 38" N	141° 50' 06" E'	100 m	Trapping Pitfall
30	Reptilia	*Nactus pelagicus*	27-Sep-1992	12° 36' 40" N	141° 56' 01" E'	100 m	Incidental
31	Reptilia	*Ramphotyphlops polygrammicus*	01-Feb-1992	12° 37' 07" N	141° 59' 08" E'	100 m	Trapping Pitfall
32	Reptilia	*Ramphotyphlops polygrammicus*	01-Feb-1992	12° 37' 38" N	141° 59' 17" E'	100 m	Trapping Pitfall
33	Amphibia	*Limnodynastes ornatus*	15-Dec-1992	12° 28' 31" N	141° 47' 00" E'	100 m	Incidental
34	Reptilia	*Nactus pelagicus*	01-Feb-1992	12° 37' 38" N	141° 59' 17" E'	100 m	Trapping Pitfall
35	Amphibia	*Litoria bicolor*	30-May-1993	12° 30' 42" N	141° 47' 59" E'	100 m	Trapping Pitfall
36	Amphibia	*Litoria bicolor*	30-May-1993	12° 30' 42" N	141° 47' 59" E'	100 m	Trapping Pitfall
37	Reptilia	*Nactus pelagicus*	27-Sep-1992	12° 36' 40" N	141° 56' 01" E'	100 m	Incidental
38	Amphibia	*Litoria bicolor*	30-May-1993	12° 30' 42" N	141° 47' 59" E'	100 m	Trapping Pitfall
39	Amphibia	*Litoria bicolor*	30-May-1993	12° 30' 42" N	141° 47' 59" E'	100 m	Trapping Pitfall
41	Amphibia	*Litoria bicolor*	30-May-1993	12° 30' 42" N	141° 47' 59" E'	100 m	Trapping Pitfall
43	Amphibia	*Limnodynastes ornatus*	15-Dec-1992	12° 28' 31" N	141° 47' 00" E'	100 m	Incidental
44	Amphibia	*Sphenophryne gracilipes*	30-May-1993	12° 30' 42" N	141° 47' 59" E'	100 m	Trapping Pitfall
47	Amphibia	*Sphenophryne gracilipes*	04-Mar-1992	12° 43' 22" N	141° 56' 48" E'	100 m	Trapping Pitfall
48	Amphibia	*Sphenophryne gracilipes*	30-May-1993	12° 30' 42" N	141° 47' 59" E'	100 m	Trapping Pitfall
50	Amphibia	*Sphenophryne gracilipes*	30-May-1993	12° 30' 42" N	141° 47' 59" E'	100 m	Trapping Pitfall
51	Amphibia	*Sphenophryne gracilipes*	30-May-1993	12° 30' 42" N	141° 47' 59" E'	100 m	Trapping Pitfall
52	Amphibia	*Sphenophryne gracilipes*	30-May-1993	12° 30' 42" N	141° 47' 59" E'	100 m	Trapping Pitfall
54	Reptilia	*Chelodina rugosa*	28-May-1993	12° 30' 44" N	141° 48' 01" E'	100 m	Incidental
55	Mammalia	*Mesembriomys gouldii*	01-Jun-1993	12° 39' 59" N	141° 52' 08" E'	200 m	Incidental
56	Reptilia	*Varanus tristis*	12-Apr-1993	12° 36' 40" N	141° 56' 01" E'	100 m	Incidental
57	Mammalia	*Melomys burtoni*	11-Apr-1993	12° 37' 16" N	141° 56' 27" E'	100 m	Trapping Elliott
59	Amphibia	*Sphenophryne gracilipes*	08-Dec-1992	12° 37' 05" N	141° 59' 05" E'	100 m	Night Arboreal
60	Amphibia	*Litoria bicolor*	30-May-1993	12° 30' 42" N	141° 47' 59" E'	100 m	Trapping Pitfall
61	Reptilia	*Carlia storri*	02-Feb-1992	12° 28' 37" N	141° 50' 03" E'	100 m	Incidental
64	Reptilia	*Carlia jarnoldae*	03-Feb-1992	12° 28' 37" N	141° 50' 03" E'	100 m	Trapping Elliott
65	Reptilia	*Nactus pelagicus*	03-Feb-1992	12° 37' 07" N	141° 59' 08" E'	100 m	Trapping Pitfall
66	Reptilia	*Morethia taeniopleura*	03-Feb-1992	12° 37' 07" N	141° 59' 42" E'	100 m	Trapping Pitfall
68	Reptilia	*Diporiphora bilineata*	03-Feb-1992	12° 40' 00" N	141° 58' 11" E'	300 m	Incidental
69	Reptilia	*Dendrelaphis punctulata*	04-Feb-1992	12° 34' 00" N	141° 53' 14" E'	1000 m	Incidental
70	Reptilia	*Tropidonophis mairii*	03-Feb-1992	12° 39' 29" N	141° 53' 30" E'	150 m	Incidental
71	Reptilia	*Carlia jarnoldae*	01-Feb-1992	12° 37' 07" N	141° 59' 08" E'	100 m	Incidental
72	Reptilia	*Carlia storri*	05-Feb-1992	12° 28' 48" N	141° 54' 09" E'	200 m	Night Mixed
73	Reptilia	*Carlia storri*	05-Feb-1992	12° 28' 48" N	141° 54' 09" E'	200 m	Night Mixed
74	Reptilia	*Carlia storri*	06-Feb-1992	12° 28' 48" N	141° 54' 09" E'	200 m	Incidental
75	Reptilia	*Carlia storri*	06-Feb-1992	12° 28' 48" N	141° 54' 09" E'	200 m	Incidental
79	Reptilia	*Carlia storri*	11-Feb-1992	12° 28' 30" N	141° 46' 57" E'	100 m	Trapping Pitfall
80	Reptilia	*Delma tincta*	14-Feb-1992	12° 28' 31" N	141° 47' 00" E'	100 m	Trapping Pitfall
82	Amphibia	*Sphenophryne gracilipes*	12-Feb-1992	12° 28' 56" N	141° 46' 53" E'	100 m	Trapping Pitfall
83	Amphibia	*Litoria rothii*	01-Jan-1993	12° 37' 19" S'	141° 56' 25" E'	200 m	Incidental
84	Reptilia	*Carlia longipes*	21-May-1992	12° 43' 17" N	141° 56' 48" E'	100 m	Trapping Pitfall
87	Reptilia	*Carlia jarnoldae*	21-May-1992	12° 43' 22" N	141° 56' 48" E'	100 m	Trapping Pitfall
89	Reptilia	*Ctenotus spaldingi*	21-May-1992	12° 43' 22" N	141° 56' 48" E'	100 m	Trapping Pitfall
90	Reptilia	*Diporiphora bilineata*	20-May-1992	12° 43' 17" N	141° 56' 48" E'	100 m	Incidental
97	Amphibia	*Limnodynastes ornatus*	27-Sep-1992	12° 36' 40" N	141° 56' 01" E'	100 m	Incidental
100	Amphibia	*Bufo marinus*	28-May-1992	12° 37' 17" N	141° 56' 27" E'	100 m	Incidental
106	Reptilia	*Demansia atra*	16-Jun-1993	12° 34' 00" N	141° 53' 14" E'	1000 m	Incidental

Field No	Class	Species	Date	Latitude	Longitude	Geocode Accuracy	Survey Method
107	Reptilia	*Demansia atra*	19-May-1993	12° 24' 00" N	141° 30' 00" E'	400 m	Incidental
108	Amphibia	*Uperoleia mimula*	27-Sep-1992	12° 36' 40" N	141° 56' 01" E'	100 m	Incidental
109	Reptilia	*Lialis burtonis*	11-Jun-1992	12° 28' 31" N	141° 47' 00" E'	100 m	Night Ground
110	Reptilia	*Lophognathus temporalis*	27-Jun-1992	12° 37' 05" N	141° 59' 05" E'	100 m	Trapping Pitfall
111	Reptilia	*Carlia jarnoldae*	27-Jun-1992	12° 37' 07" N	141° 59' 08" E'	100 m	Trapping Pitfall
112	Reptilia	*Heteronotia binoei*	21-Jun-1992	12° 29' 43" N	141° 54' 30" E'	100 m	Incidental
113	Amphibia	*Litoria nasuta*	02-Jun-1992	12° 37' 17" N	141° 56' 27" E'	100 m	Incidental
114	Amphibia	*Litoria pallida*	18-Feb-1992	12° 36' 40" N	141° 56' 01" E'	100 m	Trapping Pitfall
116	Reptilia	*Gehyra dubia*	11-Jun-1992	12° 28' 31" N	141° 47' 00" E'	100 m	Incidental
117	Amphibia	*Litoria nasuta*	11-Jun-1992	12° 28' 31" N	141° 47' 00" E'	100 m	Incidental
118	Reptilia	*Carlia longipes*	21-May-1993	12° 43' 22" N	141° 56' 48" E'	100 m	Trapping Pitfall
119	Reptilia	*Morethia taeniopleura*	29-May-1992	12° 37' 16" N	141° 56' 27" E'	100 m	Trapping Pitfall
120	Amphibia	*Litoria nigrofrenata*	24-May-1992	12° 43' 22" N	141° 56' 48" E'	100 m	Incidental
121	Reptilia	*Diporiphora bilineata*	21-Mar-1992	12° 43' 22" N	141° 56' 48" E'	100 m	Incidental
122	Reptilia	*Ctenotus spaldingi*	19-Feb-1992	12° 36' 47" N	141° 56' 29" E'	100 m	Trapping Pitfall
123	Amphibia	*Limnodynastes ornatus*	17-Feb-1992	12° 36' 47" N	141° 56' 29" E'	100 m	Trapping Pitfall
124	Reptilia	*Carlia jarnoldae*	02-Mar-1992	12° 43' 17" N	141° 56' 48" E'	100 m	Incidental
125	Reptilia	*Ctenotus spaldingi*	16-Feb-1992	12° 36' 40" N	141° 56' 01" E'	100 m	Trapping Pitfall
126	Amphibia	*Litoria bicolor*	23-Feb-1992	12° 30' 44" N	141° 48' 01" E'	100 m	Incidental
127	Amphibia	*Crinia remota*	26-Feb-1992	12° 30' 44" N	141° 48' 01" E'	100 m	Trapping Pitfall
128	Amphibia	*Uperoleia mimula*	26-Feb-1992	12° 30' 44" N	141° 48' 01" E'	100 m	Trapping Pitfall
129	Amphibia	*Crinia remota*	26-Feb-1992	12° 30' 44" N	141° 48' 01" E'	100 m	Trapping Pitfall
130	Amphibia	*Crinia remota*	26-Feb-1992	12° 30' 44" N	141° 48' 01" E'	100 m	Trapping Pitfall
131	Amphibia	*Crinia remota*	26-Feb-1992	12° 30' 44" N	141° 48' 01" E'	100 m	Trapping Pitfall
133	Reptilia	*Diporiphora bilineata*	16-Feb-1992	12° 37' 16" N	141° 56' 27" E'	100 m	Trapping Pitfall
134	Reptilia	*Carlia storri*	12-Feb-1992	12° 28' 30" N	141° 46' 57" E'	100 m	Trapping Pitfall
135	Reptilia	*Glaphyromorphus nigricaudis*	15-Feb-1992	12° 37' 17" N	141° 56' 27" E'	100 m	Trapping Pitfall
136	Reptilia	*Diporiphora bilineata*	03-Mar-1992	12° 43' 22" N	141° 56' 48" E'	100 m	Trapping Pitfall
137	Reptilia	*Carlia storri*	16-Oct-1991	12° 37' 59" S'	142° 00' 00" E'	01 min	Incidental
138	Reptilia	*Carlia jarnoldae*	02-Mar-1992	12° 43' 17" N	141° 56' 48" E'	100 m	Incidental
139	Amphibia	*Cyclorana novaehollandiae*	03-Mar-1992	12° 37' 14" N	141° 52' 30" E'	100 m	Incidental
140	Reptilia	*Glaphyromorphus nigricaudis*	17-Feb-1992	12° 37' 17" N	141° 56' 27" E'	100 m	Incidental
141	Reptilia	*Diporiphora bilineata*	14-Feb-1992	12° 28' 47" N	141° 47' 13" E'	100 m	Trapping Pitfall
142	Amphibia	*Uperoleia mimula*	18-Feb-1992	12° 37' 16" N	141° 56' 27" E'	100 m	Trapping Pitfall
143	Reptilia	*Carlia storri*	17-Feb-1992	12° 37' 16" N	141° 56' 27" E'	100 m	Incidental
145	Amphibia	*Limnodynastes convexiusculus*	26-Feb-1992	12° 30' 42" N	141° 47' 59" E'	100 m	Trapping Pitfall
146	Amphibia	*Sphenophryne gracilipes*	14-Feb-1992	12° 36' 47" N	141° 56' 29" E'	100 m	Incidental
147	Reptilia	*Morethia taeniopleura*	12-Feb-1992	12° 28' 56" N	141° 46' 53" E'	100 m	Trapping Pitfall
148	Amphibia	*Limnodynastes ornatus*	03-Mar-1992	12° 43' 22" N	141° 56' 48" E'	100 m	Trapping Pitfall
149	Amphibia	*Limnodynastes ornatus*	19-Feb-1992	12° 36' 40" N	141° 56' 01" E'	100 m	Trapping Pitfall
150	Amphibia	*Limnodynastes ornatus*	24-Sep-1992	12° 43' 22" N	141° 56' 48" E'	100 m	Trapping Pitfall
151	Amphibia	*Limnodynastes convexiusculus*	02-Mar-1992	12° 43' 22" N	141° 56' 48" E'	100 m	Trapping Pitfall
152	Reptilia	*Carlia jarnoldae*	31-Jan-1992	12° 37' 38" N	141° 59' 17" E'	100 m	Incidental
153	Reptilia	*Glaphyromorphus nigricaudis*	01-Feb-1992	12° 35' 59" S'	141° 52' 59" E'	15 km	Incidental
154	Amphibia	*Litoria gracilenta*	21-Feb-1992	12° 37' 14" N	141° 52' 30" E'	100 m	Incidental
155	Amphibia	*Limnodynastes ornatus*	02-Mar-1992	12° 42' 36" N	141° 56' 47" E'	100 m	Trapping Pitfall
156	Reptilia	*Diporiphora bilineata*	14-Feb-1992	12° 28' 30" N	141° 46' 57" E'	100 m	Trapping Pitfall
157	Reptilia	*Glaphyromorphus nigricaudis*	04-Mar-1992	12° 43' 22" N	141° 56' 48" E'	100 m	Trapping Pitfall
158	Reptilia	*Carlia storri*	16-Feb-1992	12° 37' 17" N	141° 56' 27" E'	100 m	Trapping Pitfall
159	Amphibia	*Litoria nigrofrenata*	23-Feb-1992	12° 43' 38" N	141° 56' 05" E'	100 m	Incidental
160	Reptilia	*Nactus pelagicus*	24-Jan-1992	12° 37' 07" N	141° 59' 42" E'	100 m	Incidental
161	Amphibia	*Cyclorana novaehollandiae*	17-Feb-1992	12° 36' 40" N	141° 56' 01" E'	100 m	Incidental
162	Amphibia	*Litoria bicolor*	01-Feb-1992	12° 36' 40" N	141° 56' 01" E'	100 m	Incidental
163	Reptilia	*Carlia longipes*	01-Feb-1992	12° 37' 07" N	141° 59' 08" E'	100 m	Incidental
164	Reptilia	*Nactus pelagicus*	14-Feb-1992	12° 36' 47" N	141° 56' 29" E'	100 m	Incidental
165	Reptilia	*Glaphyromorphus nigricaudis*	18-Feb-1992	12° 37' 16" N	141° 56' 27" E'	100 m	Trapping Pitfall
166	Amphibia	*Crinia remota*	26-Feb-1992	12° 30' 44" N	141° 48' 01" E'	100 m	Incidental
167	Amphibia	*Litoria nigrofrenata*	23-Feb-1992	12° 43' 38" N	141° 56' 05" E'	100 m	Incidental
168	Reptilia	*Carlia storri*	16-Oct-1991	12° 40' 00" N	142° 02' 35" E'	100 m	Incidental
169	Reptilia	*Carlia storri*	16-Oct-1991	12° 40' 00" N	142° 02' 35" E'	100 m	Incidental
170	Reptilia	*Glaphyromorphus nigricaudis*	18-Dec-1992	12° 37' 17" N	141° 56' 27" E'	100 m	Trapping Pitfall
171	Amphibia	*Crinia remota*	18-Dec-1992	12° 37' 17" N	141° 56' 27" E'	100 m	Trapping Pitfall
172	Amphibia	*Limnodynastes ornatus*	03-Mar-1992	12° 42' 36" N	141° 56' 47" E'	100 m	Trapping Pitfall
173	Amphibia	*Limnodynastes ornatus*	03-Mar-1992	12° 42' 36" N	141° 56' 47" E'	100 m	Incidental
174	Reptilia	*Carlia longipes*	02-Mar-1992	12° 43' 22" N	141° 56' 48" E'	100 m	Trapping Pitfall
175	Amphibia	*Limnodynastes ornatus*	02-Mar-1992	12° 43' 22" N	141° 56' 48" E'	100 m	Incidental
176	Amphibia	*Limnodynastes ornatus*	02-Mar-1992	12° 43' 22" N	141° 56' 48" E'	100 m	Incidental
177	Amphibia	*Limnodynastes ornatus*	02-Mar-1992	12° 43' 22" N	141° 56' 48" E'	100 m	Incidental
178	Amphibia	*Uperoleia mimula*	02-Mar-1992	12° 43' 22" N	141° 56' 48" E'	100 m	Incidental
179	Amphibia	*Crinia remota*	23-Feb-1992	12° 43' 38" N	141° 56' 05" E'	100 m	Incidental
180	Amphibia	*Crinia remota*	23-Feb-1992	12° 43' 38" N	141° 56' 05" E'	100 m	Incidental
181	Amphibia	*Crinia remota*	23-Feb-1992	12° 43' 38" N	141° 56' 05" E'	100 m	Incidental
182	Amphibia	*Limnodynastes ornatus*	02-Mar-1992	12° 43' 22" N	141° 56' 48" E'	100 m	Trapping Pitfall
183	Amphibia	*Limnodynastes ornatus*	02-Mar-1992	12° 43' 22" N	141° 56' 48" E'	100 m	Trapping Pitfall
184	Reptilia	*Diporiphora bilineata*	02-Mar-1992	12° 43' 17" N	141° 56' 48" E'	100 m	Incidental
185	Reptilia	*Diporiphora bilineata*	02-Mar-1992	12° 43' 17" N	141° 56' 48" E'	100 m	Incidental

Field No	Class	Species	Date	Latitude	Longitude	Geocode Accuracy	Survey Method
186	Amphibia	*Crinia remota*	27-Feb-1992	12° 30' 27" N	141° 47' 37" E'	100 m	Incidental
187	Amphibia	*Litoria nasuta*	29-Feb-1992	12° 30' 44" N	141° 48' 01" E'	100 m	Incidental
188	Amphibia	*Limnodynastes ornatus*	03-Mar-1992	12° 42' 45" N	141° 56' 57" E'	100 m	Trapping Pitfall
189	Amphibia	*Limnodynastes ornatus*	03-Mar-1992	12° 42' 45" N	141° 56' 57" E'	100 m	Incidental
190	Amphibia	*Crinia remota*	03-Mar-1992	12° 42' 45" N	141° 56' 57" E'	100 m	Incidental
191	Amphibia	*Limnodynastes ornatus*	03-Mar-1992	12° 42' 45" N	141° 56' 57" E'	100 m	Incidental
192	Amphibia	*Litoria nigrofrenata*	19-Aug-1992	12° 30' 44" N	141° 48' 01" E'	100 m	Incidental
193	Amphibia	*Limnodynastes convexiusculus*	19-Aug-1992	12° 30' 44" N	141° 48' 01" E'	100 m	Incidental
194	Amphibia	*Litoria bicolor*	19-Aug-1992	12° 30' 44" N	141° 48' 01" E'	100 m	Incidental
195	Amphibia	*Litoria bicolor*	19-Aug-1992	12° 30' 44" N	141° 48' 01" E'	100 m	Incidental
196	Amphibia	*Crinia remota*	19-Aug-1992	12° 30' 44" N	141° 48' 01" E'	100 m	Incidental
197	Amphibia	*Litoria nasuta*	19-Aug-1992	12° 30' 44" N	141° 48' 01" E'	100 m	Incidental
198	Reptilia	*Carlia storri*	29-Jan-1992	12° 28' 37" N	141° 50' 03" E'	100 m	Incidental
199	Reptilia	*Carlia jarnoldae*	29-Jan-1992	12° 28' 37" N	141° 50' 03" E'	100 m	Incidental
200	Amphibia	*Crinia remota*	29-Jan-1992	12° 28' 37" N	141° 50' 03" E'	100 m	Incidental
201	Amphibia	*Uperoleia mimula*	29-Jan-1992	12° 28' 37" N	141° 50' 03" E'	100 m	Incidental
202	Amphibia	*Crinia remota*	29-Jan-1992	12° 28' 37" N	141° 50' 03" E'	100 m	Incidental
203	Amphibia	*Crinia remota*	29-Jan-1992	12° 28' 37" N	141° 50' 03" E'	100 m	Incidental
204	Amphibia	*Crinia remota*	29-Jan-1992	12° 28' 37" N	141° 50' 03" E'	100 m	Incidental
205	Mammalia	*Melomys burtoni*	01-Sep-1992	12° 37' 05" N	141° 59' 05" E'	100 m	Trapping Elliott
206	Reptilia	*Oedura rhombifer*	04-Jul-1992	12° 28' 41" N	141° 50' 37" E'	100 m	Incidental
209	Amphibia	*Limnodynastes ornatus*	24-Sep-1992	12° 43' 22" N	141° 56' 48" E'	100 m	Trapping Pitfall
210	Amphibia	*Limnodynastes ornatus*	24-Sep-1992	12° 43' 22" N	141° 56' 48" E'	100 m	Trapping Pitfall
211	Amphibia	*Uperoleia mimula*	08-Dec-1992	12° 37' 05" N	141° 59' 05" E'	100 m	Trapping Pitfall
212	Amphibia	*Uperoleia mimula*	08-Dec-1992	12° 37' 05" N	141° 59' 05" E'	100 m	Trapping Pitfall
218	Amphibia	*Sphenophryne gracilipes*	05-Dec-1992	12° 37' 07" N	141° 59' 08" E'	100 m	Incidental
228	Amphibia	*Uperoleia mimula*	27-Sep-1992	12° 36' 40" N	141° 56' 01" E'	100 m	Incidental
229	Amphibia	*Crinia remota*	22-May-1992	12° 43' 22" N	141° 56' 48" E'	100 m	Trapping Pitfall
230	Amphibia	*Uperoleia mimula*	08-Dec-1992	12° 37' 05" N	141° 59' 05" E'	100 m	Trapping Pitfall
231	Mammalia	*Macropus agilis*	08-Dec-1992	12° 37' 38" N	141° 59' 17" E'	100 m	Incidental
237	Amphibia	*Limnodynastes ornatus*	11-Jun-1992	12° 28' 30" N	141° 46' 57" E'	100 m	Trapping Pitfall
239	Reptilia	*Gehyra dubia*	09-Dec-1992	12° 37' 38" N	141° 59' 17" E'	100 m	Incidental
241	Reptilia	*Nactus pelagicus*	18-Dec-1992	12° 28' 47" N	141° 47' 13" E'	100 m	Trapping Pitfall
242	Reptilia	*Furina ornata*	17-Dec-1992	12° 35' 59" S'	141° 52' 59" E'	10 km	Incidental
243	Reptilia	*Carlia longipes*	25-Feb-1992	12° 30' 28" N	141° 47' 52" E'	100 m	Trapping Pitfall
244	Reptilia	*Carlia jarnoldae*	31-Dec-1992	12° 28' 41" N	141° 50' 37" E'	100 m	None
245	Amphibia	*Rana daemeli*	05-Jan-1993	12° 37' 17" N	141° 56' 27" E'	100 m	Incidental
247	Reptilia	*Glaphyromorphus nigricaudis*	03-Sep-1992	12° 37' 05" N	141° 59' 05" E'	100 m	Trapping Pitfall
248	Reptilia	*Glaphyromorphus nigricaudis*	03-Sep-1992	12° 37' 05" N	141° 59' 05" E'	100 m	Trapping Pitfall
250	Amphibia	*Litoria rothii*	14-Aug-1992	12° 28' 31" N	141° 47' 00" E'	100 m	Incidental
251	Reptilia	*Ctenotus spaldingi*	15-Jun-1992	12° 30' 27" N	141° 47' 37" E'	100 m	Trapping Pitfall
252	Reptilia	*Carlia longipes*	16-Jun-1993	12° 28' 41" N	141° 50' 37" E'	100 m	Trapping Pitfall
253	Reptilia	*Carlia longipes*	16-Jun-1993	12° 28' 41" N	141° 50' 37" E'	100 m	Trapping Pitfall
254	Reptilia	*Oedura rhombifer*	25-Jun-1993	12° 29' 27" N	141° 54' 10" E'	100 m	Incidental
255	Amphibia	*Crinia remota*	22-Aug-1992	12° 30' 44" N	141° 48' 01" E'	100 m	Trapping Pitfall
256	Reptilia	*Oedura castelnaui*	22-Jun-1993	12° 39' 23" N	141° 59' 32" E'	100 m	Incidental
258	Reptilia	*Oxyuranus scutellatus*	01-Oct-1992	12° 36' 47" N	141° 56' 29" E'	100 m	Incidental
260	Reptilia	*Oedura castelnaui*	21-Mar-1993	12° 28' 30" N	141° 46' 57" E'	100 m	Incidental
269	Amphibia	*Limnodynastes convexiusculus*	10-Jun-1993	12° 37' 05" N	141° 59' 05" E'	100 m	Trapping Pitfall
270	Reptilia	*Ramphotyphlops sp. aff. minimus*	10-Jun-1993	12° 37' 05" N	141° 59' 05" E'	100 m	Trapping Pitfall
272	Reptilia	*Glaphyromorphus nigricaudis*	10-Jun-1993	12° 37' 05" N	141° 59' 05" E'	100 m	Trapping Pitfall
273	Reptilia	Glaphyromorphus nigricaudis	10-Jun-1993	12° 37' 05" N	141° 59' 05" E'	100 m	Trapping Pitfall
274	Amphibia	*Rana daemeli*	08-Apr-1993	12° 37' 24" N	141° 51' 55" E'	200 m	Incidental
275	Amphibia	*Litoria bicolor*	30-May-1993	12° 30' 27" N	141° 47' 37" E'	100 m	Trapping Pitfall
276	Amphibia	*Crinia remota*	30-May-1993	12° 30' 27" N	141° 47' 37" E'	100 m	Trapping Pitfall
277	Amphibia	*Sphenophryne gracilipes*	30-May-1993	12° 30' 42" N	141° 47' 59" E'	100 m	Trapping Pitfall
278	Reptilia	*Diporiphora bilineata*	25-May-1993	12° 35' 59" S'	141° 52' 59" E'	15 km	Incidental
279	Amphibia	*Sphenophryne gracilipes*	13-Jun-1993	12° 37' 07" N	141° 59' 08" E'	100 m	Trapping Pitfall
280	Amphibia	*Sphenophryne gracilipes*	30-May-1993	12° 30' 42" N	141° 47' 59" E'	100 m	Trapping Pitfall
282	Amphibia	*Sphenophryne gracilipes*	19-Feb-1992	12° 37' 17" N	141° 56' 27" E'	100 m	Trapping Pitfall
283	Amphibia	*Sphenophryne gracilipes*	30-May-1993	12° 30' 42" N	141° 47' 59" E'	100 m	Trapping Pitfall
284	Mammalia	*Isoodon macrourus*	12-Jun-1992	12° 28' 47" N	141° 47' 13" E'	100 m	Trapping Cage
285	Amphibia	*Litoria bicolor*	07-Jun-1993	12° 36' 47" N	141° 56' 29" E'	100 m	Trapping Pitfall
287	Amphibia	*Sphenophryne gracilipes*	30-May-1993	12° 30' 42" N	141° 47' 59" E'	100 m	Trapping Pitfall
288	Reptilia	*Morethia taeniopleura*	19-Jun-1993	12° 28' 01" N	141° 50' 34" E'	100 m	Trapping Pitfall
299	Amphibia	*Limnodynastes ornatus*	05-Mar-1992	12° 42' 45" N	141° 56' 57" E'	100 m	Trapping Pitfall
306	Amphibia	*Sphenophryne gracilipes*	22-Aug-1992	12° 30' 44" N	141° 48' 01" E'	100 m	Trapping Pitfall
308	Amphibia	*Litoria bicolor*	22-Aug-1992	12° 30' 44" N	141° 48' 01" E'	100 m	Trapping Pitfall
309	Amphibia	*Litoria bicolor*	22-Aug-1992	12° 30' 44" N	141° 48' 01" E'	100 m	Trapping Pitfall
314	Amphibia	*Sphenophryne gracilipes*	22-Aug-1992	12° 30' 44" N	141° 48' 01" E'	100 m	Trapping Pitfall
315	Amphibia	*Sphenophryne gracilipes*	22-Aug-1992	12° 30' 44" N	141° 48' 01" E'	100 m	Trapping Pitfall
318	Amphibia	*Sphenophryne gracilipes*	22-Aug-1992	12° 30' 44" N	141° 48' 01" E'	100 m	Trapping Pitfall
321	Amphibia	*Sphenophryne gracilipes*	22-Aug-1992	12° 30' 44" N	141° 48' 01" E'	100 m	Trapping Pitfall
323	Amphibia	*Sphenophryne gracilipes*	22-Aug-1992	12° 30' 44" N	141° 48' 01" E'	100 m	Trapping Pitfall
326	Amphibia	*Uperoleia mimula*	03-Sep-1992	12° 37' 05" S'	141° 59' 04" E'	500 m	Incidental
328	Amphibia	*Litoria bicolor*	26-May-1993	12° 30' 28" N	141° 47' 52" E'	100 m	Trapping Pitfall

Field No	Class	Species	Date	Latitude	Longitude	Geocode Accuracy	Survey Method
342	Amphibia	*Limnodynastes ornatus*	18-Feb-1992	12° 36' 40" N	141° 56' 01" E'	100 m	Trapping Pitfall

228	Count of specimens lodged with Queensland Museum